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Report of the 2006 session of the Joint EIFAC/ICES Working Group on Eels

Rome, 23–27 January 2006

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European Inland Fisheries Advisory Commission
Food and Agriculture Organization of the United Nations
Rome

International Council for the Exploration of the Sea
Copenhagen

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2006

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
Copenhagen, 2006

Preparation of this document

This publication is the report of the 2006 session of the Joint European Inland Fisheries Advisory Commission (EIFAC) and International Council for the Exploration of the Sea (ICES) Working Group on Eels which was held at FAO headquarters in Rome from 23 to 27 January 2006.

The Working Group on Eels consisted of experts from EIFAC, whose Secretariat is located in the Fisheries Department of the FAO, and ICES experts. The draft was prepared by the Working Group.

This report has been divided into seven sections to cover the material reviewed and discussed, focussing on the European eel. Sections 1 and 2 examine the status of the stock and fisheries; Section 3 looks at the quality of spawners; Sections 4 and 5 explore methodology for recovering the stock based on spatial distribution and management considerations; Sections 6 and 7 study restocking as an option.

The Working Group would like to acknowledge ICES for undertaking the editing and formatting of this publication.

Contact addresses:

European Inland Fisheries Advisory Commission
Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00153 Rome, Italy
Telephone (+39) 06 5705 4376
Telefax (+39) 06 5705 3360
www.fao.org publications-sales@fao.org

International Council for the Exploration of the Sea
H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V, Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk info@ices.dk

Abstract

This publication is the report of the 2006 session of the Joint European Inland Fisheries Advisory Commission (EIFAC) and International Council for the Exploration of the Sea (ICES) Working Group on Eels which was held in Rome from 23 to 27 January 2006.

The Working Group, after reviewing the available information on the status of the stock and fisheries of the European eel, supported the view that the population as a whole has declined in most of the distribution area, that the stock is outside safe biological limits and that current fisheries are not sustainable. Recruitment is at a historical low and most recent observations do not indicate recovery. Opportunities for protection and restoration of spawner escapement are fading.

Earlier reports indicate that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. climate change, predation) may have contributed to the decline. Measures aimed at recovery of the stock are well known and may include control of exploitation, restocking of recruits and restoration of habitats (including access to and from).

Recent research shows that the quality of the spawners escaping from the continent might be seriously impaired by pollution, diseases and parasites. Additionally, the quality of spawners varies with biological characteristics such as size and fat content. None of these quality parameters is currently included in the assessment of the status of the stock or in setting management targets. Implementation of basic field sampling programmes, i.a. within the EU Water Framework Directive (WFD) and National Management Plans, and further analysis will be required, in order to include quality aspects in future management advice.

The objective of recovery of the stock necessitates restoration of the spawning stock, for which the European Commission has proposed a target of 40% of the potential production under unfished, unpolluted and unobstructed conditions. Methodology for elaboration of this reference level is described, but actual implementation requires field data and analysis for each spatial management unit. Analysis of stock dynamics under different fisheries management regimes indicates that recovery times may vary from 20 up to 200 years, depending on the intensity of implemented fisheries restrictions. However, restrictions on fisheries alone will be insufficient, and management measures aimed at other anthropogenic impacts on habitat quality, quantity and accessibility will also be required.

The continental population extends throughout Europe and northern Africa and fisheries are scattered over many large and small water bodies, both marine and freshwater. The overall objective will have to be achieved by implementation of protective measures at a regional scale, presumably at the level of River Basin Districts (RBDs as defined for the WFD). The compilation of information on the spatial distribution of the current eel fisheries in this report shows that almost all RBDs will be involved. Spatial differentiation in targets, controls and post-evaluation procedures might facilitate the implementation.

Restocking has been practised by some countries for decades, generally to maintain fisheries rather than improve the stock or recruitment. There are concerns over the unknown risks of moving fish between rivers. Restocking may be beneficial to rebuilding the stock, but it is highly unlikely that the 40% objective will be met in all European river basins in the medium term by restocking alone. Only a combination of several measures can be expected to bring the stock out of its current critical state. The current glass eel catches are probably insufficient to restock inland waters, and any further decline in glass eel recruitment could result in total loss of the option to use restocking as a measure.

Recommendations to protect the stock, and suggestions for a forward focus of the work of this group are presented.

FAO European Inland Fisheries Advisory Commission; International Council for the Exploration of the Sea. Report of the 2006 session of the Joint EIFAC/ICES Working Group on Eels. Rome, 23–27 January 2006. EIFAC Occasional Paper. No. 38, ICES CM 2006/ACFM:16. Rome, FAO/Copenhagen, ICES. 2006. 352p.

Executive summary

This report summarises the presentations, discussions and recommendations of the 2006 session of the Joint EIFAC/ICES Working Group on Eels which took place in Rome (Italy) from 23 to 27 January 2006.

In this section, the findings in this report are summarised, a forward focus for the Working Group is suggested, and main recommendations are presented.

Summary of this report

Review of the available information on the status of the stock and fisheries of the European eel supports the view that the population as a whole has declined in most of the distribution area, that the stock is outside safe biological limits and that current fisheries are not sustainable. Recruitment is at a historical minimum and most recent observations do not indicate recovery. The level observed since 1990 is below 20% of the level observed not more than three generations ago; the European eel therefore qualifies for the IUCN Red List of endangered species. Opportunities for protection and restoration of spawner escapement are fading (Section 2).

Evidence has been given in earlier reports that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. climate change, predation) may have contributed to the decline. Measures aimed at recovery of the stock are well known and may include control of exploitation, restocking of recruits and restoration of habitats (including access to and from).

Recent research reviewed in this report has indicated that the quality of the spawners escaping from the continent might be seriously impaired by pollution, diseases and parasites. Additionally, the quality of spawners varies with biological characteristics such as size and fat content. None of these quality parameters is currently included in the assessment of the status of the stock or in setting management targets. Implementation of basic field sampling programmes, i.a. within the European Union Water Framework Directive (WFD) and National Management Plans, and further analysis will be required, in order to include quality aspects in future management advice (Section 3).

The objective of recovery of the stock necessitates restoration of the spawning stock, for which the EC has proposed a target of 40% of the potential production under unfished, unpolluted and unobstructed conditions. Methodology for elaboration of this reference level is described in this report, but actual implementation will require field data and analysis for each spatial management unit. Analysis of stock dynamics under different fisheries management regimes indicates that recovery times may vary from 20 up to 200 years, depending on the intensity of implemented fisheries restrictions. However, restrictions on fisheries alone will be insufficient, and management measures aimed at other anthropogenic impacts on habitat quality, quantity and accessibility will also be required (Section 4).

The continental population extends throughout Europe and northern Africa and fisheries are scattered over many large and small water bodies, both marine and fresh water. The overall objective will have to be achieved by implementation of protective measures at a regional scale, presumably at the level of River Basin Districts (RBDs as defined for the WFD). The compilation of information on the spatial distribution of the current eel fisheries in this report shows that almost all RBDs will be involved. Spatial differentiation in targets, controls and post-evaluation procedures might facilitate the implementation (Sections 4 and 5)

Restocking has been practised by some countries for decades, generally to maintain fisheries rather than improve the stock or recruitment. There are concerns over the unknown risks of moving fish between rivers. Restocking may be beneficial to rebuilding the stock, but it is highly unlikely that the 40% objective will be met in all European river basins in the medium term by re-stocking alone. Only a combination of several measures can be expected to bring the stock out of its current critical state. The current glass eel catches are probably insufficient to re-stock inland waters, and any further decline in glass eel recruitment could result in total loss of the option to use restocking as a measure (Section 7).

Forward Focus

The information in this report constitutes a further step in an ongoing process of documenting eel stock status and fisheries and developing a methodology for giving scientific advice on management, to effect a recovery of the European eel. To this end, a line of thought has been generated in previous reports (ICES, 2000a; 2002; EIFAC, 2003); spatial and temporal trends in the stock and fisheries have been documented; options for deriving reference levels have been reviewed; potential management measures have been listed; spatial levels for effective management have been explored; and opportunities for post-evaluation have been considered. Given the depleted state of the stock, urgent management actions are required to protect and restore the spawning stock, in order to restore natural recruitment.

The Communication from the Commission (COM 2003, 573 final) and the Proposal for a Council Regulation Establishing Measures for the Recovery of the stock of European Eel (COM 2005, 472 final) now provide impetus to the development of recovery plans, at the regional, national and international level. Inclusion of the eel in the Data Collection Regulation is foreseen (Dekker, 2005). The development of (national) management plans according to the proposed Council Regulation will benefit from reports of this Working Group, but it is recognised that scientific advice may fall short of that required due to budgetary constraints on past monitoring and research, as repeatedly reported in previous meetings (ICES, 1999, 2001, 2002, 2003, 2004a, 2005a).

As a consequence, it is time to re-focus the objectives of this Working Group. Considerably more, and more reliable, information will become available, which might have implications for the temporal consistency in available data series. Past efforts of this Working Group to document the decline of the stock and to support the development of protective measures (targets, measures, post-evaluation) have effectively supported the recent developments. Specific support to the development of the EC recovery plan and (national) Management Plans will probably be organised in other ways, responding more rapidly than this joint EIFAC/ICES Working Group can do.

Future focus of the Working Group might concentrate on:

1) establishment of an international data base for data on eel stock and fisheries, as well as habitat related data, aiming at:

2) development of methodology, for assessment of the status of the eel population, the impact of fisheries and other anthropogenic impacts and of implemented management measures, at the international level;

3) response to specific requests in support of the development of the stock recovery plans, when made;

4) compilation of a comprehensive and realistic research agenda, aiming at elucidation of the causes of the decline in and quantification of their impacts on the stock (ocean and continent, anthropogenic and natural, etc) [hidden agenda: FP7 proposal on eel. Making eel one case in single-discipline multi-species projects turns out to be unsatisfactory; we need a single-species inter-disciplinary project. Make sure that single-discipline sub-projects are realistic and well integrated into overall programme].

Main Recommendations

The 2006 session of the Joint EIFAC/ICES Working Group on Eels at FAO headquarters in Rome (Italy) recommends that:

a) the rapid development and implementation of management plans is facilitated in a work programme of workshops and guidelines, i.a. for

- re-stocking practices,
- recruiting eel immigration passages,
- silver eel deflection schemes,
- monitoring and post-evaluation procedures, potentially in pilot projects,
- pollution and disease monitoring,
- development of models and tools for management of the stock;

b) areas producing high quality spawners (large sized females, low contaminant and parasite burdens, unimpacted by hydropower stations) be identified in order to maximise protection for these areas;

c) management targets are set for spawner escapement with reference to the 1950s–1970s, either identifying the actual spawner escapement levels of that period in full, or 30–50% of the calculated spawner escapement that would have existed if no anthropogenic mortalities would have impacted the stock – and where adequate data are absent, with reference to similar river systems (ecology, hydrography);

d) under the implementation of the WFD eel specific extensions should be implemented as an indicator of river connectivity and ecological and chemical status.

Contents

1 Introduction

At the 92nd Statutory Meeting of ICES (2005) it was decided that the **Joint EIFAC/ICES Working Group on Eels** [WGEEL] [Chair: W. Dekker (The Netherlands) would meet from 23–27 January 2006 in Rome, Italy, to:

a) describe the eel stock and fisheries in Europe, focusing on improved spatial coverage (cf. Moriarty and Dekker, 1997);
b) assess trends in recruitment, stock and fisheries indicative for the status of the stock, and the impact of exploitation;
c) evaluate the effect of glass eel restocking on the restoration of the spawning stock in relation to the established rebuilding goals, considering options from no re-stocking to full re-stocking of all available glass eel;
d) review and revise where appropriate the catch statistics for European eel;
e) discuss EU considerations regarding a management plan for European Eel and comment in relation to the precautionary approach;
f) consider the feasibility of potential inclusion of spawner quality parameters in stock management advice, specifically focusing on the quantification of the impact of pollution and parasitism;
g) describe and advise on the tools for post-evaluation of the status of the stock and the impact of management measures on stock and fisheries;
h) continue work to expand the data bases and knowledge on eels, to provide a more complete basis for recovery plans of the stocks/populations.

33 people attended the meeting, from fourteen countries (see Annex 1).

The current Terms of Reference and Report constitute one step in an ongoing process of documenting the status of the European eel stock and fisheries and compiling management advice. As such, the current Report does not present a comprehensive overview, but should be read in conjunction with previous reports (ICES, 2000a, 2002, 2003, 2004a, 2005a).

The structure of this report does not strictly follow the order of the Terms of Reference for the meeting, since different aspects of subjects where covered under different headings and a rearrangement of the Sections by subject was considered preferable.

Section 2 present trends in recruitment, stock and fisheries indicative for the status of the stock and the impact of exploitation (ToR b.).

Section 3 discusses the feasibility of inclusion of spawner quality parameters in stock management advice (ToR f.).

Section 4 discusses the objective of stock recovery, explores options for deriving management targets, and analysis the time span required for actual recovery (ToR e. and h.).

Section 4.4 considers the spatial resolution in potential management targets, in implementing controls on anthropogenic impacts, and in monitoring the stock for post-evaluation (ToR e. and g.).

Section 5 presents available data in the spatial distribution of the fishery in Europe (ToR a.).

Section 7 analyses options for applying re-stocking of glass eel as a potential management measure, aiming at recovery of the stock (ToR c.).

The summary of **main conclusions and recommendations**, and an outlook for future focus of this Working Group are presented at the very start of this report.

Terms of Reference d. (revision of catch statistics) is the follow-up of the analysis made in the report of the 2004 meeting of the Working Group (ICES, 2005a, specifically Annex 2). Following that meeting, a Workshop has been held under the umbrella of the European Data

Collection Regulation DCR, in September 2005, Sånga Säby (Stockholm, Sweden) (Dekker, 2005). The Workshop report presents catch statistics in greater detail than has been handled by this Working Group before. Additionally, a further improvement of the catch statistics is foreseen, when the DCR is actually implemented for the eel fisheries across Europe. For the time being, review and revision of the catch statistics was therefore considered rather ineffective.

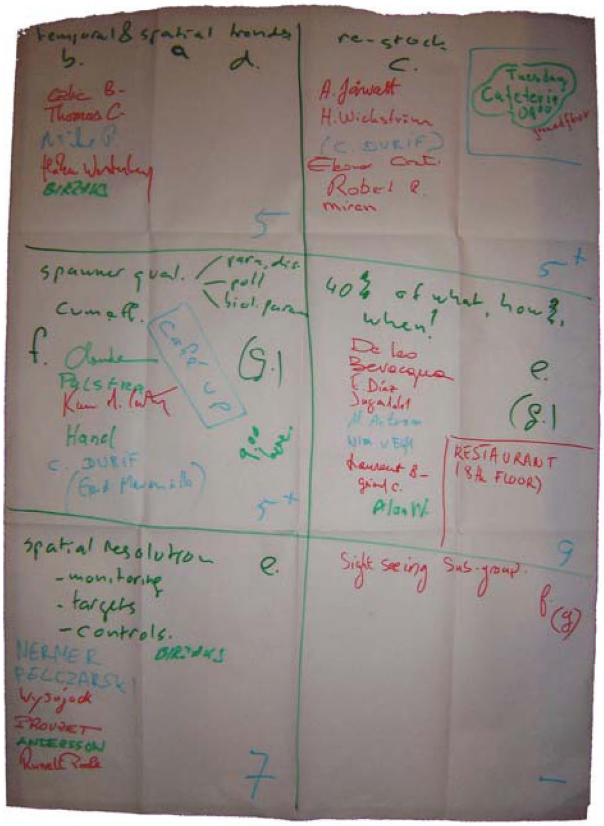


Figure 1.1 Breaking down the tasks during the meeting of the WG.

2 Trends in Recruitment, Stock and Yield

This Section presents the trends observed in recruitment, stock and fisheries, indicative for the status of the stock and the impact of exploitation (ToR b).

2.1 Trends in recruitment

There are relatively few data sets that provide information on changes in the level of recruitment of the European eel, and those there are relate to various stages (pigmentation, behaviour) of the recruitment into continental habitats (Dekker, 2002). Available time-series from 19 river catchments in 12 countries have been examined for trends, with data from 11 rivers available for 2005, and additional information reported for 2003 and 2004 (Table 2.1.1). The data analysed were derived from both fishery-dependent sources (i.e. catch records) and fishery-independent surveys across much of the geographic range of the European eel, and cover varying time intervals.

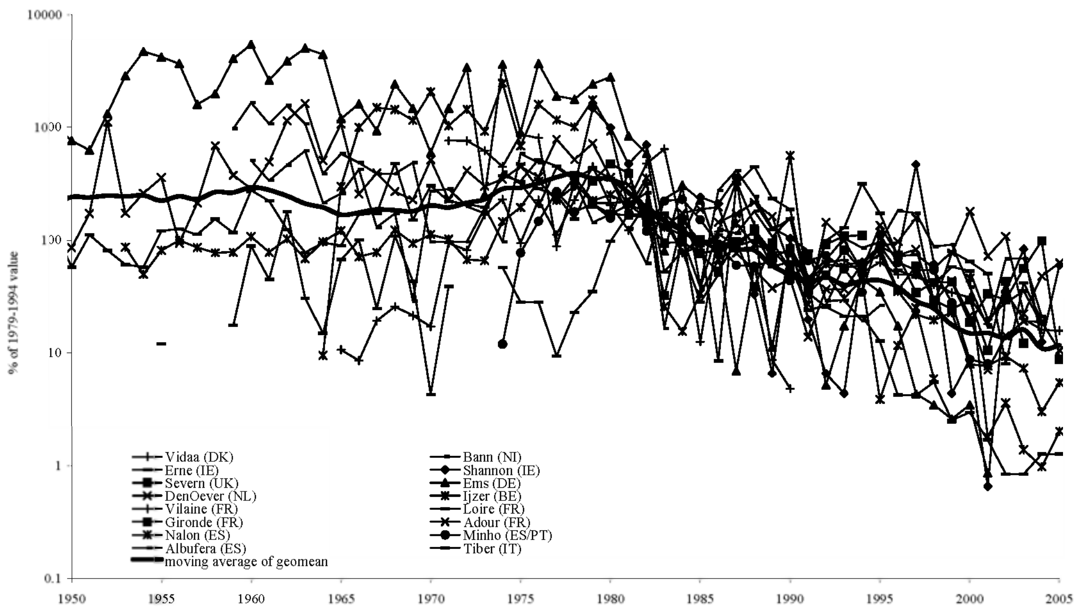


Figure 2.1.1. Time-series of monitoring glass eel recruitment in European rivers, for which data are reported for 2005. Each series has been scaled to its 1979–1994 average.

Downward trends are evident over the last two decades of all time-series, reflecting the rapid decrease after the high levels of the late 1970s. Through the 1980s and 1990s, the overall trend was downwards (Figure 2.1.1 and 2.1.2).

Data collected for 2004/2005 show that recruitment might now be lower than the minimum level of 2001. The low level of recruitment in 2001 was synchronous with a low NAO index and a smaller size of glass eels. The lower level of recruitment in 2004/2005 did not coincide with a low NAO index or small size, and might therefore correspond to a further deterioration of the status of the stock.

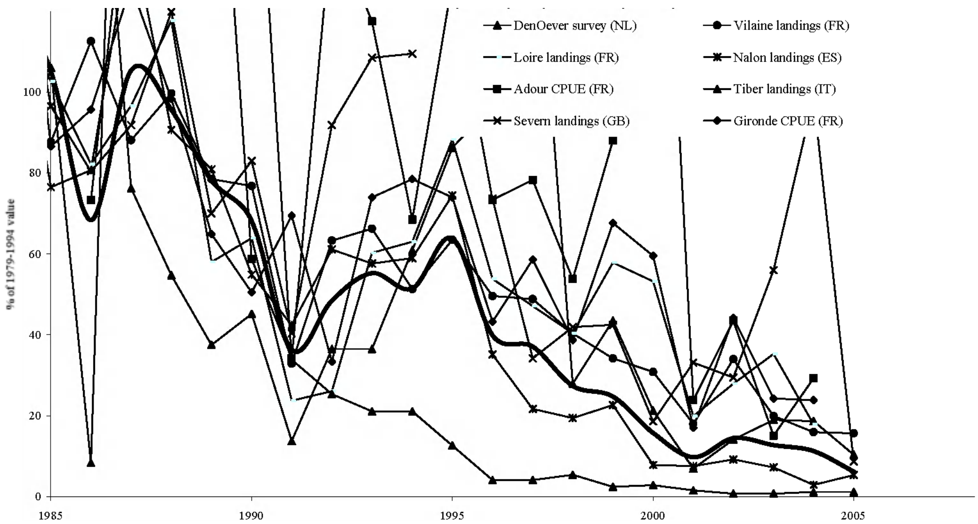


Figure 2.1.2. Time-series of monitoring glass eel recruitment in European rivers; data limited to estuarine fisheries. Each series has been scaled to its 1979–1994 average.

In northern areas, no glass eels are found to recruit into the rivers, while the transition to the yellow eel stage happens long before the immigration into fresh water. Figure 2.1.3 presents the results of these data series. In the early-mid 1990s, there was a moderate recovery in glass eel recruitment (Figure 2.1.1), which may have been reflected in the data on yellow eel recruitment that showed an increasing trend in the late-1990s.

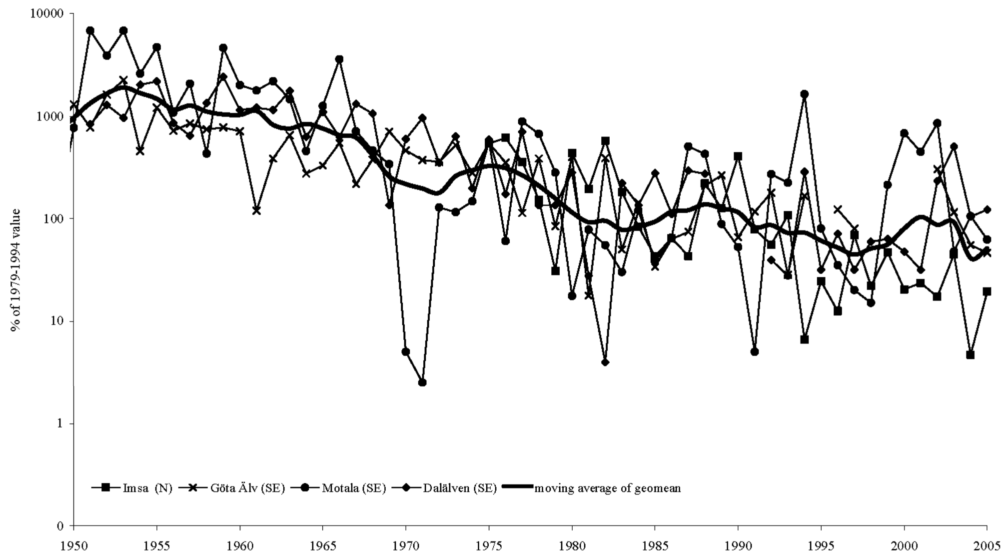


Figure 2.1.3. Time-series of monitoring yellow eel recruitment (older than one year) in European rivers, for which data are reported for 2005. Each series has been scaled to the 1979–1994 average.

Table 2.1.1 Recruitment data series. Part 1. Scandinavia and British Isles. The data units vary between data series; see the detailed Country Reports at the end of this report.

	N	S	S	S	S	DK	D	N.Irl.	Irl	Irl	UK
year	Imsa	Göta Älv	Viskan	Motala	Dalälven	Vidaa	Ems	Bann	Erne	Shannon	Severn
1950		2947		305			875				
1951		1744		2713	210		719				
1952		3662		1544	324		1516				
1953		5071		2698	242		3275				
1954		1031		1030	509		5369				
1955		2732		1871	550		4795		167		
1956		1622		429	215		4194				
1957		1915		826	162		1829				
1958		1675		172	337		2263				
1959		1745		1837	613		4654		244		
1960		1605		799	289		6215	7409	1229		
1961		269		706	303		2995	4939	625		
1962		873		870	289		4430	6740	2469		
1963		1469		581	445		5746	9077	426		
1964		622		181.6	158		5054	3137	208		
1965		746		500	276		1363	3801	932		
1966		1232		1423	158		1840	6183	1394		
1967		493		283	332		1071	1899	345		
1968		849		184	266		2760	2525	1512		
1969		1595		135	34		1687	422	600		
1970		1046		2	150		683	3992	60		
1971		842	12	1	242	787	1684	4157	540		
1972		810	88	51	88	780	3894	2905			
1973		1179	177	46	160	641	289	2524			
1974		631	13	58.5	50	464	4129	5859	794		
1975	42945	1230	99	224	149	888	1031	4637	392		
1976	48615	798	500	24	44	828	4205	2920	394		
1977	28518	256	850	353	176	91	2172	6443	131	1.02	
1978	12181	873	533	266	34	335	2024	5034	320	1.37	
1979	2457	190	505	112	34	220	2774	2089	488	6.69	40.1
1980	34776	906	72	7	71	220	3195	2486	1352	4.5	32.8
1981	15477	40	513	31	7	226	962	3023	2346	2.15	32
1982	45750	882	380	22	1	490	674	3854	4385	3.16	30.4
1983	14500	113	308	12	56	662	92	242	728	0.6	6.2
1984	6640	325	21	48	34	123	352	1534	1121	0.5	29
1985	3412	77	200	15.2	70	13	260	557	394	1.09	18.6
1986	5145	143	151	26	28	123	89	1848	684	0.95	15.5
1987	3434	168	146	201	74	341	8	1683	2322	1.61	17.7
1988	17500	475	92	170	69	141	67	2647	3033	0.15	23.1
1989	10000	598	32	35.2		9	13	1568	1718	0.03	13.5
1990	32500	149	42	21		5	99	2293	2152	0.47	16
1991	6250	264	1	2			52	677	482	0.09	7.8
1992	4450	404	70	108	10		6	978	1371	0.03	17.7
1993	8625	64	43	89	7		20	1525	1785	0.02	20.9
1994	525	377	76	650	72		52	1249	4400	0.29	21.1
1995	1950		6	32	8		40	1403	2400	0.40	
1996	1000	277	1	14	18		20	2667	1000	0.33	14.2
1997	5500	180	8	8	8		5	2533	1038	2.12	6.6
1998	1750		5	6	15		4	1283	782	0.28	8.1
1999	3750		2	85	16		3	1345	1246	0.02	8.2
2000	1625		14	270	12		4	563	1074	0.04	3.6
2001	1875		2	178	8		1	250	699	0.00	6.4
2002	1375	685	26.2	338.8	58.6		-	1000	112	0.18	5.7
2003	3775	261	44.13	19	126.7		-	1010	580	0.38	10.8
2004	375	125	5	42	26.4		-	308	269	0.06	19
2005	1550	105	25.8	24.8	30.9				836	0.04	

(continued)

Table 2.1.1 Recruitment data series; <u>continued</u>. Part 2: Mainland Europe. The data units vary between data series; see the detailed Country Reports at the end of this report.

	NL	B	F	F	F	F	F	E	P/E	It	
	DenOever	Ijzer	Vilaine	Loire	Gironde (CPUE)	Gironde (Yield)	Adour	Nalon	Minho	Tiber	**Geomean**[1]
1950	7.15			86							**240**
1951	14.07			166							**239**
1952	90.95			121							**247**
1953	14.78			91				14,529			**243**
1954	22.06			86				8,318			**248**
1955	30.35			181				13,576			**223**
1956	7.96			187				16,649			**244**
1957	18.2			168				14,351			**230**
1958	58.11			230				12,911			**265**
1959	31.98			174				13,071			**264**
1960	24.23			411				17,975			**292**
1961	42.05			334				13,060			**278**
1962	97.01			185				17,177			**246**
1963	138.42			116				11,507			**210**
1964	43.17	3.7		142				16,139			**194**
1965	90.39	115	5	134				20,364			**168**
1966	21.71	385	4	253				11,974			**175**
1967	33.31	575	9	258				12,977			**187**
1968	22.94	553.5	12	712				20,556			**183**
1969	19.35	445	10	225				15,628			**180**
1970	43.76	795	8	453				18,753			**203**
1971	19.53	399	44	330				17,032			**194**
1972	34.99	556.5	38	311				11,219			**214**
1973	26	356	78	292				11,056			**230**
1974	29.62	946	107	557				24,481	1.642		**285**
1975	38.05	264	44	497				32,611	10.578	11	**290**
1976	30.96	618	106	770				55,514	20.048	6.7	**318**
1977	67.32	450	52	677				37,661	36.637	5.9	**360**
1978	43.97	388	106	526				59,918	24.334	3.6	**388**
1979	60.91	675	209	642	19.7	286.2		37,468	28.435	8.4	**352**
1980	30.54	358	95	525.5	25.9	404.8		42,110	21.32	8.2	**343**
1981	26.04	74	57	302.7	20	332.2		34,645	54.208	4	**263**
1982	16.42	138	98	274	15	123.3		26,295	16.437	4	**187**
1983	10.99	10	69	259.5	13.6	80.3		21,837	30.447	4	**148**
1984	14.76	6	36	182.5	19.2	82		22,541	31.387	1.8	**121**
1985	15.3	13	41	154	9.6	64.5		12,839	20.746	2.5	**97**
1986	16.05	26	52.6	123.4	10.6	45.2	8	13,544	12.553	0.2	**96**
1987	6.25	33	41.2	145	14	82.4	9.5	23,536	8.219	7.4	**83**
1988	4.67	48	46.6	176.6	10.9	33	12	15,211	8.001	10.5	**81**
1989	3.2	30	36.7	87.1	7.2	80	9	13,574	9	5.5	**59**
1990	3.9	218.2	35.9	96	5.6	48.1	3.2	9,216	6	4.4	**49**
1991	1.18	13	15.4	35.7	7.7	64	1.5	7,117	9	0.8	**42**
1992	3.12	18.9	29.6	39.3	3.7	41.7	8	10,259	10	0.6	**47**
1993	3.14	11.8	31	90.5	8.2	69.4	5.5	9,673	7.6	0.5	**40**
1994	5.01	17.5	24	94.6	8.7	45.8	3	9,900	4.7	0.5	**43**
1995	7.12	1.5	29.7	132.5	8.2	73.2	7.5	12,500	15.2	0.3	**44**
1996	7.97	4.5	23.2	80.8	4.8	30.7	4.1	5,900	8.7	0.1	**38**
1997	12.97	9.8	22.85	70.8	6.5	50.5	4.6	3,656	7.4	0.1	**29**
1998	2.31	2.3	18.9	60.7	4.3	25	1.5	3,273	7.4	0.13	**25**
1999	3.6		16	86.9	7.5	44.1	4.3	3,815	3.8	0.06	**18**
2000	1.76	17.85	14.45	79.9	6.6	25.1	10	1,330	1.2	0.07	**15**
2001	0.58	0.7	8.46	30	1.9	9	4	1,285	1.149	0.04	**15**
2002	1.17	1.4	15.9	42	4.9	36.8	6	1,569		0.02	**14**
2003	1.56	0.539	9.37	53	2.7	10.4	1.24	1,231		0.02	**16**
2004	1.57	0.381	7.49	27			2.67	506		0.03	**11**
2005	0.85	0.787	7.36				3.5	914		0.03045	**12**

[1]: The column **Geomean** presents the geometric mean of the three longest glass eel data series (Loire, Den Oever and Ems), after standardisation to their 1979–1994 level.

Table 2.4.1. Aquaculture production of European eel in Europe and Japan. Compilation of production estimates (tonnes) derived from reports of previous WG meetings, FAO, FEAP and others. Data for Sweden and the Netherlands have been revised.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Norway										120	200	200	200	200								
Sweden	12	41	51	90	203	166	157	141	171	169	160	139	161	189	204	222	273	200	167	170	158	
Denmark	18	40	200	240	195	430	586	866	748	782	1034	1324	1568	1913	2483	2718	2674	2000	1880	2050	1700	
Ireland																	100					
UK				20	30	0	0				25		25									
Germany												186	204	221	260	400	422	347	381	372	328	
Netherlands				100	300	200	600	900	1100	1300	1450	1540	2800	2450	3250	3500	3800	4000	4000	4200	4500	4500
Belgium/Lux.					30	30	125	125	125	125	150	140	150	150	40	20	50	55				
Spain	15	20	25	37	32	57	98	105	175	134	214	249	266	270	300	425	200	259				
Portugal	60	60	590	566	501	6	270	622	505	979	200	110	200	200	200	200						
Morocco							35	41	68	85	55	55	56	42	27	28	60	28				
Algeria					72	53	22	1	0	22	20	17	17	17	22	15	18	20				
Tunisia							150	151	250	260	108	158	147	108								
Italy	2600	2800	4200	4600	4250	4500	3700	4185	3265	3000	2800	3000	3000	3100	3100	3100	2750	2500	1900	1550		
Greece			6	4	10	54	94	132	337	341	659	550	312	500	500	300	600	735				
Turkey																						
Macedonia									1	0	70	83	60	72	60	50	32					
Yugoslavia	44	52	48	49	19	10	5	1	8	2	9	5	5	5	6	6	5	4				
Croatia								7	5	5	7	6	7									
Hungary					90	39	73	33		50		50			19	19						
Czech. Rep.									2	4	4	3	3	3	1	1	1	1				
Sum EU	1950	2229	3448	4729	5517	5159	6667	6098	6818	7721	7689	8935	9031	10646	11059	10839	10510	8435				
Japan		3000															10000					

2.2 Trends in re-stocking

Data on re-stocking were obtained from a number of countries, separate for glass eels and for young yellow eels. The size of 'young yellow eel' varies between countries. Most data available were on a weight base. Weights were converted to numbers, using estimates of average individual weights of the eels re-stocked. These were 3.5 g for Denmark, 33 g for the Netherlands, 20 g for (eastern) Germany, and 90 g for Sweden. An overall number of 3000 glass eels per kg was applied. The trend obtained while summing all series might be confusing and show a drop in 1969, as at that time, Polish restocking figures ceased to be recorded.

An overview of data available up to 2005 is compiled in Tables 2.2.1 and 2.2.2

Re-stocking in other EU countries:

Latvia - during Soviet time (since the 1960s) 30.1 million glass eels were stocked into 51 lakes. At present, restocking in small amount continues only in some lakes.

Lithuania – the first restocking was in 1928–1939, when 3,2 million elvers were released in the lakes. Since the 1960s, about 50 million elvers or young yellow eels have been stocked.

France – no stocking on central level.

Italy – stocking in considerable amounts in lagoons and lakes, but no central recording.

Germany – no central database for eel stocking.

Spain – no stocking on central level.

Ireland – Juvenile eel (as reported in Table 2.1.1) were stocked upstream into local freshwaters.

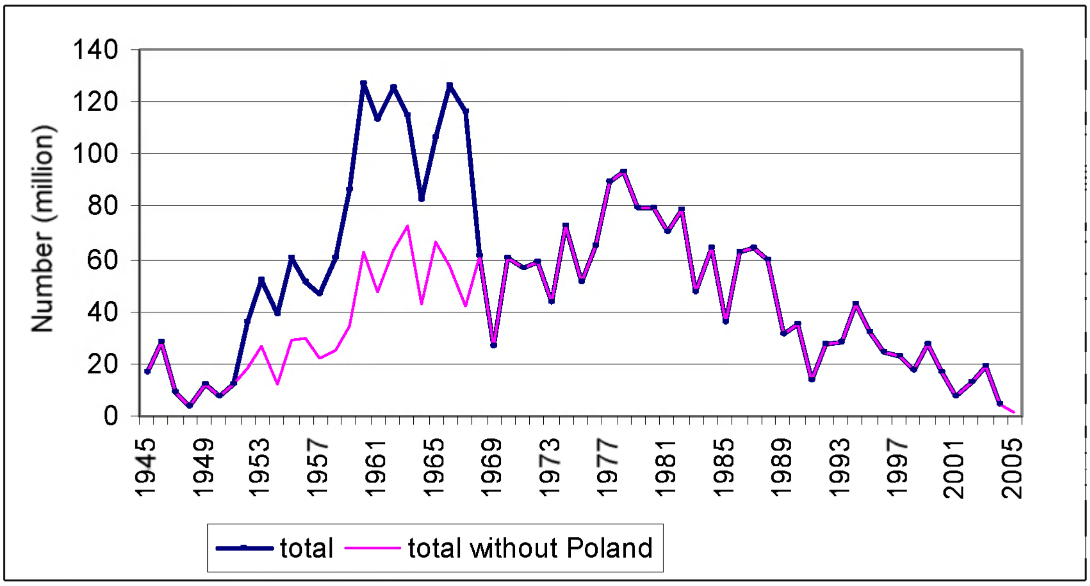


Figure 2.2.1 Re-stocking of glass eel and young yellow eel in Europe (East Germany, Netherlands, Denmark, Poland, Sweden, Northern Ireland, Belgium, Finland, Estonia), in millions re-stocked. The data series of Polish re-stockings was discontinued in 1968, while the re-stockings continued.

Table 2.2.1 Re-stocking of glass eel. Numbers of glass eels (in millions) re-stocked in (eastern) Germany (D east), the Netherlands (NL), Sweden (S), Poland (PO), Northern Ireland (N.Irl.), Belgium (BE), Estonia (EE) and Finland (FI).

Year	D east	NL	SE	PL	N.Irl.	BE	EE	FI
1945					17			
1946		7,3			21			
1947		7,6						
1948		1,9						
1949		10,5						
1950	0	5,1						
1951	0	10,2						
1952	0	16,9		17,6				
1953	2,2	21,9		25,5				
1954	0	10,5		26,6				
1955	10,2	16,5		30,8	0,5			
1956	4,8	23,1		21			0,2	
1957	1,1	19		24,7				
1958	5,7	16,9		35				
1959	10,7	20,1		52,5	0,7			
1960	13,7	21,1		64,4	25,9		0,6	
1961	7,6	21		65,1	16,7		0	
1962	14,1	19,8		61,6	27,6		0,9	
1963	20,4	23,2		41,7	28,5		0	
1964	11,7	20		39,2	10		0,2	
1965	27,8	22,5		39,8	14,2		0,7	
1966	21,9	8,9		69	22,7		0	1,1
1967	22,8	6,9		74,2	6,7		0	3,9
1968	25,2	17		data	12,1		1,4	2,8
1969	19,2	2,7		series	3,1		0	
1970	27,5	19		discontinued;	12,2		1	
1971	24,3	17		restocking	14,1		0	
1972	31,5	16,1		continued.	8,7		0,1	
1973	19,1	13,6			7,6		0	
1974	23,7	24,4			20		1,8	
1975	18,6	14,4			15,1		0	
1976	31,5	18			9,9		2,6	
1977	38,4	25,8			19,7		2,1	
1978	39	27,7			16,1		2,7	3,7
1979	39	30,6			7,7		0	
1980	39,7	24,8			11,5		1,3	
1981	26,1	22,3			16,1		2,7	
1982	30,6	17,2			24,7		3	
1983	25,2	14,1			2,9		2,5	
1984	31,5	16,6			12		1,8	
1985	6	11,8			13,8		2,4	
1986	23,8	10,5			25,4		2,5	
1987	26,3	7,9			25,8		2,5	
1988	26,6	8,4			23,4		0	
1989	14,3	6,8			9,9		0	0,001
1990	10,65	6,1	0,7		13,3		0	0,06
1991	2,01	1,9	0,3		3,5		2	0,1
1992	6,36	3,5	0,3		9,4		2,5	0,1
1993	7,62	3,8	0,6		9,9	0,8	0	0,1
1994	7,6	6,2	1,7		16,4	0,5	1,9	0,1
1995	0,99	4,8	1,5		13,5	0,5	0	0,2
1996	0,05	1,8	2,4		11,1	0,5	1,4	0,07
1997	0,38	2,3	2,5		10,9	0,4	0,9	0,08
1998	0,3	2,5	2,1		6,2	0	0,5	0,08
1999	0	2,9	2,3		12	0,8	2,3	0,06
2000	0	2,8	1,3		5,4	0	1,1	0,06
2001		0,9	0,8		3,04	0,2		0,05
2002		1,6	1,4		6,6	0		0,06
2003		1,6	0,6		9,2	4,5		0
2004		0,3	0,8		3	0		0,06
2005			0,7					0,06

Table 2.2.2 Re-stocking of young yellow (bootlace) eel. Numbers of young yellow eels (in millions) re-stocked in (eastern) Germany (D east), the Netherlands (NL), Sweden (S), Denmark (DK), Belgium (BE), Estonia (EE) and Finland (FI).

YEAR	DE EAST	NL	SE	DK	BE	EE	FI
1945							
1946							
1947		1,6					
1948		2					
1949		1,4					
1950	0,9	1,6					
1951	0,9	1,3					
1952	0,6	1,2					
1953	1,5	0,8					
1954	1,1	0,7					
1955	1,2	0,9					
1956	1,3	0,7					
1957	1,3	0,8					
1958	1,9	0,8					
1959	1,9	0,7					
1960	0,8	0,4					
1961	1,8	0,6					0,05
1962	0,8	0,4					0,14
1963	0,7	0,1					0
1964	0,8	0,3					0,08
1965	1	0,5					0,11
1966	1,3	1,1					0,05
1967	0,9	1,2					0
1968	1,4	1					0
1969	1,4	0					0,04
1970	0,7	0,2					0,03
1971	0,6	0,3					
1972	1,9	0,4					
1973	2,7	0,5					
1974	2,4	0,5					
1975	2,9	0,5					0,04
1976	2,4	0,5					0,02
1977	2,7	0,6					0,03
1978	3,3	0,8					0,01
1979	1,5	0,8					0,08
1980	1	1					
1981	2,7	0,7					
1982	2,3	0,7					
1983	2,3	0,7					
1984	1,7	0,7					
1985	1,1	0,8					
1986	0	0,7					
1987	0	0,4		1,6			
1988	0	0,3		0,8		0,2	
1989	0	0,1		0,4			
1990	0,1	0	0,8	3,5			
1991	0,1	0	0,9	3,1			
1992	0,1	0	1,1	3,9			
1993	0,2	0,2	1	4	0,2		
1994	0,2	0	1	7,4	0,1		
1995	0,7	0	0,9	8,4	0,1	0,2	
1996	0,9	0,2	1,1	4,6	0,1		
1997	1,5	0,4	1,1	2,5	0,1		
1998	1,2	0,6	0,9	3	0,1		
1999	1,1	1,2	1	4,1	0,1		
2000	1	1	0,7	3,8	0		
2001		0,1	0,4	1,7	0	0,4	
2002	0,4	0,1	0,3	2,4		0,4	
2003		0,1	0,3	2,2		0,5	
2004		0,1	0,1			0,4	
2005						0,4	

2.3 Critically Endangered status of the eel stock

IUCN has compiled criteria for ranking species in specific classes of endangerment. For the Critically Endangered CR status (the most severe category except for Extinct), the criteria are that 2% or more of the total population resides within the area (country) under consideration, and that the stock has declined by 80% or more over not more than three generations. Since these criteria are currently met (Section 2.1), Sweden has listed the eel on the national Red List, during this list's revision in spring 2005. No other countries have placed eel on their Red Lists.

IUCN (The World Conservation Union, http://www.redlist.org)

3 Spawner quality

3.1 General introduction

The EU eel recovery plan requires that, through collective implementation of national plans, for each river basin district sufficient spawner escapement takes place in future. The objective of these measures is generally discussed by reference to the need to ensure that adequate spawner biomass escapement takes place. However, as is now well established, many silver eels migrating from European eel producing hydrosystems are adversely affected by anthropogenic environmental factors that limit their capacity to reach the Sargasso spawning area and / or to produce viable offspring. In this Section, the principal factors affecting spawner quality are critically reviewed and specific recommendations to ensure that spawner quality issues are adequately addressed in national eel management plans are made.

3.2 Impact of environmental factors on reproductive capacity

3.2.1 Reproduction capacity of silver eels

Reproduction capacity relates to 3 different aspects of eels in the last phase of their life cycle: silvering, spawning migration, and sexual maturation. The overall capacity of the eels to complete each of these aspects determines the actual reproduction capacity. There are two major factors in general which determine the variability of performance, namely the environment and the genetic make-up, both aspects were studied in the EU-EELREP program (Estimation of the reproduction capacity of European eel). In EELREP (2005a, 2005b) the process of silvering in different locations and the physiological performance of silver eels from different locations was analyzed, including seawater tolerance, pressure tolerance, swimming fitness and maturation sensitivity. The genetic variability of eels from different locations was measured by using multiple biomarkers.

Inter-relationships between the silvering and migration/maturation performance were established (Figure 3.1). High silver index (Durif *et al.*, 2005) correlates with an improved sea water and high pressure tolerance. However, no effect was evident on the swim fitness. High silver index correlates with high maturation index. High length and high fat content improves maturation as well as swim endurance. Furthermore, it was found that swimming induced silvering and maturation. Negative environmental factors interfere neither with silvering nor with seawater/pressure tolerance. These factors, however, particularly affect the swim endurance and the maturation index. Infections with EVEX/parasites are devastating for swimming eels, while PCBs impair fertility.

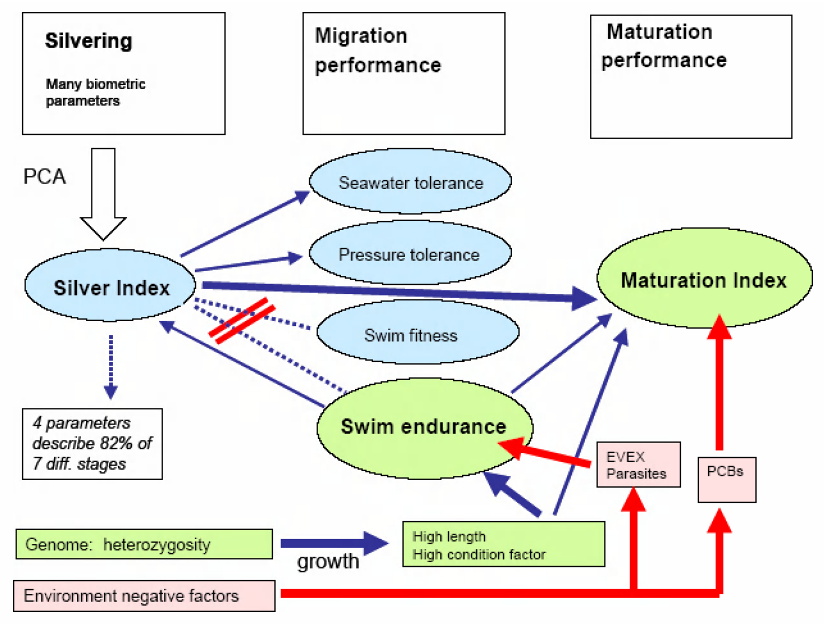


Figure 3.1. Inter-relationships between the silvering and migration/maturation performance.

3.2.2 Biological parameters of reproduction capacity

Several parameters were found to be biological requirements for successful reproduction as determined by response to short term and long term responses to hormonal stimulation. These parameters included the degree of silvering, body length, condition factor/fat content and age. Due to the overall high energy costs of migration, the energy reserves may become a limitation to reach the Sargasso Sea when fat levels drop below 15% of the body weight. In addition to the requirements for swimming, the eels need energy for gonadal growth which suggests that the eels with the highest fat stores have the highest recruitment capacity. The reproduction capacity was found highest for large (>70 cm, >0.7 kg), fatty (>20%) silver eels (stage V; Table 3.1; see also Durif *et al.*, 2006). These are also silver eels in a migratory stage. Age was found to correlate positively with the amount of fat in the gonads and negatively with the amount of fat in the muscle implying that older eels have higher capacity to incorporate fat in the oocytes (Palstra *et al.*, 2006). These eels also needed less hormonal injections to fully mature.

Estimation of reproductive capacity concerned mainly female silver eels until now. Male parameters still have to be established. Since generation time is shorter for males, impact of environmental factors is expected to be much lower than females.

Table 3.1. The reproduction capacity was found highest for large (>70 cm, >0.7 kg), fatty (>20%) silver eels (stage V). These are also silver eels in a migratory stage.

Silver stage	I	II	III	IV	Va	Vb
Body length	--	--	--	--	<70cm	>70cm
Fat content	--	--	--	< 13%	13- 20%	>20%
Reproductive capacity	0	0	0	*	***	******

3.3 Contaminants in eel

3.3.1 Introduction on contaminants

Due to specific ecological and physiological traits, eels are particularly sensitive to bioaccumulation of lipophilic contaminants. Eel muscle concentrations are much higher than in all other so far investigated fish species. From recent scientific evidence there is reason for serious concern as the level of measured concentrations of some contaminants has been shown to have adverse effects on the reproduction success of the silver eel.

3.3.2 Spatial coverage

There is an increasing awareness in member countries that it is essential to monitor these contaminants in eel, both for the sake of the protection of the species and of human health and food quality aspects. Table 3.2 gives an overview of the availability of data throughout Europe. From several large countries or river basins information is lacking. Furthermore there are considerable differences in the way data are presented, substances, units, results on fat basis or body weight, etc, making comparisons difficult.

Table 3.2. Overview of status of knowledge on contaminants over the countries.

Country	RBD	PCB	OCP	HV	other	References
Belgium	Ijzer catchment	+	+	+	BFR, VOCs, Fluorcompounds, PAKs,	Belpaire et al., 2003, Goemans et al., 2003, Goemans and Belpaire, 2004, Hoff et al., 2005, Roose et al., 2003
	Scheldt catchment	+	+	+	BFR, VOCs, Fluorcompounds, PAKs,	Belpaire et al., 2003, Goemans et al., 2003, Goemans and Belpaire, 2004, Hoff et al., 2005, Roose et al., 2003
	Meuse catchment	+	+	+	BFR, VOCs, Fluorcompounds, PAKs,	Belpaire et al., 2003, Goemans et al., 2003, Goemans and Belpaire, 2004, Hoff et al., 2005, Roose et al., 2003
Denmark						
Estonia						
France	Gironde	+				Goursolle, 2002
Germany	Rhein	+	+	+		Lehmann et al. 2005
	Mosel	+	+	+		Lehmann et al. 2005
	Elbe	+	+	+		Reincke et al. 2000
Ireland	Shannon		+		BFR	ongoing
	Burnshoole Catchment		+		BFR	ongoing
	Ahalia Catchment		+		BFR	ongoing
	Erne Catchment		+		BFR	ongoing
	Loch Furnace	+			BFR	Sambo, 2005
	Owengarve River	+			BFR	Sambo, 2005
Italy						
Latvia						
Netherlands	Rhein	+		+		Pieters et al. 2004, Leonards et al. 2000
	Haringvliet	+		+		Pieters et a. 2004
	Maas	+		+		Pieters et a. 2004
	Ijselmeer	+		+		Pieters et a. 2004
Norway						
Poland						
Spain						
Sweden	Baltic Sea	+				www.slv.se
	North Sea		+			Bignert et al. 1994
	Lake Malaren		+			Bignert et al. 1994
	Lake Hjalmaren		+			Bignert et al. 1994

3.3.3 Effects of dioxin-like contaminants (PCBs)

At the University of Leiden, eggs of 13 different batches of silver eels have been fertilized. Embryonic development of healthy embryos was followed until 4 days after fertilization (Palstra *et al.*, 2005). Embryos of other batches showed serious oedema of the yolk sac, a deformed head region and absence of a heartbeat. Such embryonic malformations are typical for PCB-exposed eggs and indicate negative interference with dioxin-like contaminants (Helder, 1980; Walker and Peterson, 1991; Walker *et al.*, 1994; Stouthart, *et al.*, 1998). Therefore parental levels of dioxin-like contaminants were measured and their distribution correlated to embryonic survival and development. A negative correlation exists between dioxin-like contaminants (>80% PCBs in eel) and embryonic survival and development (Figure 3.2.; Palstra *et al.*, 2006). Effects occur already below the maximal allowable level for fish consumption (i.e. 4 ng TEQ/kg fish). Monitoring studies (van Leeuwen *et al.*, 2002) show that most silver eels have too high TEQ values. Matured eels with values > 1 ng TEQ/kg gonad presumably can not participate in successful production of vital offspring. A difficulty remains to extrapolate this threshold value to reference values for eels that have not matured yet and per kg muscle. However, fats incl. accumulated PCBs that were originally in the muscle have been incorporated in the oocytes of the mature female. Under this assumption we can extrapolate the found values to ng TEQ/kg muscle in wild silver eels.

Thus, values > 1 ng TEQ/kg muscle are indicative for the extremely low levels at which impairment of reproduction occurs. Experimentally deduced dose-effect ratios need to be determined to establish reference levels for use in the field.

EELREP (2005a, 2005b) and Palstra *et al.* (2006) results suggests that current gonadal levels of dioxin-like contaminants, including PCBs, in eels from most European locations impair normal embryonic development. PCBs and other contaminants might have contributed to the decline of eel recruitment observed since 1980. Historical data series on PCB levels in eel, starting in the late 1970s (Pieters *et al.*, 2004, Figure 3.3), have shown a gradual decline from the very start onwards; circumstantial evidence suggests that PCB levels in eel presumably peaked around 1970, before the onset of the recruitment decline. It is therefore unclear, to what extend contaminants were actually involved in the decline, or what delayed their impact.

EELREP (2005a, 2005b) and Palstra *et al.* (2006) results suggests that current gonadal levels of dioxin-like contaminants, including PCBs, in eels from most European locations impair normal embryonic development. This conclusion is further strengthened by the fact that the emission of PCBs in the environment (van Leeuwen and Hermens, 1995) preceded the decline of European eel. Therefore we consider it likely that dioxin-like PCBs contributed to the current collapse of the European eel populations.

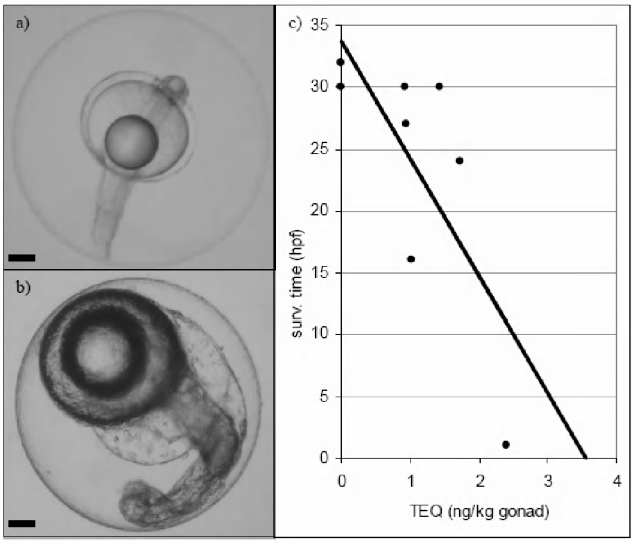


Figure 3.2.a. Healthy European eel embryo at 30–35 hpf with heartbeat and yolk sac with large fat droplet, b) Larger embryo of an unhealthy batch at identical time of development displaying yolk sac oedema, deformed head region and absence of heartbeat. Scale bars represent 100 µm. c) Negative correlation between total TEQ values (ng/kg gonad) and embryo survival time (hours post fertilisation) of fertilised eggs of 8 hormone induced, stripped females.

A molecular study (Maes *et al.*, 2005) showed a significant negative correlation between heavy metal pollution load and condition, suggesting an impact of pollution on the health of sub-adult eels. In general, a reduced genetic variability in strongly polluted eels was observed, as well as a negative correlation between level of bioaccumulation and allozymatic multi-locus heterozygosity (MLH). Microsatellite genetic variability did not show any pollution related differences, suggesting a differential response at metabolic enzymes and possibly direct overdominance of heterozygous individuals. Effects of a known, experimentally induced PCB-load on migration performance are currently investigated (van Ginneken *et al.*, in prep.).

3.3.4 Accumulation of effects

Agents most probably interact. PCB contamination may increase risks for infections and diseases like Sures and Knopf (2004) showed for PCB 126 suppressing antibody response in European eel and with that increasing the chance of infection of *A. crassus*.

3.3.5 Spatial coverage of PCBs

The longest data series for bioaccumulation of contaminants in eels is available from the Netherlands, where a monitoring network for PCBs, OCPs and mercury in eel is in place since the 1970s. Results are annually reported (Pieters *et al.*, 2004; Figure 3.3), focusing on areas where consumption norms are exceeded. The PCB figures show a slow decrease in PCB body burden in the Netherlands during the last 25 years, however at some heavily polluted sites (like the river Meuse) PCB levels in eels do not seem to decrease the last 10 years. Although general decrease occurs, levels are still well above effect levels and even consumption levels in the majority of habitats.

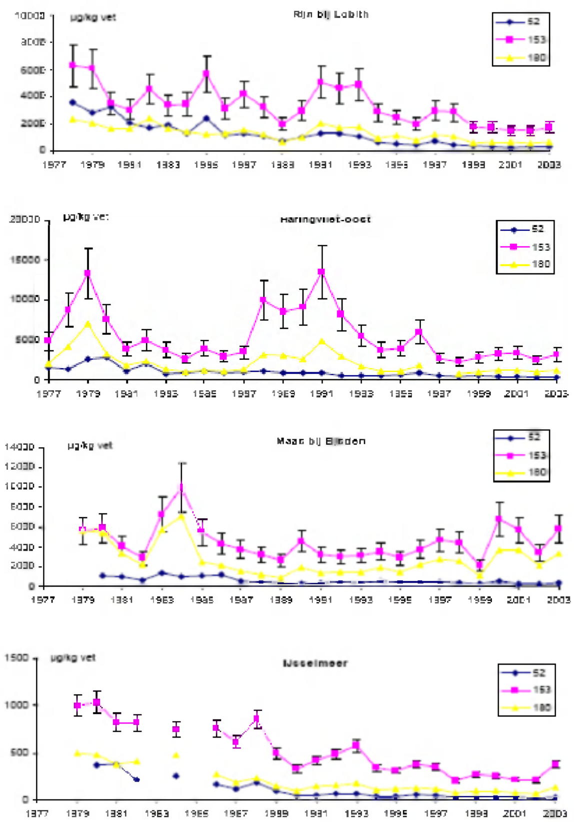


Figure 3.3. Trends in PCBs in eel, observed in the Dutch sampling programme for angler catches (Pieters *et al.*, 2004).

The data from the Netherlands show that PCB values in eel vary from 6 to 1600 ng/g BW (Pieters *et al.*, 2004), eels from the River Meuse being the most heavily polluted.

Also in Flanders (Belgium) there is a pollutant monitoring network for public water bodies using yellow eel as a biomonitor. Contaminants analyzed were heavy metals, PCBs, organochlorine pesticides (Belpaire *et al.*, 2003; Goemans *et al.*, 2003; Goemans and Belpaire, 2004) At present the dataset included results from approximately 2000 individually analyzed eels originating from 325 different localities in Flanders. In some sites PCB values as high as 7000 ng/g body weight (BW) (measured as the sum of the 7 indicator PCBs) were measured, nearly exceeding the Belgian PCB food safety standard (75 ng/g BW) with a factor 100 (Figure 3.4).

Results from e.g. Flanders and the Netherlands show clearly that considerable variation in PCB load exist within river basin districts, according to local anthropogenic pollution, linked with land use. From the figures it is obvious that in some parts of river basins extremely high concentrations do occur. There are reasons to believe that also on a pan-European scale large differences between catchments occur. However there is no comprehensive overview available on contaminant load in eel over its distribution area.

In Ireland, some samples have been taken in 2005 and are currently undergoing analysis for contaminants (PCBs, dioxins, BFRs). Recent data of Ireland (Lake Furnace and River Owengarve) showed low PCB levels for eels (Santillo *et al.*, 2005).

In Germany the concentrations of the sum of the 7 indicator PCBs is ranging from 43 and 1900 ng/g BW (Müller *et al*., 1999).

During another survey in 1999 a total of 147 individual eels were analyzed from eleven locations along the River Elbe. PCB levels are so high that Elbe fish cannot be marketed (Reincke *et al.*, 2000).

Rehulka (2002) reports from eels from the Kruzberg dam reservoir (Czech Republic) concentrations between 674 and 1800 ng/g BW.

In a preliminary study Van Leeuwen *et al.* (2002) analysed eels imported in the Netherlands and originating from various European catchments. In general levels were lower than eels from Dutch rivers, but show considerable variations.

3.3.6 Dioxines

EC Regulation (EC) No 466/2001 sets maximum levels for certain contaminants (polychloordibenzo-p-dioxines and polychloordibenzofuranes) in foodstuffs allowing for a maximum of 4 pg PCDD/F-TEQ /g fresh weight for muscle meat of fish and came into force on 1 July 2002.

In Sweden, PCDD/F-TEQ values in eels (both yellow and silver eels) of 9 sites in fresh water lakes, in the Baltic Sea and along the west Coast, were all lower than the maximum level (http://www.slv.se). Recent results of analysis of wild eels in the Netherlands, however, showed that 7 sites of 39 (18%) exceeded the allowable levels (Van Leeuwen *et al*., 2002). In Lake Ijsselmeer, eels from 2 of 6 sites were higher than this maximum level. In Nordrhein-Westfalen in 2002 the concentrations of eel from 7 of 7 sites exceeded the 4 pg/g standard (Lehmann *et al.*, 2005). Food safety managers should be advised to control dioxins in eels with respect to existing food safety regulations and to close fisheries immediately where standards are exceeded.

3.3.7 Other contaminants

In this report specific attention have been set on PCB data series in eels, as new evidence have been shown on the detrimental effects of PCBs on spawner quality. But also for other contaminants such as organochlorine pesticides and heavy metals extensive data series exist for a number of countries, e.g. Germany (River Elbe), the Netherlands and Belgium. Less is known about the specific effects of these substances on the eel. However also for these contaminants it is obvious that concentrations vary considerably between sites but in some cases attain very high levels.

In contrast to OCPs, PCBs and HM where to some extent some information on bioaccumulation in eels is available, from a very high number of relatively new chemicals (approximately 30 000 new substances), no or only very little information is available. Very recent advances in knowledge of the negative effects of some of these compounds on biota gave rise to serious concern.

For a number of chemical groups like fluorcompounds, volatile organic compounds and BFRS bioaccumulation data in eel were reported.

A perfluorooctane sulfonic acid (PFOS) assessment was conducted eel in Flanders (Belgium) (Hoff e*t al.*, 2005). Presence of PFOS in fish was linked to fluorochemical production. The liver PFOS concentrations in eel was varying considerably between locations (17–9031 ng/g wet weight), but were among the highest in feral fish worldwide. The study suggests that these compounds cause serological alterations in eel (hematocrit values).

In eels from 22 Belgian sites 52 different volatile organic compounds (VOCs) were analysed. 25 out of 52 substances were found to be present in eel. The most prominent VOCs are the BTEX and a number of chlorinated compounds such as chloroform and tetrachloroethene. They were present in all sites The observed concentrations could be linked to the major emission sources (e.g. combustion of fossil fuels) in the environment. The concentration levels in eels seem to be a reflection of the actual concentrations in their environment. The study suggests that the yellow eel can possibly be used as a biomonitor or sentinel organism for VOCs. (Roose *et al.*, 2003)

Serious concern has arisen from the increasing use of brominated flame retardants (BFRs), these have received increasing attention during the past years. This is due to their massive use to improve fire safety in both commercial and domestic applications. These chemicals have shown a rise in production since they were first introduced in the 1960s, with a substantial increase since the end of the 1970s. The physicochemical properties of these compounds lead to biomagnification, as they are lipophilic and extremely resistant to degradation, aquatic organisms are particularly (Voorspoels *et al.*, 2003). New insights of the effects of BFRs are known to be similar to PCB effects. It now has been detected in eels.

On 18 locations in Flanders (Figure 3.5), eels were analysed for the brominated flame retardants HBCD, TBBPA and PBDE12. TBBP-A levels were low at all stations. The concentrations of HBCD and PBDE however varied considerably between stations and in some cases extremely high values for both groups were recorded (maximum of 33 000 ng/g lipid weight; 5500 ng/g BW for HBCD and 32 000 ng/g lipid weight; 5300 ng/g BW for PBDE's). Such high concentrations in fish were never found elsewhere, except for one single carp (*Cyprinus carpio*) from Virginia Hyco River in the US. Other concentrations found in literature are at least 10 times less than the concentrations found in eel from Flanders (Morris *et al.*, 2004).

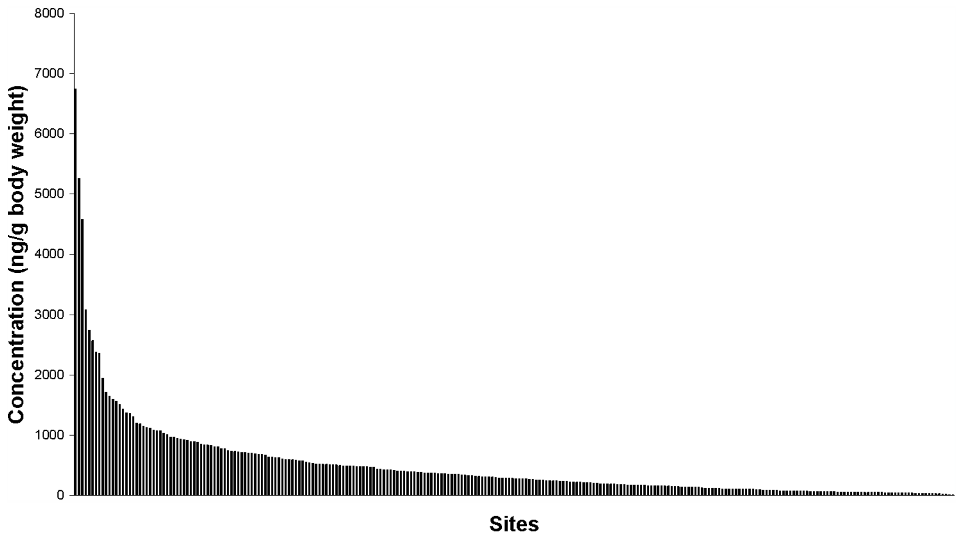


Figure 3.4. Mean PCB concentrations (ng/g body weight) in eels from Flanders (260 stations, 1994–2001). The legal food safety limit in Belgium is 75 ng/g body weight. (Goemans *et al.,* 2003)

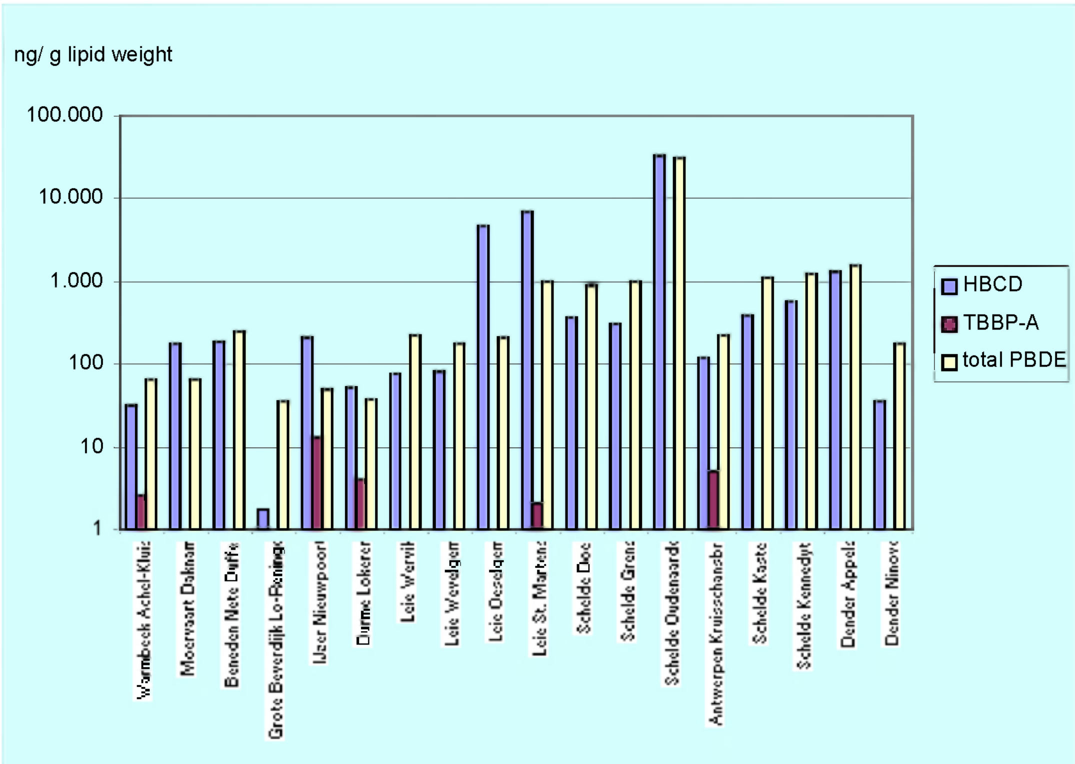


Figure 3.5. Brominated flame retardant concentrations in eels from Flanders (18 stations, 2000) (Belpaire *et al.*, 2003)

3.4 Diseases in eel

3.4.1 Introduction on diseases

The occurrence of diseases and parasites in eels has been recorded for some time. Up to now, consequences on the ability of eels to carry out their long-distance migration and reproduction were unknown, although these have been suggested as potential causes for the decline in eel populations. Recent investigations on spawner quality have yielded essential knowledge on the effects of such pathogens. While further studies are needed, these results allow us to draw some recommendations.

3.4.2 Effects of swim-bladder parasite *Anguillicola crassus*

Infected eels, but especially non-infected eels with swim-bladder damage show a much higher cost of transport (Figure 3.6.; Palstra *et al.*, in prep.). Simulated migration trials confirmed fast migration failure (< 1000 km). Especially silver eels have high infection levels. So, in the case of heavy swimbladder damage, even those eels that have very high scores for the reproduction index will in fact never reach the spawning grounds and can not contribute to recruitment. Heavy swim-bladder damage results from heavy infection which in practice is >5 nematodes.

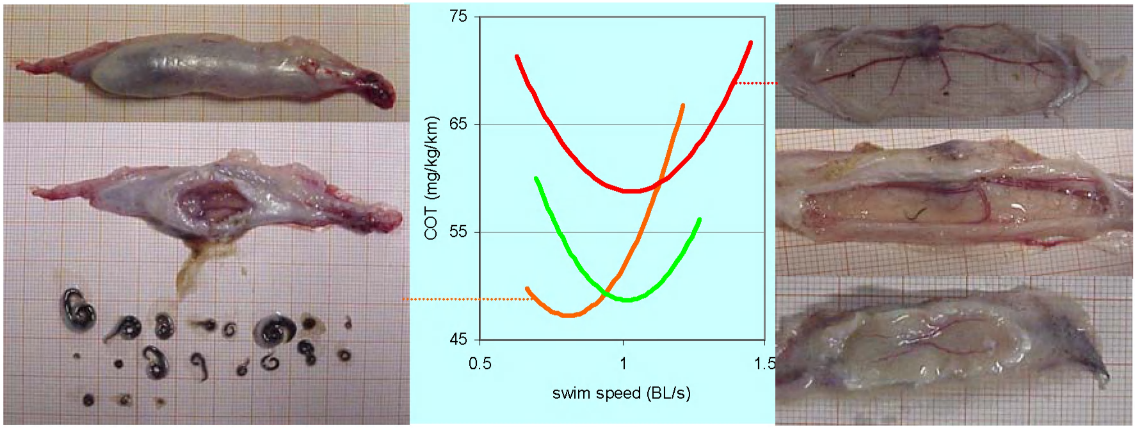


Figure 3.6. Cost of transport (COT in mg O_2 per kg eel per km) at swim speeds 0.5 to 1.5 bodylengths per second of healthy, infected and non-infected eels with high swim-bladder damage. Healthy eels (polynomial trendline-lower right) show an optimum swim speed (at which the COT is lowest) of about 1 BL/s and a COT of 47 mg O_2 per kg eel per km. Infected eels (polynomial trendline-lower left) show slightly lower optimum swim speed but COT is similar. Photographs on the left show a large swim-bladder and cut open showing the infestation load. Non-infected eels with high swim-bladder damage (upper polynomial trendline) show a 20% increased COT which will be a serious impairment of migration. Photographs on the right show three conditions of the non-infected swim-bladder. In the upper picture, the swim-bladder is large, transparent and considered healthy. In the middle, and more in the lower, photograph, the wall of the swim-bladder is thickened by fibrosis and the volume of the bladder reduced.

3.4.3 Spatial coverage swim-bladder parasite *A. crassus*

Anguillicola crassus infections can adversely affect spawner quality in European eel by reducing the migratory capacity of silver eels. Eels with damaged swimbladders, as a consequence of previous infections from which they have recovered, are similarly limited in their migratory abilities. Such eels might have been excluded from data on *A. crassus* prevalence, such as that reviewed during this meeting (Table 3.3) and consequently extrapolation from these data will underestimate the negative impact that this introduced parasite can have on the spawning stock of the host population.

The available information on the introduction and spread of *Anguillicola crassus* in Europe illustrates how through live-transport of eels, within and between countries, and through stocking programmes the parasite has been rapidly dispersed to all major spawner producing areas. The parasite is widespread in European inland waters, and it also occurs in mixohaline waters, such as the Baltic and various estuaries and coastal lagoon habitats. The potential for natural range extension, through local migrations of some of its many potential paratenic fish hosts or by piscivorous birds, is recognised. However, it is clear that dispersal through human agency has been the most important mechanism involved in this bioinvasion.

A more comprehensive review of the available data on infection rates of eels by *A. crassus* is needed in order that an adequate assessment can be made of the negative impact of this pathogen on the spawning potential of European eel. In future the country reports to the EIFAC/ICES Working Group should provide better data on *A. crassus* distribution and levels. National eel management plans, will have to take account of these data for evaluation of the quality of spawners and to ensure that escapement targets are being met.

There are a number of studies on other parasites of eel, including some still in progress, listed in country reports (e.g. for Italy and Ireland) which illustrate the diversity of, indigenous and introduced, the helminth species assemblages of natural eel populations. There appears to be little published evidence of serious pathogenic effects associated with many of these parasite taxa. However, following the Eel-Rep, demonstration of *A. crassus* effects on spawner quality through reduction in eel migratory abilities, it would be prudent to investigate this topic further.

Table 3.3. Spatial coverage *A. crassus*

area	status	prevalence	comments
Norway	Unpublished record	n/a	Dispersal slow due to lack of commercial eel fisheries
Sweden FW	Widespread	70%	accidentally dispersed during stocking of lakes
Sweden Coastal	Widespread	10-62%	Increasing prevalence noted along coast from Kattegat to mid Baltic
Outlet Baltic	Widespread	43%	No other information on locality
Latvia	Present	n/a	No accessible data
Estonia	Etablished	20-40%	Introduced to L. Vortjarv with stocked juvenile eels from Germany
Poland	Established	n/a	Present in Vistula lagoon limited data on other localities
Germany	Widespread	60-70%	Introduced from Asia n 1982, all major riversaffected. Additional unanalysed data available.
Rhine /Mosel	Established	60-80 %	Probably widespread
Denmark FW/ coastal	Widespread	> 50% / < 50%	
Netherlands	Widespread	50%	Recorded from 1985, initially higher prevalence noted, widespread by 1990.
Belgium	Widespread	67%	Detailed analyses of distribution and infection parameters
England Wales	Widespread	?%	Distributional maps available
Scotland	Unknown	n/a	Very limited commercial fishing and research
Northern Ireland	Established	? %	Recently introduced and rapidly established in two major commercial fisheries
Ireland	Established	3-85 %	Introduced in 1987, spread rapidly to most commercial fisheries
France	Widespread	n/a	Common in Brittany and southern coastal lagoons, no recent review on distribution
Spain	Present	n/a	No data acessed
Italy	Established 12-37 %		Data for Tiber R. and 7 coastal lagoons

3.4.4 Effects of virus infection EVEX

European eels infected with EVEX-virus showed hematocrit decrease related to distance, developed hemorrhage, anemia and died after 1000–1500 km migration. Virus-negative eels swam the complete 5500 km (Figure 3.7.; Van Ginneken *et al.*, 2005). In the case of EVEX infection, even those eels that have very high scores for the reproduction capacity, will in fact never reach the spawning grounds, and can not contribute to recruitment.

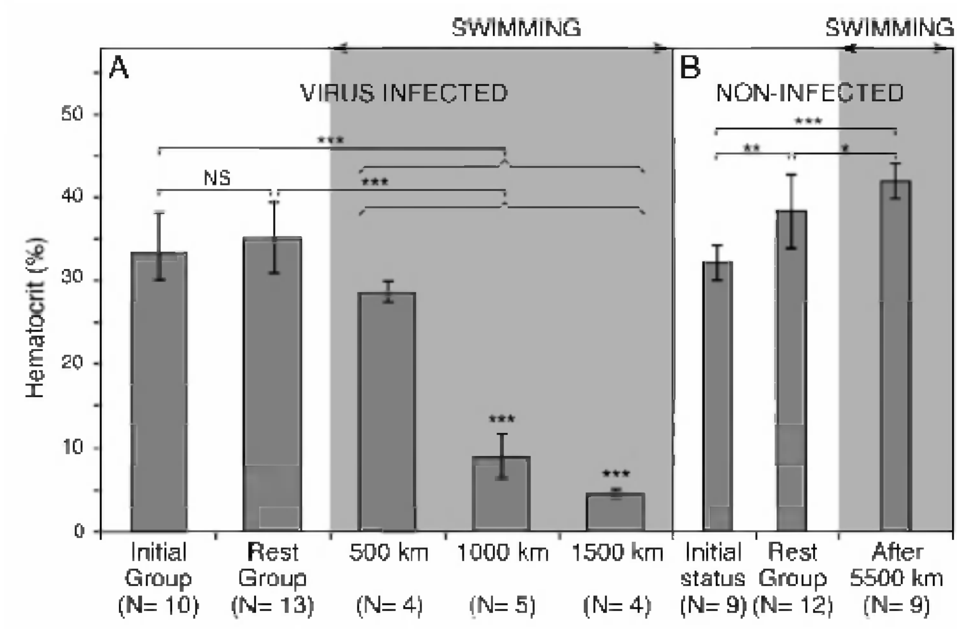


Figure 3.7. European eels infected with EVEX-virus showed hematocrit decrease related to distance, developed hemorrhage, anemia and died after 1000–1500 km migration. Virus-negative eels swam the complete 5500 km

3.4.5 Spatial coverage viruses

Virus infections, such as EVEX and *Herpesvirus anguillae*, which have been reported in wild and /or farmed eels in widely separated parts of the world, represent a serious threat to European eel. The demonstration by the Eelrep project that the EVEX virus significantly reduces the migratory capacity of infected silver eels, and concern about potential damage to eel stocks by such pathogens, suggests that more systematic monitoring is required. Information on the presence of EVEX virus in the Netherlands has been reviewed in the EEL-REP report. However, it is clear that further sampling and on-going monitoring is urgently required. National eel management plans, and country reports to EIFAC/ICES, should be required to provide information on the distribution and pathology of this and other eel diseases, and to take account of their potential impact on spawner quality. EVEX was detected in wild and farmed European eels from The Netherlands, Italy, Morocco and in *A. dieffenbachi* from New Zealand (Van Ginneken *et al.*, 2004).

The risks to eel stocks, and other fishery resources, associated with the extensive and largely unregulated live transport of eels can be demonstrated by reference to the spread of *A. crassus.* Blanc (1997) points out that nearly one hundred pathogens have been introduced in European hydrosystems since the introduction of aquaculture. The vectors and dispersal routes that facilitated the *A. crassus* bioinvasion can be expected to result in future threats European spawner quality unless controls are improved.

3.5 Hydroelectric facilities

3.5.1 Introduction on hydroelectric facilities

Mortalities due to turbine entrainment can be extremely high. The physical or physiological effects on eels passing through hydropower stations can seriously impair their ability to reach their spawning grounds. Efforts have been made regarding upstream migration and several dams have been equipped with eel ladders (particularly in Denmark where all migration barriers are equipped with eel ladders or upstream devices, but also France, Sweden, Belgium, and Ireland). However, bypasses for downstream migration of silver eels at European power stations are rare. Several investigations have been made on mitigation measures and these are briefly reviewed below.

3.5.2 Effects

The effects of migration barriers, and in particular hydroelectric facilities, have been documented in the WGEEL 2002 report (ICES, 2002a). Mortality varies considerably depending on the turbine characteristics and the mode of operation of the power plant (EPRI, 2001; Larinier and Dartiguelongue, 1989; Hadderingh and Baker, 1998). General effects can be summarized into the following categories:

- Physical damage: whether it is external or internal (less documented) eels can be greatly affected by sudden changes in hydraulics (water velocities and pressure), by direct contact with turbines, or impingement on screens (trash rack) at the intakes.
- Concentration of individuals upstream of the barrier and therefore higher vulnerability to predators.
- Delays in migration: Power plants may also affect the ability of eels to orient relative to the earth's magnetic field. Moreover, if eels do not find a passage they will delay their migration possibly until the next migratory season.
- Changes in characteristics of the subpopulation: Depending on the type of hydroelectric facility, certain size-classes may be more affected than others. Large eels may suffer from higher impingement rates (where trash racks are present) and more severe damage from turbines, while smaller eels (such as males) will not be deflected as efficiently by the same trash rack. This can also lead to a serious impact on the sex-ratio.

3.5.3 Study difficulties

The lack of efficient devices for downstream migration can be partly explained by study difficulties, which are specific to eel migratory behaviour. Downstream migration occurs during periods of high discharge (floods). Evaluation of turbine induced mortalities, behavioural studies, or bypass efficiency tests generally involve trapping of eels and the setup of monitoring arrays (i.e.: telemetry). These installations have to sustain harsh environmental conditions and very high water flow and velocities especially in the case of large power plants. Cooperation with the hydroelectric staff is also necessary, as well as continuous surveillance over several months.

Eels display a flexible migratory behaviour unlike other migratory species such as salmonid smolts for which the migratory urge seems more pronounced. Silver eels do not always show directed downstream movements and frequently stop for various time periods during their migration even after their migration has been initiated by the proper environmental factors (Durif *et al.*, 2003).

3.5.4 Mitigation measures

In recent years, different solutions have been investigated to allow safe passage of eels at hydroelectric facilities: physical barriers (screens and louvers) and behavioural barriers of light (Hadderingh *et al.*, 1999), sound (Sand *et al.*, 2001), bubbles, and electricity (Gleeson, 1997). Their efficiencies are highly site specific (size and location of the power plant). It has been shown that screens appear to have a repulsive effect, which increases with turbine generated flow and velocity (Gosset *et al.*, 2005). Although these results must be confirmed through behavioural studies, these types of physical barrier should be installed at small facilities where impingement is not a threat. In Denmark, all power plants are equipped with 10 mm screens, and they are working towards a decrease in the bar spacing to 6 mm.

Deflection from the intakes must be coupled with attractive bypasses. Only one study has dealt with bypass efficiency for eels in Europe (Gosset *et al.*, 2005). In this study the suitability of existing discharge sluices for eel downstream migration was tested. Results showed that bottom bypasses are more attractive than surface devices. This study also pointed out that already existing devices may be adapted for safe passage of eels. It therefore appears necessary to gather information on the characteristics of hydroelectric facilities in terms of existing sluices and devices that could be used for such purposes. Such a program has been initiated in Sweden and should serve as an example. During 2005 and 2006 a national inventory of obstacles for eels migrating both up- and downstream was undertaken. The inventory included obstacles (dams and hydroelectric facility) and also the occurrence of fish passes, bypasses, deflecting screens, etc. and their suitability for eels. The purpose was to achieve a database to be used as background when installing new or improving existing eel passes and deflecting devices.

Other types of suggested solutions proposed in respect of eel passage at hydropower stations (EPRI, 2001) concern altering power generation schedules. These imply the prediction of downstream runs, either in the form of models involving environmental factors or through early warning systems. At present, knowledge on the triggers of downstream migration is generally too limited to allow for reliable prediction of silver eel migratory patterns. Attempts have been made at measuring activity of captive eels to predict the runs (Adam *et al.*, 1999; Durif, 2003; Bruijs, 2005)); although it seems that there is increased activity during the runs, further studies are needed to identify activity patterns which are linked to downstream runs.

Investigated measures also concern the catch and transport of eels downstream of obstacles. Such actions are currently taking place in Ireland, where on the river Shannon 5–15% of annual silver eel catches at upstream fishing weirs (Cullen and McCarthy, 2000) are released downstream of the Ardnacrusha hydropower station.

3.6 Conclusion and recommendations on quality of spawners

- The EU Water Framework Directive should use of eels as biomonitoring organisms for monitoring the chemical status of surface waters with respect to hazardous substances, because it is a very fatty fish (strong lipophylic character of a.o. pesticides and PCBs), benthic and sedentary (during the yellow eel phase). Eels are long-living and widespread, occurring in very diverse habitats and even in polluted waters. Their position on the trophic ladder and the absence of an annual reproductive cycle, affecting lipid metabolism, are additional advantages for their use as a sentinel organism.
- Member countries should set up a national program on RBD scale to evaluate the quality of emigrating spawners. This should include at least body burden of PCBs, BFRs, infestation levels with *Anguillicola*, EVEX. It should be included in the national management plans. Special emphasis should be given to standardisation and harmonisation of results (units and methods). In order to facilitate this a concerted action is strongly recommended.
- Effects and effect levels of dioxin-like contaminants but also additional, non-covered anthroprogenic factors (other viruses, bioaccumulated heavy metals and brominated flame retardants) having impact on migration, maturation and reproduction of silver eels need to be experimentally deduced.
- The EVEX virus and *A. crassus* should be added to the list of notifiable diseases.
- Safe passage of downstream migrating eels should be restored. An inventory of the different hydropower stations and their effect on spawner quality and stock should be undertaken. Existing bypasses and their suitability for safe passage of eels should be evaluated. These recommendations should be addressed in national eel management plans.
- The EU restoration plan for the eel should take into account the differences in spawner quality. A concerted action to identify areas which currently produce

high quality spawners (large size, low contaminant load, low parasite/disease levels, unimpacted by hydropower) is recommended.

4 Objectives, targets and time frames for restoration

4.1 Introduction on objectives, targets and time frames

Scientific evidence is that the European eel stock has been in decline for several decades (recruitment and adult escapement to the oceanic spawning migration). The ecology of eels makes it difficult to demonstrate a stock-recruitment relationship. However, the Precautionary Approach requires that such a relationship should be assumed to exist for the eel until demonstrated otherwise. It has therefore been recommended, to protect and recover spawner escapement from the continent. If the current trend continues, the stock might come at the brink of extinction within a single generation from now (<10 years). In October 2005, the EC proposed a "Council Regulation establishing measures for the recovery of the stock of European eel" (COM 2005, 472 final).

In this Section, we summarise the EC proposal, outline the critical aspects of implementation of the European Recovery Plan, discuss the problem of identifying the reference stock status, and specify long term objectives and identify possible short term measures.

4.2 The Regulation proposed by EC

The objective of the proposal is "to achieve a recovery of the stock of European eel to previous historic levels of adult abundance and the recruitment of glass eel", and to ensure the sustainable use (fishing) of the stock.

The principal element of the proposed Regulation is the establishment of eel management plans for each River Basin, including trans-boundary basins (as defined according to the EU Water Framework Directive). The objective of each River Basin management plan shall be to permit, "with high probability, the escapement to sea of at least 40% of the biomass of adult silver eel relative to the best estimate of the potential escapement in the absence of human activities affecting the fishing area or the stock".

When this proposal will be approved, Member States that have not developed Management Plans, will not be permitted to allow fishing, landing or retention of eels for the first 15 days of each month, except for eels less than 12 cm which are captured for the sole purpose of stocking into European inland waters with access to the sea, in order to increase the escapement of adult silver eels. This seasonal closure will remain in force for each river basin until the approval and implementation of a basin management plan. A further, short term, exemption is possible for those river basins where it can be demonstrated, and approved by the Scientific, Technical and Economic Committee for Fisheries (STEFC), that existing measures meet the River Basin Management Plan objective. However, this exemption is available only until the 30 June 2007, after which date management plans must be implemented for these river basins too.

According to the proposal, Management Plans should be communicated to the Commission by 31 December 2006, and then plans approved by the STECF must be put in place by 1 July 2007. Subsequent monitoring of the effectiveness and outcome of the plan should be communicated to the Commission by 31 December 2009.

4.3 The urgency to act

The recruitment of glass eels to Europe has showed a sharp decline in last 25 years. The historical low levels observed in recent years are an indication that the stock is clearly out of safe biological limits (ICES, 2005a).

Recruitment and SSB data show a decline which is potentially much faster than would be expected if recruitment was still proportional to the decline in SSB (Dekker, 2003, 2004a; Figure 4.1). This suggests the existence of a critical depensation or "Allee effect" (Allee, 1931), whereby negative feedback effects occurring at low spawning stock biomass accelerate the decline of recruitment to a very low level or even to zero. When eel SSB fall to levels where spawning becomes unsuccessful due to low densities of adults on spawning grounds, depensation might occur. Recruitment is at historical low levels in recent years, with no sign of recovery. Some recruitment data for the most recent years (since 2000) even indicate an ongoing decline (See Section 2).

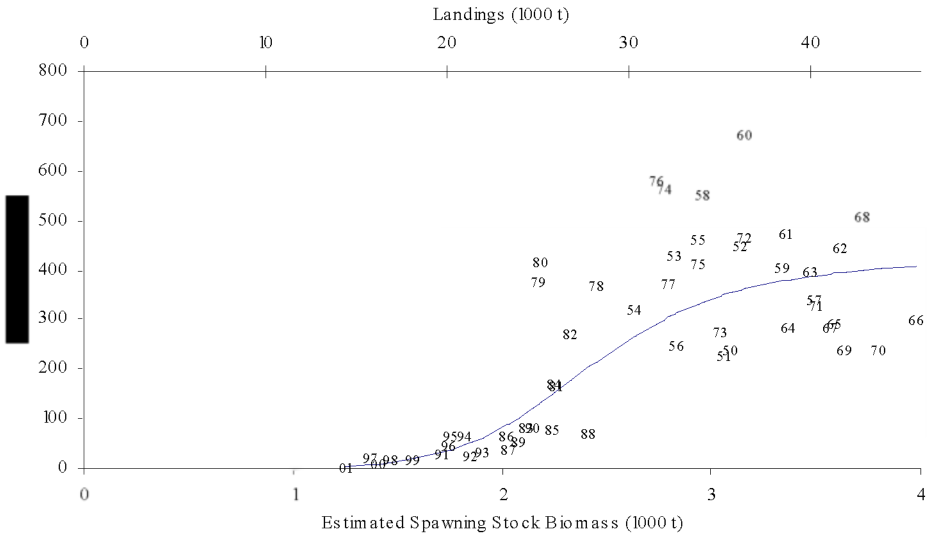


Figure 4.1. Estimated stock-recruitment relationship for the European eel. Numbers indicate the year of recruitment. The spawning stock is assumed proportional to the landings from the continental stock (after Dekker, 2004a).

In order to restore the spawning stock above levels at which the suggested depensation is likely to occur, protective measures have to be implemented. Noting the ongoing decline in the adult stock, also in relation to the decline in recruitment from which the current stock was derived, opportunities for protection and restoration are fading. All possible emergency measures to protect the stock from anthropogenic mortality must be implemented, the sooner the better. Beyond immediate measures, restoration plans have to be developed and implemented, allowing the recovery of the European eel stock.

4.4 Long term targets

Given the many uncertainties in eel biology and management, the precautionary advice of ICES (2002b) was that the European stock should be managed according to a precautionary target reference point of 50% of the potential maximum pristine spawner escapement. Since no further, specific information has been brought forward, the advice is continued.

While the proposal of the Council regulation is for a target escapement of at least 40% of the potential biomass of adult eel, the underlying reference status of the population, in terms of silver eel biomass, is not clearly defined. The proposed reference state of the habitat, "in the absence of human activities affecting the fishing area or the stock", corresponds more or less to a pristine state, which could be considered to be represented by the pre-industrial era. The potential area of productive basin during the pre-industrialised period can be estimated by imagining that no anthropogenic barriers to migrating eels exist (e.g. dams, dykes, power stations, weirs) exist. However, defining such a reference state may be unrealistically difficult. Furthermore, the escapement biomass produced by such an area within the basin cannot be predicted because of a complete lack of corresponding historic data. One might assume a level of recruitment that saturates the basin. However, while there have been some developments regarding the use of habitat suitability indices and other methods to estimate the carrying capacity of a water body, especially for other fish species, e.g. salmonids (see also Section 5), no implementable model exists for eels and neither is it likely to become available within an acceptable time frame. It is therefore suggested to refer to existing and scientifically reviewed historical data on eel abundance and glass eel recruitment as a potential reference level, where possible.

In the 1970s, recruitment of glass eel was still at historically high levels. Apparently, SSB was not limiting the production of recruits at that time. Quantification of the 1970s spawner escapement would therefore be the simplest derivation of a target reference level. Note that in this case, the full 1970s escapement corresponds to the escapement level advised by ICES (2002b), and not to the notional pristine conditions; the reduction of 50% in relation to pristine conditions and the anthropogenic impacts actually occurring in the 1970s should not be stacked one on top of the other.

For glass eel recruitment, the 1970's represents the period before the onset of the decline. In contrast, recruitment of young yellow eels into Baltic rivers had already started to decline in the early 1960's (Svärdson, 1976). It is not clear, whether this trend in yellow eel recruitment was indicative for an earlier decline in recruitment from the Ocean into the Baltic (Svärdsson, 1976), or a rise in (non-fisheries) mortality inbetween the glass eel recruiting from the Ocean and the observed yellow eel stage (Dekker, 2004a, 2004b). The former hypothesis might indicate an earlier decline of the population, initially only protracting to the southern core of its continental distribution, as also suggested for the American eel (Castonguay *et al.*, 1994). In this case (early protraction from the north towards the southern core), the historical reference period should be shifted to the 1950s for the whole population. Under the latter hypothesis (increasing mortality on young yellow eels), restoration of the 1970s spawner escapement would be adequate, but restricting anthropogenic mortalities to the 1970s level would not suffice, and management measures will have to accommodate for the higher current (non-fisheries) mortality level.

In river basins where such data do not exist we propose to use available data of adjacent or most similar (from a hydrological and ecological point of view) basins as a basis for the estimation of the reference levels of abundance and recruitment.

4.5 Estimating the potential spawning stock

The natural spawning behaviour of the eel has never been observed directly, and location, timing and abundance of the spawning process are not well known. Management advice has been given to protect the spawning stock, based on the Precautionary Approach (ICES, 1999). In this Section, a conceptual framework is presented for derivation of management targets, aiming at protection and recovery of the spawning stock. In order to support the implementation of a recovery plan, clear-cut targets must be identified. However, the derivation of practical and implementable targets in the text below should not conceal the paucity of our knowledge, and the resulting unavoidable uncertainties. In accordance with the Precautionary Approach, on top of the minimum spawning stock levels (Blim and Flim; advice to protect 30% of pristine spawner escapement), an extra safety margin has been recommended (Fpa and Bpa; advice to protect 50% of pristine spawner escapement; ICES, 1999).

To estimate the potential spawning stock it is best to rely on historical data, as shown in Dekker (2003; 2004b).

When only information on recruitment is available, estimation of potential spawning stock can be derived only through modelling population dynamics. A number of different modelling approaches can be used *a)* to identify basic vital rates that characterize eel demography; *b)* to derive the present population structure and different sources of mortality; *c)* and to estimate the fraction of the population escaping fishing and migrating to the spawning area.

Models of the continental phase of eel population dynamics have been developed along three lines (see De Leo *et al.*, 2006 for a complete review on modelling eel population dynamics and management): Leslie-matrix cohort-model approach (Gatto and Rossi, 1979); Input-Output approach to directly relate juvenile recruitment abundance to migrating mature eels (Vøllestad and Jonsson, 1988); and a number of stage and/or size structured population models which range from simple stage-structure with Beverton-Holt type of density dependence survival from a stage to the following developing stage, to more complex size/age/stage structured models that explicitly account for plasticity in eel body-size growth, variable sex ratio, survival and/or recruitment (De Leo and Gatto, 1995, 1996, 2001; Dekker, 1996, 2000a; Francis and Jellyman, 1999; Reid, 2001; Greco *et al.*, 2003; Lambert *et al.*, 2006; Åström, 2005). These models differ in terms of mathematical complexity and usability, amount and quality of the data required for calibration, realism in the description of eel life cycle and demographic parameters, possibility of analyzing different management strategies for the populations that are commercially exploited, inclusion of environmental variability and uncertainty in parameter estimation.

While site-specific analyses are still needed to correctly frame the numerous shadow-areas of eel natural life history in the continental phase, the generalized decline of eel recruitment requires a global assessment of meta-population viability under different hypotheses and scenarios. Unfortunately, despite the panmictic nature of eels, most of the modelling effort has been focused on the continental phase of eel life cycle, in restricted areas of the distribution. The first attempt to provide the estimation of the whole European stock has been done by Dekker (2000b), followed by Åström and Dekker (Annex 2). Research in this area is currently ongoing (SLIME) which should help to improve estimates of stock abundance in the present and past situations.

Given the remaining high number of unknowns and untested hypotheses, explicit inclusion of uncertainty in parameter estimation and environmental variability by using Bootstrap techniques and Monte Carlo simulations, will be required.

Once the models have been calibrated, either on the basis of data gathered in specific field campaigns or with information available in the literature, they can be used to analyse different management scenarios, to explore different hypotheses on the magnitude of historical spawning stock, to estimate the potential spawning stock under present recruitment situation and to assess the effectiveness of alternative strategies for eel recovery.

These models can then be carefully adapted to other sites where little data are available, so as to work in analogy with other systems.

Habitat Suitability Index models, described in Section 5, can also be used to provide a preliminary estimate of the potential spawning stock in historical time.

4.6 Short term measures

Both commercial landings and recruitment have declined severely over recent decades. Scientific advice has been that the population is outside safe biological limits, that fishery and anthropogenic impact should be reduced to the lowest possible level and that a recovery plan be developed (ICES, 2001, 2002b). Given the critical state of the stock of the European eel and the risk of depensation it is obvious that everything that can be done to improve the status of the spawning stock as fast as possible should be applied urgently and incorporated in the Eel Management Plans. Reversing the trend to the situation a quarter of a century ago will require clear, strong and controllable short term measures reducing all types of anthropogenic mortality.

These immediate measures should be periodically evaluated. We advice a step-wise approach, expressing intermediate short term measures in relation to current (low) recruitment, i.e. in terms of % presently possible spawner production, which in essence relates the desired total survival to the survival level that would presently occur if there was no anthropogenic mortality during the whole continental stage. Percentage present SPR can be related to a corresponding % of present total anthropogenic mortality rate allowed as %SPR=100*exp(-F*t*X/100), where F is here taken as present total anthropogenic mortality rate, t is the time span of when it applies and X is the percentage of present total anthropogenic mortality rate (cf. equation 3 in Annex 3.3 in ICES, 2005a). Anthropogenic mortality rate can be directly related to anthropogenic pressure upon the eel stock, e.g. instantaneous fishing mortality rate is in general supposed to be proportional to fishing effort. Similar relations can be supposed for other anthropogenic causes of mortality. Analyses presented in Annex 2 points to the following range of options regarding the short term measures for achieving the long term objective, depending on desired time until fulfilment:

- Spawner escapement between 0 and 60% of presently achievable spawner production (i.e. more than 16% of present total fishery mortality rate): no recovery or even a continuation of the decline is expected;
- Spawner escapement around 60% of presently achievable spawner production (i.e. ~16% of present total fishery mortality rate): breakpoint between no recovery and possible recovery;
- Spawner escapement around 80% of presently achievable spawner production (i.e. ~7% of present total fishery mortality rate): recovery and fulfilment of the long term target within 110–140 years;
- Spawner escapement at 100% of presently achievable spawner production (i.e. no fishery mortality): recovery and fulfilment of the long term target within 60–80 years.

The extremely long times needed for full recovery is partly due to the long life cycle of the eel. At the extremes of the range of the European eel, lifespan from immigrant glass eel to emigrant silver eel ranges from around 5 to 10 years in the Mediterranean region to in excess of 25 or 30 years at the northerly extremes. Another important factor is the past decline in recruitment resulting in a still declining standing stock as the base for management measures aiming at recovery.

With spawner escapement sufficiently above 60% of presently possible spawner production, it would take no less than 3–5 years before an increase in recruitment can be first detected (due to the time span between spawner escapement and glass eel return and the expected low effect of measures the first years). A significant trend of increase can only be expected to be identified after several more years because of the high variability in glass eel recruitment data series.

The overall spawner escapement can not be measured directly, but can be inferred using modelling approaches. Tools needed will be examined and developed further during the SLIME project (Study Leading to Informed Management for Eel) and subsequent work.

4.7 Management options

The management has to take into account any options that can reduce causes of anthropogenic mortality affecting spawning stock biomass through all eel life stages starting from the arrival of the glass eel to the continental shelf to the moment until mature eels leave the continental shelf. In particular, reduction of fishing effort on glass, yellow and silver eels and improvement of upstream and downstream migration can be efficient at a short term time scale. Improvement of eel health during all life span is also required to ensure quality of spawners. Improving habitat quality and restoration can be considered a necessary (yet not sufficient) condition to invert the long term trend. The proposed actions have been discussed in previous Working Group reports and other documents (ICES, 2001, 2005; Commission paper COM(2003) 573 final) and include:

- Measures to limit exploitation by fisheries
  - Prohibition of fishing
  - Total allowable catches or quotas
  - Gear controls
  - Landing size limits
  - Closed seasons and/or areas
  - Licensing of fishermen and dealers
- Measures regarding eel Habitat re-creation
  - Ensuring habitat accessibility
  - Reduction of habitat loss
  - Ensure habitat and water quality
  - Ensure downstream migration
- Controls on non-fishery mortality
  - Turbine mortality
  - Predation
  - Disease and contamination
- Restocking measures
  - Using glass eels from sources where there is still a demonstrable surplus
  - Using eels from aquaculture production (aquaculture being totally dependent on wild seed)

Following the European Commission (COM(2005) 472 final), fast development and implementation of recovery plans is needed and should include measurable targets and long term monitoring programs. Basic steps for development of recovery plans include:

- Gather data according to DCR.
- Identify the anthropogenic pressures and sources of disturbance
- Estimate their importance, extension, frequency
- Rank them in terms of importance and possibility of controlling them
- Define a road map to achieve the long term goal
- Set up periodically-revised, short-term measures
- Act on them in order to reduce pressures
- Assess the effectiveness and the overall coherence of each Management unit plan within the European Recovery Plan

Recovery plans have also to be closely coordinated with the implementation of the WFD, especially with respect to habitat improvement and restoration.

4.8 Recommendations regarding objectives, targets and time frames

We recommend that, because of the absence of data for eel stocks from the pristine, pre-industrial period, a pragmatic approach is adopted, estimating the full spawning stocks for the 1950s to the 1970s as the silver eel escapement (biomass) long-term target for the recovery plan of the European eel stock. Where such data for a river basin do not exist, data for the basin with the most similar ecology and hydrography should be used.

Long term targets are:

- to recover population and guarantee at least 50% of historic silver eel escapement and restore recruitment to historic levels. The full spawner escapement in the 1950's to the 1970's can be used as a pragmatic approximation.
- to improve the quality of existing habitat and restore lost habitats.

We recommend that short-term measures should be defined for necessary immediate action. These should be based on the potential spawner escapement from present-day stock and habitat. It has to be assured that the short-term measures produce a long-term increase in silver eel escapement, considering that the level of the short term measures will determine the recovery period.

Short terms measures aiming at long term recovery demand:

- rapid development and implementation of recovery plans including measurable targets and a long term monitoring program.
- to use the most effective short term measures to improve spawning stock biomass, e.g. the removal/reduction of legal and illegal exploitation of glass, yellow and silver eels, in combination with the removal/reduction of all other causes of anthropogenic mortality, including the impairment of upstream and downstream migration (e.g. mortality caused by turbines)

5 Spatial Resolution in targets, controls and post-evaluation

5.1 Introduction

The European eel is found and exploited in most of Europe, northern Africa, and Mediterranean parts of Asia. Presumably, there is just one single spawning stock with only weak indications of some spatial or temporal differentiation (Dannewitz *et al.*, 2005). The gradual decline in fishing yield and steep decline in recruitment, observed throughout the distribution area, necessitates urgent management measures. Typical eel fisheries are relatively small scale and widely scattered in coastal areas, lakes and rivers in each country, and these have, to date, only marginally been influenced by national or international management measures. First priority must be the protection and restoration of the spawning stock. The European Commission has issued a Proposal for a Community Action Plan for the Management of European Eel (COM 2003, 573), in which the international objective of restoration of the spawning stock is made explicit, and proposed a Council Regulation establishing measures for the recovery of the stock of European Eel (COM (2005) 472).

The challenge for the Community is the rapid design of a management system and a stock assessment methodology for eel that ensures local measures produce results in a consistent way across the various river basins, Member States, and adjacent countries. The critical target defined in the Regulation was to permit, with high probability, the escapement to the sea of at least 40% of the biomass of adult eel relative to the best estimate of the potential escapement from the river basin in the absence of human activities affecting the fishing area or the stock.

Stock-wide criteria and demonstration of compliance with escapement targets can be achieved at the Regional, National (ICES, 2000) or individual catchment (ICES, 2001) level. Pragmatic grouping of catchments into single Management Units, such as River Basin Districts (RBD) and adjacent coastal waters under the EU Water Framework Directive, will provide a more reasonable number of Units (125) than the number of individual catchments (~10,000). Local management at the catchment level can be accidentally, or intentionally off-target, as long as many local situations (e.g. different catchments within RBD) sum up to the required overall criteria or target (Dekker, in press).

Sampling of eel fisheries will presumably be mandatory from 2006 under the EU Data Collection Regulation (DCR) for fisheries (Council Regulation 1543/2000 and Commission Regulations 1639/2001, 1581/2004). However, the schedule as set-out in the DCR for eel does not provide for the collection of data with which to estimate R, SSB and F for any of the river basins. The current details of the DCR only cover marine waters, and the targets are wholly inadequate for eel assessment purposes. The DCR needs to be amended, so that it includes river basin districts and adjacent coastal waters as basic spatial disaggregation units.

Regardless of the scale at which target compliance is being demonstrated, monitoring of fisheries, stock characteristics, mortality and environmental parameters will, by necessity, have to be at the individual catchment level. The question is: how many catchments should be monitored for setting Biological Reference Points (BRPs), assessing compliance with targets and post-evaluation of management measures?

This discussion on spatial resolutions in management and monitoring has surfaced in scientific studies, scientific advice, and management policies, but a full analysis of the practical consequences is absent.

The challenge facing eel science and management is the development of a suitable system, based on an extreme paucity of quantitative data for the majority of individual river catchments. It is necessary to utilize analysis of data rich catchments and develop realistic proxy models and monitoring of data poor catchments. These should be developed at two levels, stock assessments for estimation of spawner escapement and indicators for observing changes in eel stocks within catchments.

5.2 An Eel Stock Assessment Toolbox

Any recovery plan must have a target biological reference point, or conservation limit, which can be used to assess whether sufficient potential spawners are being produced to fulfil the next generation. The objective of the Eel Recovery Plan is to set a target silver eel escapement measured against potential production from pristine conditions, with historical high recruitment levels. The target defined in the EU Regulation was to permit, with high probability, the escapement to the sea of at least 40% of the biomass of adult eel relative to the best estimate of the potential escapement in pristine conditions.

To date, setting pristine levels for catchment based silver eel production has proven to be difficult. ICES (2004a) developed and discussed a number of modelling approaches which should assist in this process; a Habitat Suitability Index Model, a Harvest Rate Model and a Reference Condition Model. It is challenging to devise suitable models which encapsulate the wide range of habitats (streams, rivers, lakes, coastal areas, lagoons, and estuaries), the flexible life history strategies of the eel and the variety of levels and types of exploitation.

Restoration of the eel stock also depends, in part, on restoration of sub-optimal or now inaccessible habitat. In order to achieve the restoration objectives, targets for habitat restoration must be quantified. This will, in the most part, be addressed by the EU Water Framework Directive. Accessibility issues for eel migrating upstream and free migration downstream for spawners must be included in this Directive.

5.2.1 Habitat Suitability Index Model

The **Habitat Suitability Index** model (ICES, 2004a), HSI, indicates to which extent a certain set of habitat variables determine the suitability of an area for that species. In a Habitat

Evaluation Procedure (HEP) ecological values of different study areas at the same time, or ecological values of one study area at unequal times, are compared for a (number of) species. In a HEP, the quantity of habitat (area) is multiplied with its quality (HSI-score), resulting in an amount of suitable habitat for different study areas or for different moments. The HSI-model developed for eel was built for use over the entire latitudinal range where eels occur, easterly from the continental slope on the European Atlantic coast. Figure 5.1 shows the structure of the draft HSI model.

Habitat models only explain a proportion of *spatial* variation in fish populations (Milner *et al.*, 1995; Milner, N. pers. comm., Environment Agency, UK). Total variance in mixed time/spatial sets of fish data is a combination of 1) spatial, 2) temporal (synchronous), 3) error, 4) interaction. Only the spatial component – that deriving from the location and features of each site – is ever accountable by habitat models, although improvements in water and habitat quality will introduce a time element to the model. Habitat models rely on there being a significant amount of spatial variation, or they become redundant.

In the case of salmonids, these empirical models, e.g. HABSCORE (i.e. Milner *et al.*, 1995), can only ever account for the spatial component of stream abundance, but have shown that for trout in English and Welsh streams this can be up to 73% of the overall variance (including temporal, error and interaction), of which the (HABSCORE) models explained up to 63%. Moreover, the proportions of spatial and temporal variation vary substantially with the scale of analysis, between tributary to catchment level (Milner *et al.*, 1995). However, they do offer a mechanism by which to predict the potential average maximum abundance, the "carrying capacity", of fish for riverine parts of a catchment, against which to compare measured densities and set BRPs. Recently, the entire freshwater salmon habitat of Ireland has been quantified in terms of wetted surface area, channel gradient and water quality using GIS (McGinnity *et al.*, 2003) and incorporated in the determination of regional and catchment based conservation limits for salmon.

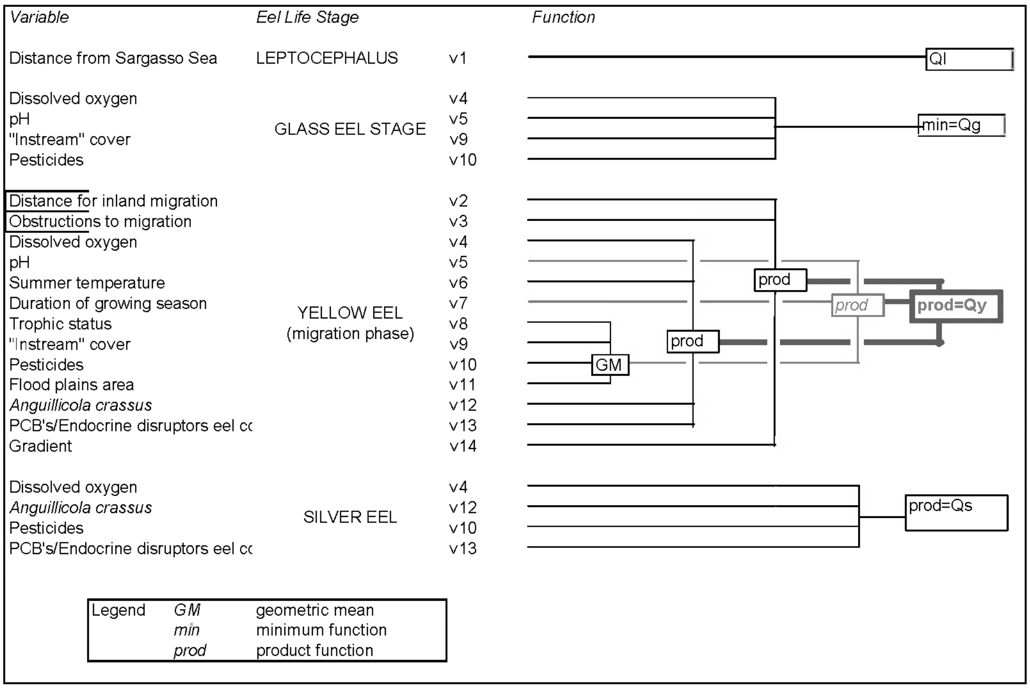


Figure 5.1. Structure of the HSI Model (ICES, 2004a).

5.2.2 Harvest Rate Model

A **Harvest Rate Model** was discussed by the WGEEL (ICES, 2004a). Standard fish stock assessment methodology (VPA) in marine fisheries is based on harvest rate models, in which the impact of fishery on the stock is assessed using information on the quantity and composition of commercial landings, assuming that natural mortality remains constant. This approach has been applied to eel fisheries in a limited number of cases. Sparre (1979) applied a cohort analysis model to data on eel fisheries in the German Bight, extending a standard age-structured model to allow for silvering and emigration. Instantaneous fishing mortality rate (F) was estimated at 0.2 for the most exploited length-groups. Dekker (1996, 2000c) developed a length-structured equivalent to age-structured cohort analysis models for the eel fisheries on lake IJsselmeer, the Netherlands, and applied it over a period of 8 years. Instantaneous fishing mortality rate (F) was estimated at 1.0 per year for the fully recruited length-classes. A strong reduction in the quality of landings data for Lake IJsselmeer has made these models less reliable.

Application of harvest rate models is limited to data rich situations, they are not applicable to unexploited catchments and when anthropogenic (except fishing) mortality is high, and just one case study exists in which long-term management advice has been based on this approach. There are, however, two major advantages over an approach based on the comparison of the actual state of a local stock to reference conditions. First, it seems likely that regulations will primarily focus on the fishing effort, which is directly related to (fishing) mortality levels. Secondly, recruitment to (local) continental waters is known to vary considerably from year to year, even in periods of high recruitment. If carrying capacity is not fully met, this translates into a delayed, but corresponding variation in exploitable biomass. Mortality rate-based management will in principle not respond to altered recruitment levels, resulting in a variation in spawner production of comparable magnitude as the recruitment variation. By definition, risk-averse reference points, such as Fpa and Flim, are inherently safe under this variation in spawner production for a given shape of the stock recruitment curve.

5.2.3 Reference Condition Model

While Harvest Rate based assessments may be suitable for lake fisheries where input and output can be effectively monitored and where standard stock assessment methodology can be applied or in river systems where there is extensive yellow or silver eel fisheries, they are expensive in terms of resources to undertake routinely in river or unexploited systems.

The ICES WGEEL (ICES, 2004a) discussed the possibility of developing a **Reference Condition Model** that would be applicable in data poor situations. Given the paucity of information on carrying capacity and historical levels of biomass production at the catchment level, consideration needs to be given to an alternative or surrogate approach to target setting and compliance. For a number of river systems it has been shown that eel density declines with distance from tidal influence in a systematic manner and can be effectively modelled. The objective is to determine the natural pattern within a river system, i.e. the pattern in the absence of fishery and anthropogenic impacts (reference condition), and compare that with the current characteristics of the population.

The approach involves modelling the relationship between eel density and distance upstream from tidal influence and needs to be undertaken on a wide range of river systems / types. This will allow assessing whether any of the variation in the relationship between river systems can be explained by differences in catchment characteristics, level of exploitation and/or geographical position. The aim is then to describe the eel population (density / biomass) in a given catchment in the absence of certain (or all) anthropogenic influences (as described in the HSI) and compare the current findings with the reference position (pristine state) determined from the model.

ICES (2003) suggested, upstream migration might be density dependent. In that case, the density (biomass) at the tidal limit (a) will be constant, provided the carrying capacity is constant too. A higher level of recruitment should then theoretically result in a lower rate of decline with distance.

5.3 Objectives for monitoring.

Monitoring of environmental characteristics, eel stock characteristics and spawner production takes place for a number of different reasons:

- As a basis for modelling target achievement
- As a basis for priorities for management options
- For post-evaluation of trends in the stock and management measures taken.

The unit for management and monitoring is the River Basin District. Based on a "dashboard" (for example, see Figure 5.3) and GIS based information system, catchments within an RBD may be classified according to potential eel production and the presence of anthropogenic mortality, including life history stage and fishery type. Monitoring should provide data with which to estimate the current level of production using appropriate models and this can then be related to the theoretical potential spawner production.

Each catchment in a RBD can be characterised into subsystems; the WFD Article 5 Characterisations may provide a reasonable platform on which to base this analysis. The distribution of eel between these subsystems may be influenced by density dependent processes (ICES, 2003); i.e. the lower areas, (coast, estuaries, lagoons) may have to be saturated in order to drive further migration upstream. This may have implications for the design of population monitoring. The design of a monitoring system, like a GIS to characterize and group different catchments within a RBD, must integrate data from as many applicable data rich sources and be capable of transferring this information to data poor systems, with suitable inter-calibration. The application of suitable BRPs and models (FP6 project 022488 SLIME) at the appropriate spatial scale (Pilot Project) will facilitate a cost-effective stock assessment toolbox to be developed (see Figure 5.2 for diagrammatic approach). Currently, the appropriate tools are not available.

Such a monitoring system and stock assessment toolbox should also provide the basis for evaluating different management actions within catchments (within RBD´s) and facilitate the post evaluation of their effectiveness.

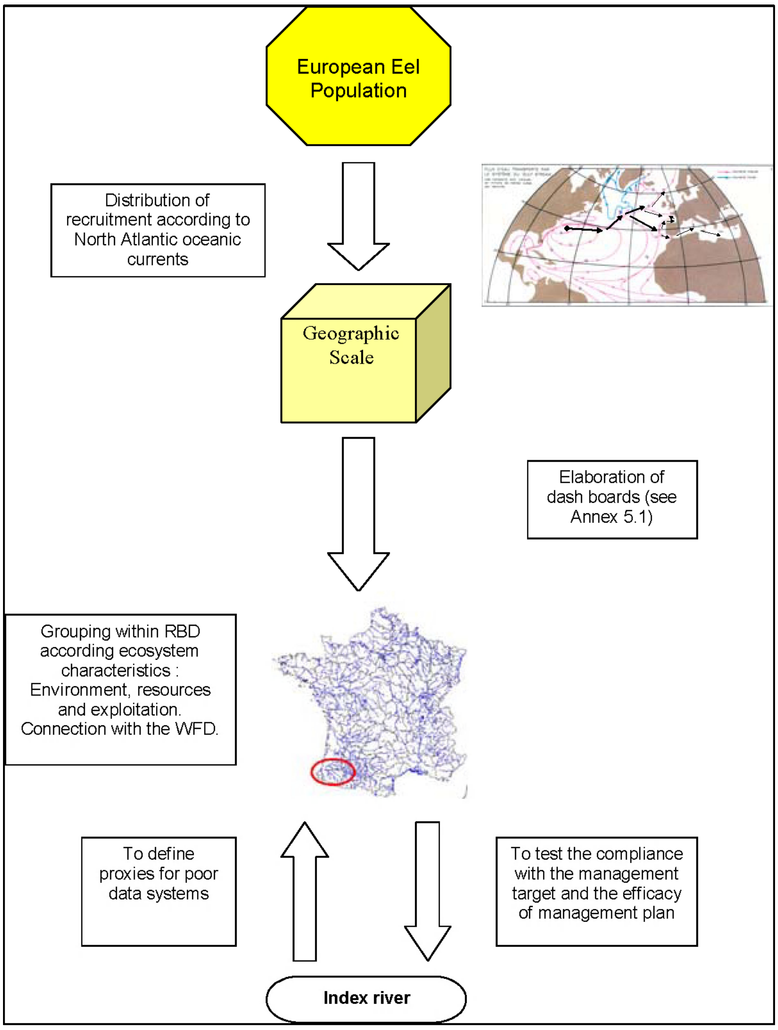


Figure 5.2. Schematic for the development of habitat and fisheries based stock assessment toolbox.

5.4 Interactions between River Basin Districts

Interactions between different Management Units (RBDs) must be addressed, both when setting targets and in designing monitoring programmes. There are situations where several RBD´s share the same source of recruits. The most evident example is the Baltic region where coastal areas in the Kattegat and in the Danish straits are target areas for primary recruitment of glass eels. Further recruitment into the Baltic is based on active migration of yellow eels. If this migration is influenced by the density of yellow eels in the primary target area, management actions in all RBD´s upstream may never be sufficient in achieving targets, unless they are coordinated with actions in RBD´s downstream. For example, a change in legal size in landings in the downstream regions could have an effect in all areas upstream.

Post-evaluation of management actions in a situation with interactions between RBDs requires co-ordination between such RBDs. In the Baltic, the contribution from each RBD to the total flow of silver eels leaving the area has to be demonstrated. Currently the only way to achieve this information is to perform coordinated mark-recapture experiments, relying on recaptures in the mainly Swedish and Danish pound net fishery. Using pit-tags and scanning landed catches should be a suitable method.

5.5 Development of a Monitoring System

Sustainable development (and consequently sustainable exploitation of fish population) is at the convergence of three components: social (equitable); economic (advantageous); environmental (viable). The Working Group treated only the 3rd component while not addressing the socio-economic parts of the ecosystem characteristics that the managers have to consider when taking management options.

An ecosystem approach allows the attaining of an objective while taking into account a wide range of knowledge and uncertainties. It considers multiple external influences, and strives to balance diverse socio-economic matters. It is geographically specified, adaptive and its implementation will need to be incremental and collaborative.

To apply an ecosystem approach, it is necessary to define that ecosystem. The scale of these ecosystems should be based on the spatial extent of the system dynamics that are be studied and /or influenced through management (Sissenwine and Murawski, 2004)

5.6 Information needed to achieve the assessment of the escapement target

Mortality due to fishery exploitation : F

Natural mortality : M_{nat}

Anthropogenic mortality : M_{antro} (depends on the number and the nature of the perturbation)

Total mortality : $Z = F + (M_{nat}+ M_{antrho})$.

Estimate of the recruitment : Glass eel stage or young yellow eel stage

Estimate of the catch at different stage.

Estimate of the escapement from the river basin (silver eel stage) to validate the model or to post-evaluate the results.

Estimate of the growth pattern (trends in growth and mean age of the cohort).

5.6.1 Proposed conceptual framework

Eel is widely distributed throughout different habitats, in salt and freshwater, and it seems impracticable to measure or estimate all the parameters in every catchment and fishery within each River Basin District.

The solution proposed is to develop an interactive GIS based database which can be used to aggregate catchments of similar characteristics within each geographical area (area of similar eel recruitment characteristics) and by River Basin District. This would provide a means of distributing the sampling effort on a spatial scale. It would also facilitate the transfer of proxy data from representative index, or data rich, catchments, to similar data poor catchments, for the purpose of setting targets Such data transfer should be validated by local 'spot check' monitoring and monitoring of fisheries.

In the initial phase of developing a framework, the principle of oceanic currents and different volumes of water governing the patterns of glass eel recruitment into geographic zones (Knights, 2003) should be taken into consideration when considering characterisations of individual water bodies and River Basin Districts for the purposes of stock evaluation and target setting. For example, from the biological (intensity of recruitment) and environmental (natural, anthropogenic and fisheries characteristics) point of view the Mediterranean and Biscay coasts of France receive different patterns of glass eel and there is a shared common resource (recruits) between RBDs in the Baltic.

The next step is to determine from a "dash board or decision matrix" the general characteristics of the water masses (connection with the WFD) and the general characteristics of the fishery (Table 5.1) an example of which has been demonstrated in the EU INTERREG III Indicang project (Figure 5.3). This will allow water bodies to be grouped at an appropriate level with regard to quality and precision of the data and resulting monitoring effort.

Table 5.1. General parameters required for catchment characterisation and aggregations.

DESCRIPTION OF CATCHMENT	GROUPINGS OF SIMILAR SYSTEMS WITHIN RBDS
Country	
Eco Region	
Geographical zone	
River Basin District	
Grid Reference	
Catchment area (surface in km)	
Wetted Surface Area (ha)	
Linear length of river (km)	
Area of Lakes (ha)	
Rate of flow of the catchment area (in cubic meter/s)	
Numerical map of hydrographical system	
Locations of dams and hydroelectric power stations	
List (description)of upstream obstacles	
List (description)of downstream obstacles	
Analysis of the efficiency of upstream facilities	
Analysis of the efficiency of downstream facilities	
Colonization area lost (%)	
Data on water quality	
Data on deposit quality	
Underlying Geology	
Gradiant	
Measure of potential productivity (alkalinity?pH?)	
Habitat Evaluation Parameters	
pH, DO, etc (see ICES, 2004a)	
Description of Fishery	By Life Stage
Number of licences	
Type of gear used	
Location of fisheries	
Catches	
Catches: glass, yellow and/or silver eel	
Restocking	
Description of Stock	By Life Stage
Historical Comparisons	
Trends in recruitment	
Trend in eel density / biomass	
Spatial pattern related to catchment/habitat	
Spatial & temporal pattern in size/growth of eel	

5.6.2 Controls

Index water bodies: It is at the catchment area, or water body level, where an estimate can be made of the production of silver eel from the data available (see above) and to model the effect of management actions on the escapement target or the impact of improvements to the environment on the carrying capacity of the different water masses (coastal lagoons, estuaries, continental areas, lakes). It seems reasonable to define a limited, but representative, number of index, data rich, water bodies.

For the other rivers, it seems possible to establish a potential estimate of the silver eel production according to the characteristics of the environment, the eel stock and the fishery by using the transfer of stock characteristics from the index systems to other catchments. As mentioned previously, such data transfer should be validated by local 'spot check' monitoring of stock and fisheries.

5.7 Recruitment monitoring

It is essential that the existing recruitment indices be continued. The network of monitoring stations should be extended and strengthened to give a better coverage of spatial scale. Monitoring of glass eel gives two measures, not necessarily from the same monitoring station: firstly success of spawning escapement and oceanic larval migration and secondly, recruitment into individual catchments.

In the first case it is important to get an index of the outcome of a change in SSB, and or a change in oceanic survival of larvae, expressed as the number of glass eels reaching the European continent. The present system covers a mixture of primary glass eel densities and abundance indices for young yellow eel ascending rivers. To meet this objective we suggest a focus on glass eel numbers arriving from the ocean, which may include a demand to strengthen this side of recruitment monitoring and, perhaps, to include new techniques for fishery independent surveys.

Monitoring ascent in rivers should reflect the general recruitment processes, but data may be influenced by density dependent and environmental factors with an influence on locomotive activity. If a consistent relationship can be applied between the recruitment to a system and the escapement of silver eel (that is: absence of exploitation, or exploitation at a fixed rate), monitoring of these stages may provide the basis to follow up if the escapement target is met. It is probable that this condition only exists in a minority of catchments and RBDs.

The estimation of the boundaries of colonisation upstream of juvenile eel within a catchment, relative densities, etc., and its evolution over time and spatial scale could also provide an indicator of the effectiveness of the eel management plan.

5.8 Yellow Eel Monitoring

Monitoring the standing stock of yellow eel may give a useful proxy for compliance to established management targets. This may be obtained by CPUE values in the lower reaches and lakes in a catchment and where possible, the relationship between CPUE data and standing crop should be established. Together with data on size and age structure, this could provide input for modelling spawner escapement. Another approach to obtain a proxy for the standing stock is yellow eel densities (electro-fishing) in the upper parts of a catchment, as in the RCM (Section 5.2.2).

5.9 Silver Eel Monitoring

Monitoring output of silver eel may be possible from mark recapture techniques (Boury P. pers. comm., University of La Rochelle, France). From such surveys, overall mortality in the continental phase may also be deduced. The number of case studies presently using this approach, however, is extremely limited: the Shannon (Ireland), the Loire (France), Rhine and Meuse (Netherlands and Germany).

5.10 Spatial Scale

The issue of spatial scale for monitoring, assessment of compliance with targets and application of controls, where necessary, to achieve compliance has not been included in any detail in discussions at the Sånga Säby Workshop, STECF and SGRN. The basis for recommending spatial scales and sampling intensity is currently weak and a number of proposals have been made and a number of projects are underway that may address many of these issues, see below.

5.10.1 FP6-project SLIME

The SLIME project is intended to produce an agreed and effective assessment methodology by mid-2006, and this will indicate to a large extent the data needs for eels. The development and application of a suite of models will become the basis for the development of stock assessment tools.

5.10.2 Data Collection Regulation

The Working Group supports the recommendations made by the SGRN meeting, December 2005, and in particular the following recommendation.

- the setting up of an internationally co-ordinated pilot project of 2 years sampling, starting as soon as possible, to establish a cost-effective system for monitoring of spawner escapement rate and F by river basin district. The results of the pilot project will be used to identify precision levels, sampling intensities and relevant spatial scales, and for setting up routine monitoring sampling programs to be included in the DCR.

The Pilot Project ToR should be expanded to include an assessment of spatial scale.

5.10.3 INDICANG Project (INTERREG III)

The aim of this project is to share knowledge about the exploitation of the European eel, its habitat and its evolution between participants who, for different reasons, all have an interest in this resource. INDICANG is the first network with participants spreading from Cornwall in the UK to Northern Portugal. Its aim is to obtain a synoptic view of the status of the species by setting up an information and action network. The project must demonstrate to the European Community and decision makers at all levels through examples, that there have been various actions and intense efforts on the part of all participants to ensure that the eel remains part of our social, economic and biological heritage. It must also explain the need to start a policy to restore habitats as soon as possible.

More information about this project can be found at http://www.ifremer.fr/indicang/.

5.10.4 EU Water Framework Directive.

The development of classification tools for assessment of fish in fresh and transitional waters within the WFD is currently being carried out. The basic information required is species composition, relative abundances and size/age composition. It is questionable whether the current WFD will have the desired level of sampling intensity and design to cater for the needs of the EU Eel Recovery Plan, but eel specific extensions have been recommended (ICES, 2005a).

5.11 Conclusions

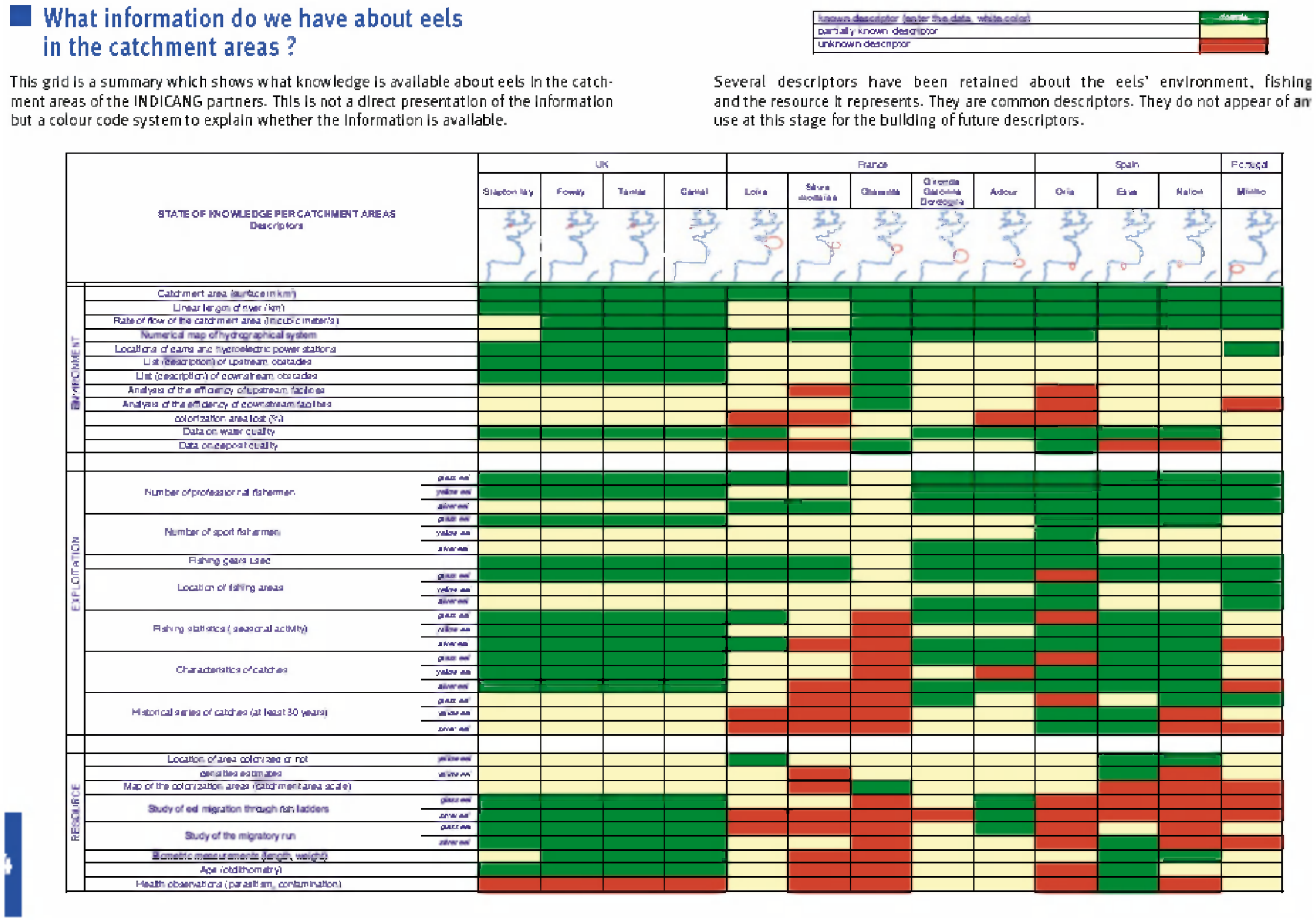
- Determination of spatial resolution in designing monitoring depends on detailed information from each catchment in all RBD´s.
- Such information is either lacking or spread over diverse sources.

- This leads to a need for creating and compiling necessary information
- To meet this a matrix system, including global recruitment patterns, for characterisation and grouping of catchments within RBD´s is suggested
- Data from WFD, SLIME, DCR pilot projects, Habitat Suitability Models, Indicang dash board etc are proposed to be used to compile and analyse necessary data in the matrix
- The matrix should be a base for defining the potential and current status of the eel stock and to define sources of anthropogenic mortality and enable results from intensively monitored systems to be extrapolated to systems with less information
- It should also be a tool when making priorities between management actions and post-evaluation of such actions.
- Target setting and monitoring must consider interactions between different RBDs

5.12 Recommendations for Section 5 – spatial resolution

- It is recommended that existing national monitoring programs and time series for eel should be continued and the data should be used in pilot projects.
- Eel should be included in the WFD as indicator of ecosystem continuity, chemical and ecological status, except in catchments where stocking are practiced on a wide scale.
- Restoration of the eel stock also depends, in part, on improvement of sub-optimal or now inaccessible habitat. In order to achieve the restoration objectives, targets for habitat restoration must be quantified. This will, in the most part, be addressed by the EU Water Framework Directive. Accessibility issues for eel migrating upstream and free migration downstream for spawners must be included in this Directive.
- The FP6-project SLIME should be a start of the of the modelling process and the development of a suite of tools that can be used for stock assessment, building on outputs from existing habitat and fishery based models.
- The DCR should be amended, so that it includes river basin districts and adjacent coastal waters as basic spatial disaggregation units.
- It would be appropriate to develop the DCR monitoring programme, in conjunction with a Stock Assessment Toolbox, to provide data of sufficient quality and detail for the estimation of spawner output and compliance with escapement targets at relevant spatial scales.
- It is recommended to set up an internationally co-ordinated pilot project of 2 years, starting as soon as possible, to establish a cost-effective system for monitoring of spawner escapement rate and fishing mortality by river basin district. The results of such a pilot project may be used to identify precision levels, sampling intensities and relevant spatial scales, and for setting up routine monitoring sampling programs to be included in the DCR.

Figure 5.3. A demonstration "dash board" from the Indicang project.



6 Spatial distribution of eel fisheries

6.1 Introduction.

The Country Reports, reproduced in Annex 3, have been used to update Table 1 of Moriarty and Dekker (1997), focussing on glass yellow and silver eel catches by River Basin District (RBD) for 2004, information on the number of different gears used (where available), and on the geographical area (km^2) and location of each RBD. While Country Reports in previous years (ICES, 2003, 2005a) reported eel catches primarily at the national level, this year's aim was to present a breakdown of the national totals by RBD. Annex 3 presents a wealth of information, but unfortunately at somewhat varying spatial scale, and not always of the same quality. Compilation of an international overview by RBD was not feasible during this meeting of the Working Group. Consequently, updated statistics per country are presented below. Further analysis of the information in Annex 3 is postponed.

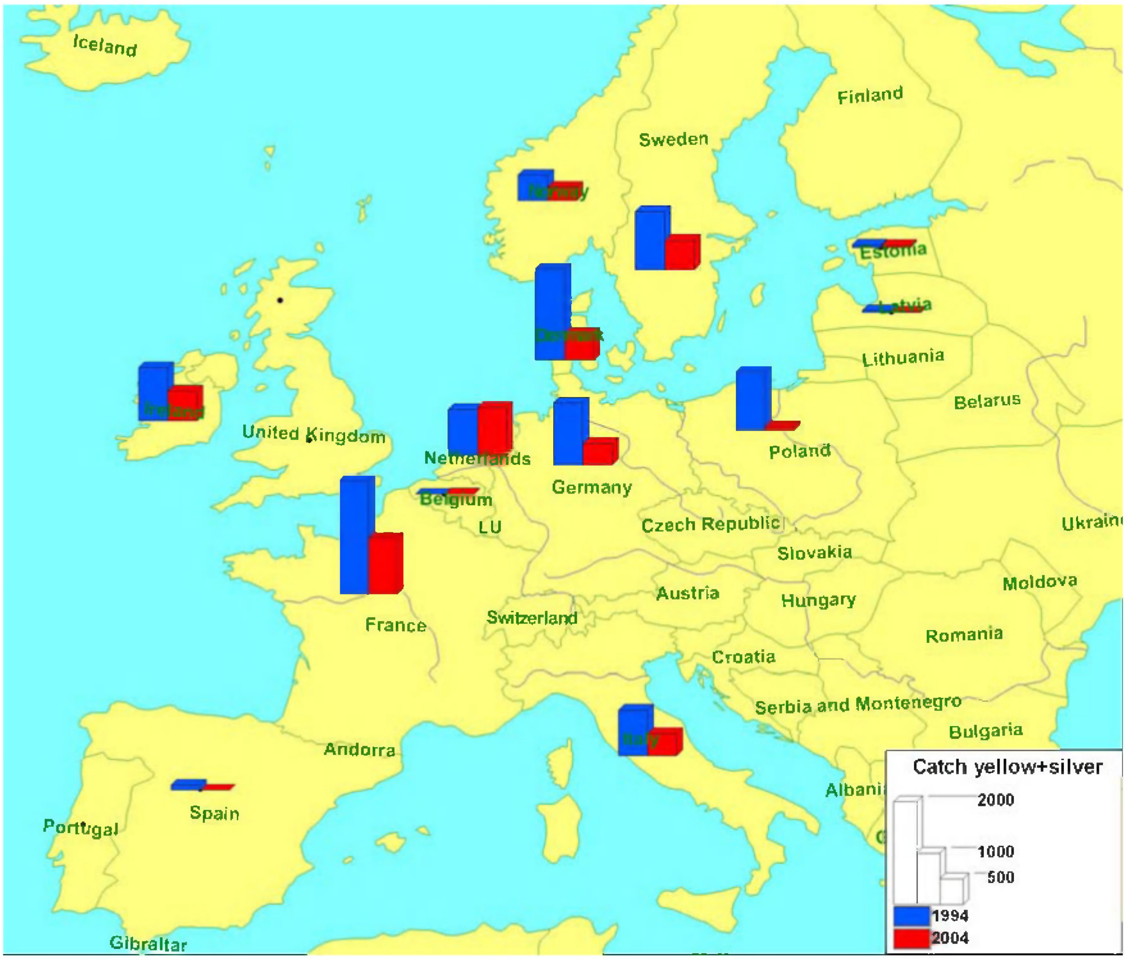


Figure 6.1. Comparison of the 1994 and 2004 estimates of eel catches, per country.

Figure 6.1 provides a schematic summary of the spatial changes in catches of yellow/silver eel combined by country across Europe over the last decade, using data for 1994 in Moriarty and Dekker (1997) and those presented for 2004 in Table 6.1. For this purpose, it is assumed that the current national reports are based on information that is no less comprehensive than that used in Moriarty and Dekker (1997), which is definitely not true for some countries (e.g. the Netherlands).

Table 6.1. Comparison of the 1994 and 2004 estimates of eel catches, per country. Sources: Moriarty (1996) and Moriarty and Dekker (1997); recent Country Reports at the end of this report.

COUNTRY	GLASS EEL (TON)		YELLOW + SILVER EEL (TON)	
	1994	2004	1994	2004
France	300.0	173.9	2200	1078
Italy	0.5	0.0	900	446
Spain	150.0	4.0	100	34
England and	18.0	14.4	293	183
Scotland	0.0	0.0	0	0
Ireland	3.0	0.7	1035	582
Poland	0.0	0.0	1137	75
Latvia	0.0	0.0	40	12
Estonia	0.0	0.0	47	39
Sweden	0.0	0.0	1130	572
Denmark	0.0	0.0	1780	530
Norway	0.0	0.0	472	240
Belgium	0.0	0.0	0	5
Netherlands	3.0	0.0	885	920
Germany	0.0	0.0	1198	416
Portugal	20.0	4.6	0	0

Glass eel fisheries are largely restricted to south-western Europe, and the main fisheries are along the Atlantic coast of France and Spain. Glass eel fisheries have collapsed in Italy and Netherlands between 1994 (Moriarty and Dekker, 1997) and nowadays. According to the data the decrease has been of 20% in England and Wales, 40% in France and even larger in Ireland, Portugal (around 80%). The reduction of 97% found in the Spanish catch might be mostly the consequence of the overestimate about the figure drawn in 1994 (150 tons), and also because both yellow and glass eel catches are underestimated as data are lacking from several autonomies.

It is apparent that production of yellow/silver eels has reduced over the last decade in all countries except Belgium, generally by about 50%, but even more in Denmark, the UK and Poland. There is no obvious north-south or east-west trend in this decreaseand it cannot be explained simply by a decline in glass eel recruitment rather than, for example, changes in stocking practices in some areas or in the motivation for eel fishing (chiefly profitability) and, therefore, the level of fishing activity.

Where possible, comparable information for previous time periods are presented to help complete the picture of changes in the spatial distribution and production of glass, yellow and silver eel fisheries over the period when the stock is assumed to have been influenced by either declining spawner escapement or failing recruitment due to other causes.

7 Re-Stocking of glass eel as a means to aid stock Recovery

7.1 Introduction

The terms of reference given to the 2006 Working group include the instruction to: "*evaluate the effect of glass eel restocking in relation to established rebuilding goals, considering options from no restocking to full restocking of available glass eel*".

This request stems from an on-going debate over the potential contribution of glass eel transfers to contribute to recovery of the stock as a whole. The continuing decline in supply of glass eels in many areas, and the potentially limited time available in which restocking remains as an option, add urgency to the need for an agreed position on this issue. It is clear that if recruitment continues to decline, there may soon be very limited scope for transfer of stock between regions. This is a now a critical consideration if stock transfer is to be used to provide any insurance against irreversible loss of spawning stock.

The Commission proposal for a council regulation (COM(2005) 472 final) spells out the objective that member states achieve a silver eel escapement per river basin, "to permit with high probability the escapement to the sea of at least 40% of the biomass of adult eel relative to the best estimate of the potential escapement from the river basin in the absence of human activities affecting the fishing area or the stock."

The issue of re-stocking has been discussed in several recent fora with varying conclusions. The EC commission report of October 2003 (COM(2003) 573 final) notes the potential use of transfer of glass eels "from nearby estuaries" in order to meet "settlement" targets for local recruitment of glass eel. Following discussions at a meeting held in Brussels, March 2005, the Commission has asked ICES advice on this issue, in a so-called fast-track procedure, with specific reference to the question of the extent of available glass eels supply and the total European capacity to accommodate seed stock. The resultant advice from ICES to the EU commission (ICES, 2005b) is that the current glass eel catch (circa 100 tonnes) is less than that required (150 to 1000 tonnes) to supply the total potential productive habitat. ACFM further concluded that full scale restocking alone is unlikely to achieve the EU objectives (40% of potential silver eel escapement from all river basins) in the medium term. The following discussion elaborates and extends earlier work by WG eel.

7.2 The concept of a local surplus of glass eel.

The final goal of eel management must be to increase the amount of viable spawners. One way to approach this goal is to stock suitable habitats with young eels. The main idea behind stocking is to increase the probability that an eel will survive, grow well and become a healthy silver eel that will find its way to the spawning area. ICES has stated in its advice to the European Commission that "it is an essential precondition that demonstrable surplus exists in the local glass-eel stock exploited for the restocking" (ICES, 2005b). However, the Commission proposal for a Council Regulation does propose that fishing for glass eels will be allowed during the monthly 15-day closure, on the condition that the catch is used for restocking, i.e. without an absolute demand for a demonstrable surplus. It might very well be that an individual eel will do better in another habitat than in its original habitat close to carrying capacity, for example by stocking in highly productive habitats in Southern Europe, or stocking in low abundance areas with good water quality. If the habitat of origin involves dams, injurious turbines etc. Restoration of migration pathways might be a slow process, while glass eel recruitment is rapidly in decline. It might be a much faster and more cost effective solution to transport the recruits to more suitable areas than solving complicated technical and downstream passage issues. Such decisions should be based on a thorough analysis in each separate case. However, trap and transport, though quick and easy, should not be an excuse for not restoring accessibility to natural habitats in a longer time frame. Contrary to most practice to date, the primary aim of restocking schemes must now be recovery of the stock, and not to fishery enhancement.

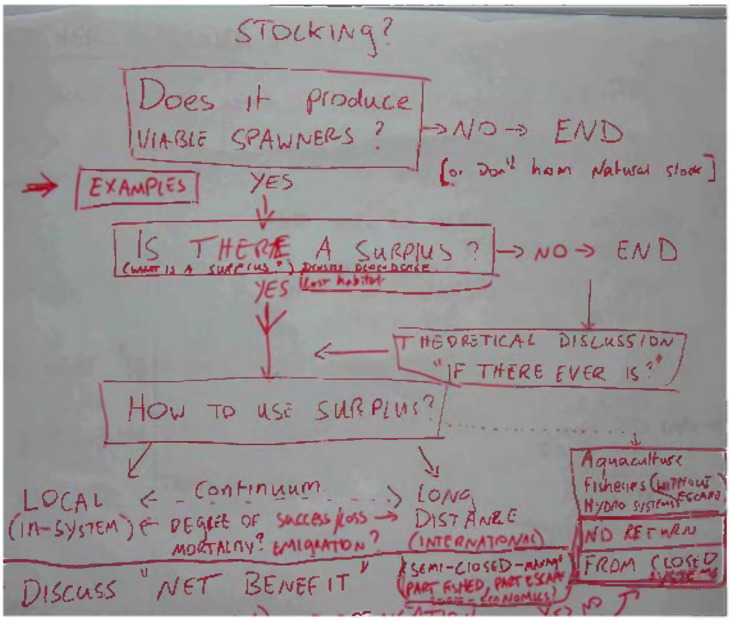


Figure 7.1. WG Stocking thought processes

7.3 Evolution of scientific advice on re-stocking for stock enhancement.

The issue of re-stocking first came to prominence as a result of the stock-wide reduction in glass eel recruitment across Europe in the 1980s. The initial thrust of scientific advice was to use restocking as a means of supporting fisheries experiencing loss of input stock. At this time there was general acceptance that the supply of glass eel to exploitable locations in Western European coasts (Bay of Biscay to the British Isles) was more than adequate to supply the river basins feeding these areas. As the focus was on its use as fishery support measure, the issue of whether or not re-stocking results in potentially viable spawner production was not considered in detail during this period (Moriarty, 1996; Moriarty and Dekker, 1997).

Subsequently, however, objections have been raised against the assumption that restocking will result in successfully emigration of viable silver eels. This issue needs due consideration if stocking is to be advocated with any degree of confidence. The following section discusses the pros and cons.

7.4 Present extent of glass eel stocking activity

Eleven country reports provide data on restocking activities All but three report that stocking has been traditionally practised for many years, with the aim of enhancing stocks and supporting a viable fishery. In several countries both glass eels and young yellow eels were used, probably depending of the availability of suitable stocking material. Both freshwater and brackish habitats have been stocked. However, stocked quantities have decreased over time, especially during the 1990's and 2000's, probably due to the increased price for glass eels. In some countries re-stocking has decreased to marginal levels. In some cases the glass eels are pre-grown to several grams, in order to increase their survival rate, thereby improving the cost-effectiveness of the re-stocking programme.

Current re-stocking quantities are reviewed in Section 2.2.

7.5 Evidence for or against successful enhancement of spawner production?

To date, stocking has been used primarily as a tool to enhance fisheries, with little importance given to successful spawner output. Given the present low and declining status of potential spawning stock, on a Europe-wide scale, the enhancement of spawning stocks is an overwhelmingly more pressing requirement than supporting fisheries.

7.5.1 Evidence that stocking effectively enhances stock, producing potential spawners.

There are many examples giving clear evidence that stocking enhances the yellow and silver eel stocks in a number of countries. These include many Swedish lakes, the fishery in Lough Neagh in Northern Ireland, and Estonian lakes. These cases will be described in more detail below.

7.5.1.1 Swedish lakes

In Sweden there are several examples from lakes where all or a considerable part of the eel stock originates from stocked eels, stocked at various stages from glass eel to medium-sized yellow eels. Currently, all lakes with a commercial eel fishery have eel stocks that rely on regular restocking. Contrary to the normal situation with declining eel stocks all over Europe several stocked lakes in Sweden show a positive trend in catches of eel (Wickström, 2001).

7.5.1.2 Lough Neagh, Northern Ireland.

The fishable stock of eel in Lough Neagh in Northern Ireland has been maintained over a 70 year period through transport of glass eel from the Estuary of its out-flowing river some 40Km downstream. There is also clear evidence that artificial stock enhancement increases the proportion of males in the catch (Rosell *et al.*, 2005). Following the pan-European crash in glass eel recruitment in 1983, the Lough Neagh fishery purchased very large quantities of glass eel from the Severn Estuary in England, which have maintained CPUE in the yellow eel fishery into a period where, had local supply been the sole source, CPUE would have been expected to decline (Rosell *et al.*, 2005). The heavy additional stocking bought in the period 1984 to 1989 shows clearly in maintained CPUE in the period 1999 to 2005, tallying with known growth parameters. Given the known escapement of silver eels from the Lough Neagh system (Rosell *et al.*, 2005) it is highly probably that both additional stock bought from the Severn (England) and local trap and transport derived glass eel contribute to spawners. Given the mean 18 year lag from input of glass eel to output of silvers, the current time series analyses are not yet long enough to detect strong signals from the heavy additional stocking of the 1980s in the silver eel output component, although it is believed that this will emerge as time series lengthen and statistical relationships become more significant (Allen *et al.*, in prep).

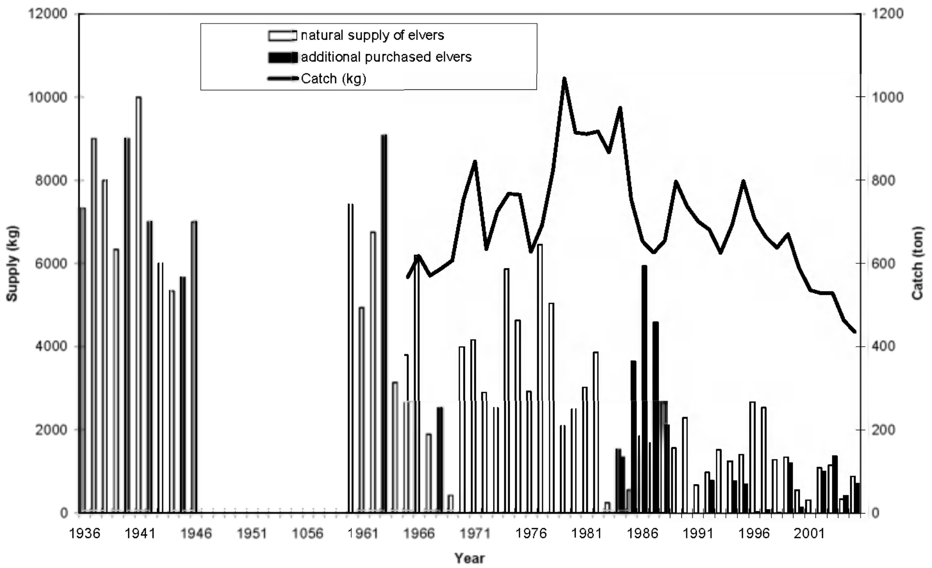


Figure 7.2. Glass eel supply and commercial (yellow + silver) eel catch in Lough Neagh, Northern Ireland, 1935 to present.

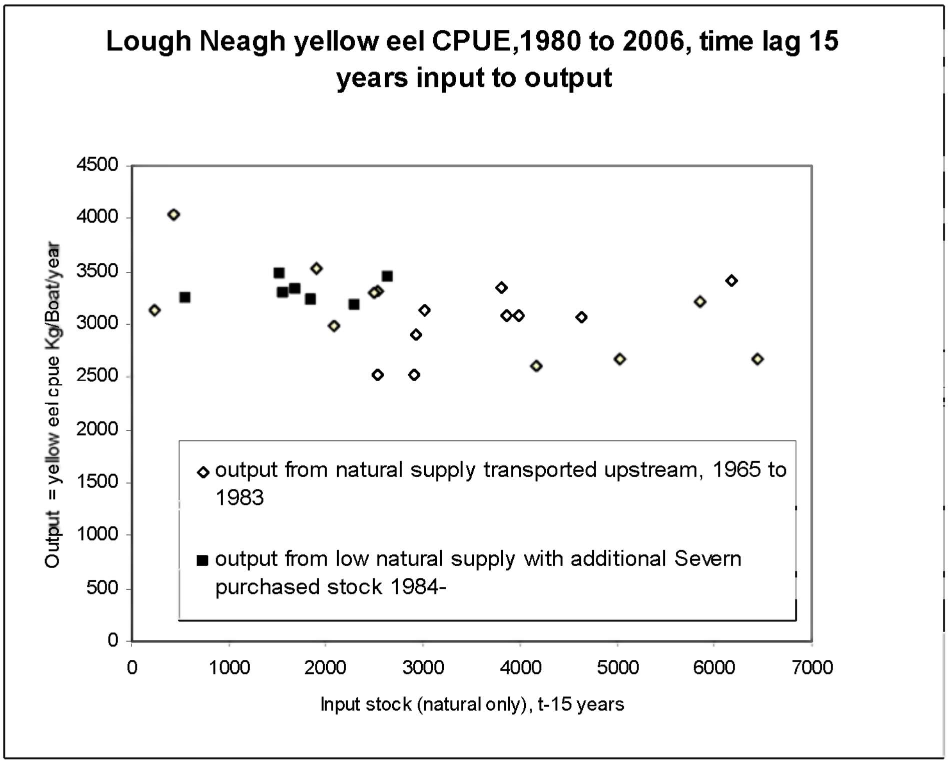


Figure 7.3. CPUE in Lough Neagh Yellow fishery maintained by stocking of glass eel transported from the river Severn fishery, England

7.5.1.3 Estonian lakes

Natural eel stocks have never been dense in Estonian large lakes. Annual catch of eel in 1939 was 3.8 tons from L. Võrtsjärv and 9.2 tons from L. Peipsi. The construction of a hydropower station in the early 1950s blocked the natural upstream migration of young eel from the Baltic Sea to the basins of these lakes. As a result, eel almost disappeared from the local fish fauna (Kangur, 1998). The current eel production of L. Võrtsjärv is entirely based on re-stocking with elvers or farmed eels (4–20 g). The average re-stocking rate with glass eels in 1956–2005 was about 33 ind. ha^{-1} with a maximum of 84 ind. ha^{-1} in 1980–1984. As a result, during the following five-eight years the catches of eel averaged 2.5 kg ha^{-1} y^{-1}.(maximum 3.7 kg ha^{-1}) (Kangur *et al.*, 2002). From 1956 to 2005, 45 million eels were stocked. The total reported catch during this period was 1340 t or 2.3 million specimens (mean weight 600 g) mostly of female silver eel. Silver eel constitute 75–80% of catch. Silver eel emigrating from Lake Võrtsjärv at the age 12–14 years, mean length 68 cm and weight 670 g. The potential output from re-stocking was one female silver eel per 20 glass eels. The proportion of males is unknown. The reported annual catch of eel was much smaller than real catch and recapture is low (5%), the real potential output to the potential spawning stock was probably much higher. Downstream migration of eel through the hydropower turbines is still problematic.

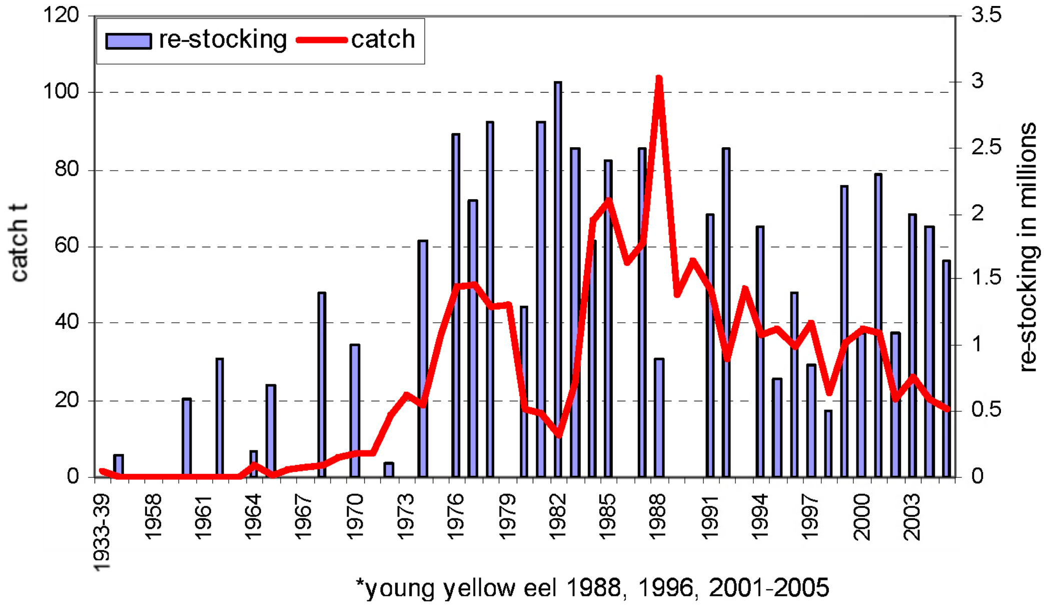


Figure 7.4. Re-stocking and catch of eel in L. Võrtsjärv. (1 young yellow eel = 5 glass eels)

7.5.2 Does successful support to fisheries mean successful spawner production?

The successful enhancement of fishable yellow eel populations through stocking does not automatically prove that the practice results in production of silver eel with full capacity to migrate to spawning grounds. However, support comes from several case studies ranging from the Mediterranean to the Baltic. The Italian Comacchio lagoons were historically stocked with glass eel captured locally and transported above barriers, resulting in major silver eel fisheries. This type of coastal lagoon fishery management targeting the emigrating silver eel was widely practiced around the Mediterranean region, in Italy (De Leo and Gatto, 2001), France (Melia *et al.*, 2006), Tunisia, Morocco, Algeria and others.

The experimental Fremur catchment, France, is an example where silver eels are trapped and counted, emigrating from artificially stocked systems in controlled conditions and lakes closed to natural immigration. Similar data exist from intensively studied Swedish lakes (Wickström *et al.*, 1996)

7.5.3 Risks in assuming successful emigration and spawning of stocked eels

7.5.3.1 Does spawner production beyond merely producing fishable yellow and silver eels ?

The case studies presented above show, that re-stocked eels will mature and silver in fresh water and emigrate as normal, at least to the adjacent sea area. Once silver eels leave controlled or restricted environments in fresh water or lagoons, there are no proven examples of re-stocked eels making successful spawning migrations in the marine environment. This is primarily attributed to the fact that migrating eels in the sea have never been tracked for anything more than a few days, even for natural silver eels. There is one example, however, where life history analysis of silver eels in Swedish coastal areas strongly suggests successful silver eel production and emigration from stocking of long distance transported yellow and glass eels (Limburg *et al.*, 2003).

There are some theoretical views and practical study results which suggest that survival to successful spawning of transported eel could be reduced or even non–existent. Westin (2003), studying the Swedish Baltic, suggests possible difficulties encountered by stocked eels when trying to find their way out of the Baltic sea.

Work in progress using the strontium-calcium ratios in eel otoliths as life-history records shows that restocked eels in general and eels from freshwater in particular contribute little to the run of silver eels leaving the Baltic Sea through the Straits between Sweden and Denmark. Preliminary results show that less than 10 and 16 % originates from freshwater and from stocked eels, respectively. Whether this is due to a strong fishing pressure along the Baltic Coast, a result of very different silver eel production from fresh-, versus brackish water or an inferior performance of stocked and/or freshwater eels is not known. Svedang and Wickström (1997) found that artificially stocked eels might migrate with low fat contents as compared with non stocked material. Such effects could clearly affect spawning migration success (EELREP, 2005)

There are inherent risks associated with the practice on stocking using on-grown eels over and above those of using glass eels. Culture situations can create conditions where diseases and parasites spread rapidly. Therefore, eels stocked after a period of culture require rigorous health checks before release to the wild. Cultured eels may also be biased in favour of males due to early onset of sexual differentiation processes. Furthermore, eels from multiple sources may become accidentally mixed in culture facilities leading to doubts as to the precise origin of the glass eels. There are cases where both Japanese eel and American eel have been placed in European farms. Re-stocking of non-native eel species has been widely practiced in Eastern Asia, and has also occurred in Europe.

7.5.3.2 The problem of how eels navigate – can stocked eels emigrate successfully?

A study is under way in Norway, which will investigate magnetic orientation mechanisms in silver eels. Westerberg (2000) conducted orientation experiments on silver eels migrating over underwater power lines, in which the eels temporarily changed orientation over active cables. The use of magnetic cues for orientation and navigation has been widely demonstrated in animals (both invertebrates and vertebrates). The underlying physiological mechanisms through which animals are able to perceive the Earth's magnetic field have not been identified, although some of their functional characteristics are known. Two types of compasses have been characterized. Inclination compasses detect the angle of the field lines with the horizon, while polarity compasses give directional information about the field. Extensive knowledge of an animal's behaviour is necessary to identify which behavioural response is due to the magnetic cue. Some animals, such as newts, use either system depending on their task

(Phillips, 1986). Navigation or homing requires that the animal (i.e. the eel) determine the correct geographic position relative to the target, as well as a compass to orient in the right direction.

It is not yet clear whether eels use the magnetic field to navigate back to their spawning grounds. One study has shown that yellow eels can sense changes in the polarity of the field as well as in the inclination (Tesch *et al.*, 1992), but there is a lack of evidence and knowledge on the possible use of the magnetic field. Magnetic particles have been found in the skull of eels, but their involvement in an orientation system has not been shown (Hanson *et al.*, 1984; Hanson and Walker, 1987). Overall and given the lack of cues in the open ocean and at great depths, it is highly probable that eels use a magnetic map to reach the Sargasso Sea. This is the case for other animals, which perform long-distance migrations (Lohmann and Lohmann, 1996). This suggests that eels might be able to evaluate their position relative to their target, and therefore could deal with a displacement (i.e. restocking). However, there is yet no evidence on a possible "navigational map sense" in eels. It appears important to carry out further experiments on this issue, as well as to identify the functional characteristics of the eel's magnetic compass.

7.5.3.3 Genetic risks

The ICES Working Group on the Application of Genetics in Fisheries and Mariculture (ICES, 2004b) reported on the possible genetic risks of transferring eels over long distances. There is a reasonably spread consensus that the European eel stock is one panmictic homogeneous stock (Dannewitz *et al.*, 2005), but there are dissenters from this view. The ICES WGAGFM concluded that application of the precautionary principle obliges to minimise transfer distances and to manage the stock to produce spawning eels naturally recruited to as wide a geographical area as possible.

7.5.3.4 Risks to donor sites – effects of low stock density

Under the current situation of critical low stock levels, removal of glass eel from any site to stock another should only be done with full assessment of the effect on recruitment into growing areas dependent on that donor site. High abundances of glass eel in estuaries, over and above local optimum capacity, may drive the subsequent upstream migration, as eels seek lower density in growing and feeding areas. There is therefore a need for assurance that such process are not impaired by removal of glass eel, whether for stocking other sites, or for sale to aquaculture.

7.5.3.5 Stock density and sex ratio

This issue of local stock density is intrinsically linked with sex ratio generation or manipulation. High natural or artificial glass eel stock levels produce high abundances of males. The Lough Neagh, Northern Ireland situation, is a classic example of this, as changing stocking practice has driven repeated switching from male to female dominance of the silver eel run over 80 years. Current sex ratio in Lough Neagh is circa 50%:50% male to female, presumably as there is now insufficient stocking to induce the high male dominance once observed. A similar situation under natural recruitment change may have been observed in the Burrishoole system, Ireland (Poole *et al.*, 1990). Cultured eels may also be biased in favour of males due to early onset of sexual differentiation processes under aquaculture conditions.

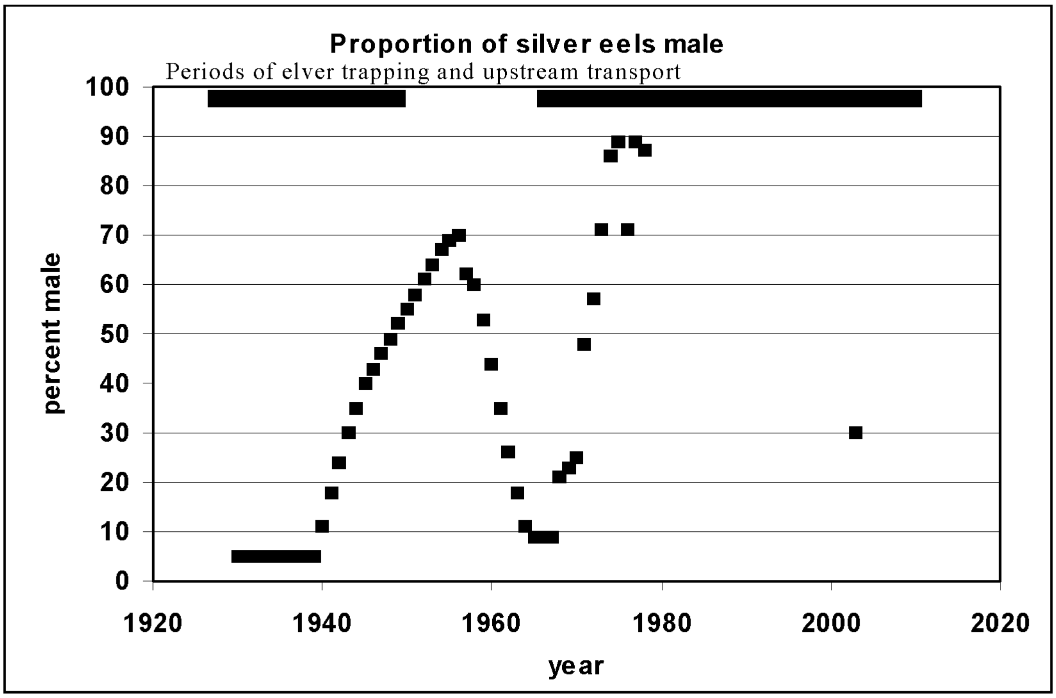


Figure 7.5. Changing sex ratio of Lough Neagh eels (Biomass) following periods of artificial upstream transport (given by black bars at the top) -from Rosell *et al.* (2005).

7.5.3.6 Risks due to competition/interaction with other species.

Eels are a key component of natural systems, as predators in their own right and as an importance food source for higher predators including fish, mammals and birds. In the case of deliberate stocking and movement of the restricted glass eel resource, the ultimate objective is clearly spawning stock maintenance and enhancement. Therefore, eels the environments and aquatic species communities into which eel are stocked need careful assessment of pre stocking conditions. Where eel is critical to system biodiversity and balance, there may be arguments for stocking to support rare or endangered eel predators. There is clearly an ethical difficulty if this results in less than optimal use of scarce glass eel stock while eel stocks themselves are in difficulty.

7.5.3.7 Risks when doing no stocking with the remaining glass eel

The main risk associated with this “do nothing option” is that, should recruitment decline further, the option of using transfer of stock, either as measure designed to have a quick effect on spawner production form highly productive waters, or as a long-term insurance policy in slow eel growth areas, will be lost as the possibility of even local surplus becomes obsolete with falling stocks.

7.6 Is there sufficient glass eel for re-stocking

7.6.1 On a European scale?

The total area of costal waters, lagoons and estuaries is estimated at 18 000 km^2, plus over 21 000 km^2 along coastal area of the Baltic Sea, suitable for eel and re-stocking of eel. The potential production, specially lagoons and brackish costal habitats are very high. Total surface area of freshwater waterbodies suitable for eel thus comprises nearly 40 000 km^2. In northern Germany, Poland and Baltic countries most of the lakes are shallow, eutrophic and re-stocking can potentially support spawning stocks. Sweden has the largest surface of freshwater habitat in Europe, with 48% of lakes and rivers suitable for eel. Due to the ineffective fish passes the proportion of open habitats in inland waters supporting emigration of silver eel are estimated less than 70% of total. In some countries (Portugal, Spain, Estonia) more than 90% of freshwaters are inaccessible for glass eel or have no free way out for silver eel to sea or ocean.

Table 7.1. Surface area (thousands km^2) of eel habitat in freshwaters (Moriarty and Dekker, 1997)

COUNTRY	EEL HABITAT (1000 KM^2)
Sweden	19
Estonia (L. Peipsi)	4
Netherland	3.4
Germany	3
Italy	2.5
Poland	2.3
Ireland	2
Great Britain	1.9
France	1.7
Spain	0.7
Denmark	0.6
Portugal	0.3
Total	41.4

ICES (2005b) estimates the required stock to adequately re-stock this area at 150 to 1000 tonnes of glass eel. The 1994 catch of glass eel was estimated at 644 tonnes (Moriarty and Dekker, 1997). By 2005 catch is estimated to have fallen to circa 100 tonnes, considerably less than would be required to stock the entire potential European eel habitat.

Given the currently available stock and its inadequacy to supply the total growing area, the option of achieving the stock restoration targets of 40% potential SSB can clearly not now be met by stocking alone. Stocking therefore represents one available measure, but to be applied in conjunction with other measures, such as fishery restrictions. Furthermore, restocking, particularly in northern waters, will have a long turn round time to eventual effect.

Despite the current inability to meet stock level targets by restocking alone, stocking could make a contribution. If the 100 tonnes of glass eel currently fished and lost to spawner production annually were solely used to re-stock productive wild and unfished waters, there could be an additional production of circa 10 000 tonnes of silver eel emigration to sea (based on the potential return rates estimated by Moriarty and Dekker (1997). Dekker (2004a) estimates current fishery catch of at 5844 tonnes and escapement at 30% of this, at 1742 tonnes. Maximising use of the glass eel supply for judicious re-stocking could potentially produce at least a potential doubling of the present output of eel. In conjunction with effective fishery controls, the potential to increase spawning stock through glass eel stocking is highly significant.

In this context, it should be noted that historically, very large quantities have bee re-stocked on a European scale, albeit mainly for fishery enhancement. The historical maximum was in excess of 120 million individuals, or circa 40 tonnes of glass eel.

7.6.2 Could there be surplus on a local scale ?

The local scale is the only scale at which there might be any “surplus” stock, which now occurs in a very limited set of special cases. Example sites probably include the Severn estuary, England, where the presence of a considerable glass eel fishery does not yet seem to have had any measurable negative impact on upstream stocks of eel in the feeder river basin (See UK country report 2006). Some of the French estuaries currently exporting glass eel are probably having a detrimental effect on the corresponding freshwater stocks of eel. This situation can occur where the fishery opportunity may be created where artificial barriers which create easy fishing and prevent upstream migration of eel. Clearly, the problem in such cases is two fold – the fishery for glass eel and the barrier – and both need improvement. After such considerations are addressed at the local scale, the possibility of a fishery for exporting glass eel to stock other basins can be revisited. The difficulty in dealing with barriers may be a reason for moving glass eel to other sites only where there is an insurmountable problem within the likely time to emigration of those eel. Perhaps the classic example of this is a lethal hydropower turbine which will not be altered before the eels, which could otherwise simply be moved upstream over it, are due to migrate as silvers.

7.7 Choosing between risks – the changing scientific advice

Scientific advice on re-stocking has changed over the years, from clearly in favour (Moriarty and Dekker, 1997), to against on precautionary grounds (ICES, 2000). In our previous report (ICES, 2005a), the risks involved were discussed, balancing potential genetic effects against the risk that the current stock might suffer from depensatory effects in the reproductive phase, for which re-stocking might be one solution. The above discussion on re-stocking elaborates on the various arguments. Clearly, arguments both pro and contra re-stocking remain valid, and no final and scientific advice can be derived. However, the previous advice was based on the potential of depensation occurring in the reproductive phase. All arguments pro and con being as they are, a more practical and nearby argument has come to the fore in this report: that seed stock areas might progressively become depleted due to a continued decline in glass eel immigration. Options for potentially successful restoration of the stock by glass eel re-stocking are fading. Re-stocking of glass eel, either in southern areas rapidly contributing to silver eel production, or in northern areas with a long postponed and long lasting contribution to silver eel production, therefore needs urgent consideration.

Of all the above considerations, the starkest is the fact that we could soon lose the restocking option simply due to the failure to demonstrate a case of even local surplus. Once local surplus becomes the over-riding consideration, there is only one potential argument which might over-ride this, and that concerns a movement of significant quantity of eel to a slow growing, northern habitat as an insurance policy (Note the discussion on depensation on the 2004 WGEEL report and in section 4 of this report). Movement of glass eel away from a site where there is no local surplus could be a final precautionary action to ensure that something is left for a future scenario where a currently un-surmountable problem (such as oceanic conditions potentially being the main cause of migration failure) will change to the benefit of eel. While there are a few cases of local surplus available, it is imperative that these are used to absolute maximum spawning stock benefit. With each report since 1999, WGEEL's view of this has strengthened, minds focussed by continuing low stock levels, still declining in some areas.

7.8 Stocking to enhance global spawner emigration

Stocking needs to be considered at two levels, firstly with regard to the European stock where it could help with the rebuilding goals and secondly at a local level where best practice needs to be adopted to maximise output of spawners.

7.8.1 European scale

On a European scale it has been concluded that there are no surplus glass eel available, however on a local scale there may be a surplus of glass eel, which can be used. This surplus arises, as a result of density-dependent mortality being higher in the absence of fishing. Consideration also needs to be given to the fact that an individual eel will do better in another habitat than in its original habitat, where stock abundance may be close to carrying capacity. For example stocking in highly productive habitats in Southern Europe, where the abundance of eel is low and the water quality is suitable. If the habitat of origin involves dams, injurious turbines etc. it might be a much faster and more cost efficient solution to transport the recruits to more suitable areas instead of solving quite complicated technical issues. However, such decisions should be based on a thorough analysis in each separate case. Contrary to earlier times the primary aim with restocking schemes should always be toward recovery of the stock, i.e. not to enhance a fishery.

Stock is limited and thus it is not possible to fully stock all available habitat to carrying capacity (ICES, 2005b). A strategic stocking plan is needed that involves those countries where eel is part of the indigenous fish fauna and thus communication is needed with those who are not a member of the EU.

The overall objective is for stocking to provide a net benefit and thus contribute positively towards the rebuilding of the stock. One key factor that needs to be considered is generation time (the time between glass eel immigration, until the silver eel stage) and how that differs across the eel's range. A latitudinal cline in generation time exists with eel maturing at a younger age in the South of the range and increasing northward (Vøllestad, 1992). This in part is related to growth rate, which increases from North to South (Table 7.2). Published annual growth rate of eel ranges from 14 to 62 $mmyr^{-1}$ and can be in excess of 100 $mmyr^{-1}$. Assuming that maturation is size dependent (Durif *et al*., 2006), the generation time for stocks from southern Europe may be a half to a third that of stocks from northern Europe. The aim of a global stock recovery can most rapidly be achieved by stocking in the southern part of the range. However, there is some evidence to suggest distinct regional subpopulations (Daemen *et al*., 2001; Wirth and Bernatchez, 2001, 2003; Maes and Volckaert, 2002), but more recently Dannewitz *et al*. (2005) described the small variation due to a temporal pattern as opposed to spatial confirming that eel are a panmictic species. The longer generation time for Northern European eel populations also acts as insurance against environmental conditions, which at present may not be favourable for eel survival (Knights, 2003).

Table 7.2. Annual growth rate (SE) of eel from various catchments within Europe

Water body (Country)	Annual growth rate $mmyr^{-1}$	Reference
Burrishole (Ireland)	13.8 (0.5) – 14.1 (0.3) Male 14.3 (2.2) - 14.8 (0.2) Female	Poole and Reynolds (1996b)
Burrishole (Ireland)	14.0 (0.3) - 20.8 (0.4)	Poole and Reynolds (1996a)
Severn (England)	16.4 – 27.9	Aprahamian (2000)
Cavan lakes (Ireland)	18.9 – 40.5	Moriarty (1973)
Ballynahinch (Ireland)	19.0	Moriarty (1988)
Koge-Lellinge ∆(Denmark)	23.1	Rasmussen and Therkildsen (1979)
Giber X (Denmark)	24.5 (1.3)	Bisgaard and Pedersen (1991)
Various waters (Europe)	30.0 – 60.0	Berg (1990)
Barrow (Ireland)	33.0 (0.8)	Moriarty (1983)
Thames (England)	33.8 (1.4) – 66.2 (2.5)	Naismith and Knights (1990b, 1993)
Quadalquivir (Spain)	37.0 – 152.0	Fernandez-Delgado *et al.* (1989)
Jezioral Lake (Poland)	40.7 (0.9)	Nagiec and Bahnsawy (1990)
Rhine (Germany)	55.0	Meunier (1994)
Aveiro Lagoon (Portugal)	54.6	Gordo and Jorge (1991)
Isma (Norway)	62.0	Vollestad and Jonsson (1986)

7.8.2 At a local level

Given the fact that surplus of glass eels is available today only at a local scale, in relation to receiving habitat conditions (high mortalities of glass eels related to pollution, turbines, etc) and to density-dependent effects on local stocks, restocking at the local level assumes a fundamental importance as local measures that contribute to the stock recovery at a global level. Therefore they must be carried out in the best possible way, to reduce losses to the minimum and to achieve their full potential in terms of contribution to spawner production and in the end to overall escapement.

Therefore, it seems important to draft a general set of rules, a "best practice" manual specially focused to glass eel restocking in coastal waters and inland waters bodies.

In order to apply those guidelines, attention must be given to the fact that most existing information is related to closed water bodies, lakes and lagoons, mainly because yellow eels and emigrant silver eels in lakes can be more efficiently exploited. In rivers, eels tend to migrate throughout the catchment and are difficult to recapture on a commercial scale as such very few attempts have been made to study and monitor stocking into rivers or open coastal waters. Lakes in North-Eastern and central Europe suffer naturally low recruitment and have been more intensively studied. Most studies tend to refer to the pre-1980s situation, before stocking was discouraged by concerns about disease introductions and by rising seed stock costs.

Eight main steps can be recognised in the process of developing a stocking programme :

1) Assessment of the eel local stock status
2) Evaluation of habitat
3) Evaluation of the system carrying capacity
4) Evaluation of risks, considering all levels (from local to global)
5) Development of a stocking strategy.
6) Evaluation of the stocking programme.
7) Consideration of alternatives to stocking or 'do nothing'.
8) Implementation of the stocking programme and evaluation of results.

In every case, points to be considered are:

a) balance between the viability of a fishery and enhancing the spawning stock;
b) the value of stocking to waters where barriers to upstream and downstream migration exist;
c) the effects on resident species, as eels occupy a significant position in the aquatic ecosystem, both as predator and prey species;
d) a need to meet conservation requirements and promote biodiversity
e) the cost benefit, in terms of returns to a fishery as well as to the spawning stock.

The following will elaborate the above points.

7.8.2.1 Assess Stock Status

Before proceeding with the development of a stocking plan, the current status of the eel population in a water body needs to be assessed. Any perceived loss or reduction in stock levels should be quantified to establish the nature of the population structure, enable the carrying capacity of the water to be assessed and if there is a need for stocking.

Assessment of an eel population in a lake or river or lagoon requires an eel-specific surveying approach. Multi-species surveys underestimate the number of eels in a water body (ICES, 2003). This is because the gear may be inappropriate for example the use of gill nets in lakes or that eel are not the target species. However, an initial species-specific survey followed by a multi-species survey will allow for the degree of underestimation to be calculated. Routine monitoring could then possibly be carried out via multi-species surveys.

The use of density/biomass in combination allows for a clearer understanding of the nature of the eel population structure i.e. if the population is composed of a small number of large females or a high density of smaller males (Table 2).

Table 7.3. Density and Biomass classification (Knights *et al.*, 2001).

Biomass Class (g 100m^{-2})	Density Class (eels 100m^{-2})
A- ≥570	a- ≥20
B- 280	b- 10
C- 140	c- 2
D- 70	d- 1
E- >0	e- >0
F- Absent	f- Absent

7.8.2.2 Habitat survey.

The potential productivity of a water body should ideally be high to ensure optimum survival and growth rates. Productivity is expected to be highest in alkaline-neutral, meso-eutrophic waters with a high diversity of marginal vegetation, and hence niche and prey diversity. Benthic macroinvertebrates are generally preferred prey (Tesch, 1999; Deelder, 1984).

There is little quantitative data on the physical habitat requirements of eel, it can be concluded that eel appear very catholic in their choice of habitat. Suitable habitat for stocking eel would be every typology of water body (salt, brackish or fresh waters) where natural recruitment has reduced, upstream of major obstructions to their migration and in the middle and upper reaches of catchments where the eel density is low and likely to be less than the carrying capacity of the habitat. The sites should have a dissolved oxygen concentration greater than 5 mgl^{-1} and a pH in excess of 5 (ICES, 2003). The sites should also have a high degree of physical heterogeneity providing a high amount of cover and a diverse food supply. Sites with soft sediment, crevices and vegetation allowing the eel to burrow and hide are preferable (Knights *et al.*, 2001). The trophic status of the site is important, but this mainly affects the density of eel that can be stocked at a given site. Success of stocking is related to spawner production as well as to spawner quality (See Section 3). Thus consideration needs to be given to habitat quality evaluation with regard to pollution with PCBs, flame retardants, heavy metals and parasites. Priority should be given to those sites where such contaminates are absent or at a low level. A summary of habitat related issues that should be considered in an assessment of habitat are presented in table 7.4.

Table 7.4. Summary of habitat-related issues applicable to eels (Knights *et al*, 2001).

1. Acute pollution impacts • Gross localised pollution • Accidental discharges 2. Chronic pollution impacts • Over-enrichment (low dissolved oxygen, high ammonia) • Bioaccumulation/magnification • Acidification 3. Flood control and water level management • Tidal barrages • Tidal flaps, doors and sluices • Weirs and sluices • Pump drainage • Water transfers • River regulation 4. Habitat loss and Degradation • Land drainage	5. General habitat quality • Canalisation • Culverting • Siltation • Concretion • Loss of/change in in-river vegetation 6. Low flows • Droughts and over-abstraction 7. Water abstraction • Entrapment losses • Losses to pumps, hydroelectric dams, etc. 8. Biological factors • Infestation of eels by *Anguillicola crassus* 9. Long-term climate change • Increases in average temperatures and changes in rainfall pattern

7.8.2.3 Is the system at carrying capacity?

The suitability of any water body for stocking depends upon several factors particularly its natural productivity and the resulting carrying capacity. Carrying capacities are not easy to predict and the potential effects of density on sex ratios may also be a consideration (see below).

There is very little information on carrying capacity. However, in the UK and in Brittany (Northern France) the carrying capacity for small streams is in the region of 25 g m^{-2} (Aprahamian, 2000). In the southern part of their range the carrying capacity is likely to be higher temperatures and productivity resulting in a shorter generation time, even if extremely variable among sites. No recent evaluations are available, but given the potential for spawner production of those environments, the enhancement of evaluation studies on this aspect seems recommendable. Greater importance should be given to biomass when trying to assess whether a site is or is not at carrying capacity. This is because there is a smaller variation in biomass when compared to density both within and among river systems (Aprahamian, 1986) and it is more related to carrying capacity (Knights *et al*., 2001).

7.8.2.4 Evaluate risks

To any particular problem there will be a number of solutions; each will be associated with its own risks. For each potential solution there will be a need to identify the biological and social consequences. Ideally the solution to the particular management problem should aim to achieve best environmental practice.

Possible sources of risk can be viewed at two levels, firstly in relation to the European stock and these relate to genetic issues and successful homing and secondly the impact at a local level specifically the impact on other species and the possibility of environmental damage. There is also a risk that the stocking may not be successful and not produce a net benefit to the spawning stock or fishery. In the past this may have been viewed as a monetary loss but today with the eel population being below safe biological limits the loss in terms of recruits to the European stock.

In order to ensure that the risk is minimised it is imperative that any scheme is adequately assessed. The major concern, other than the possible impact on other species and/or on the fish community structure as a whole, and the transfer of disease / parasites is that the stocking may not be successful. The impact on other fish species as well as any genetic or environmental impacts is considered minimal.

7.8.2.5 Genetic issues

Dannewitz *et al.* (2005) concluded that eel are a panmictic species and thus the risk to the population is low.

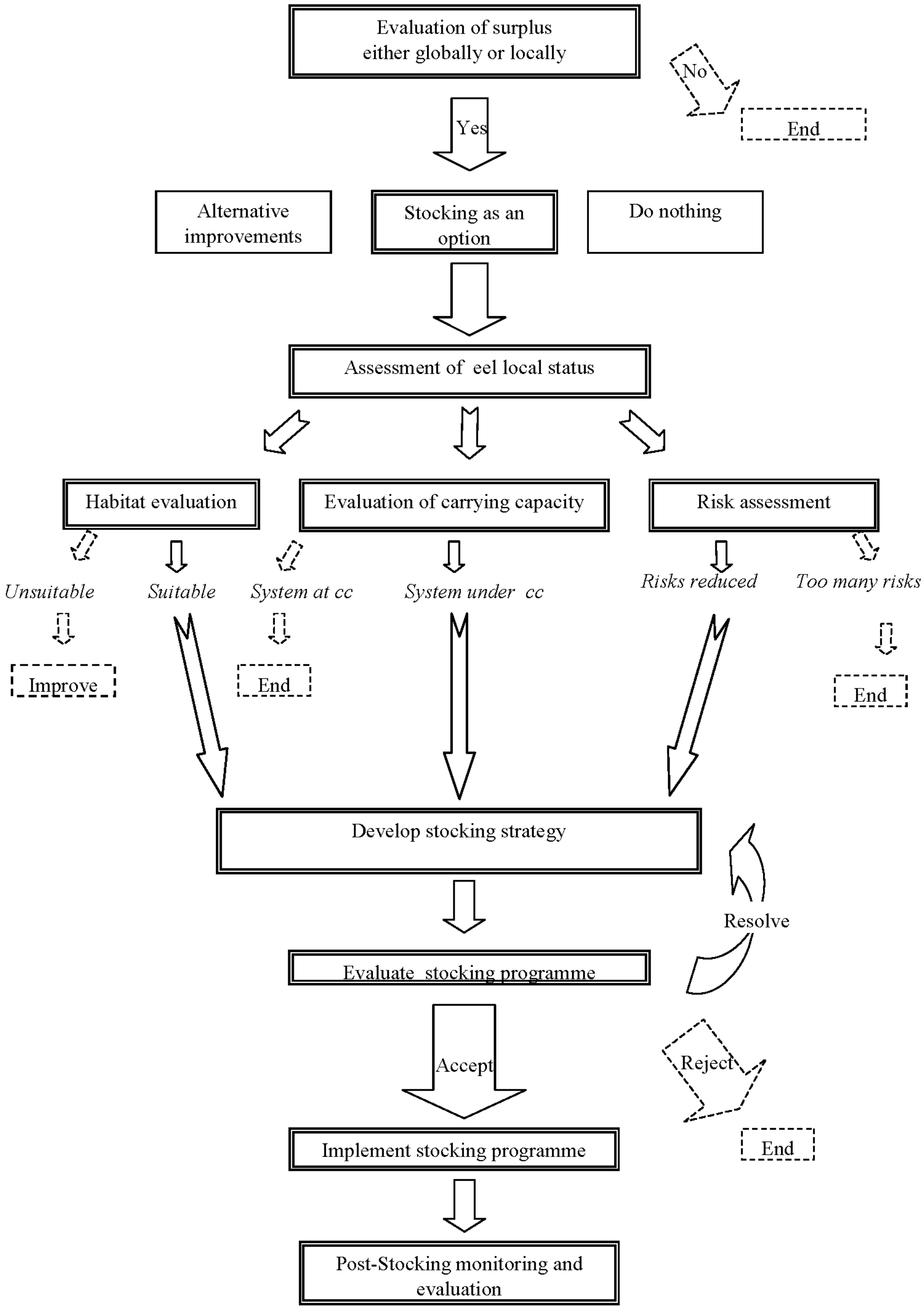


Figure 7.6. Stocking strategy – overview of decision process. The inner box ("Develop stocking strategy") is further detailed in Figure 7.7.

7.8.2.6 Species interactions

Concerns have been expressed about possible competition with resident fish and other species, predation by eels on eggs or fry, and losses of other fish as bycatch. Though with the exception of crayfish, *Astacus astacus* and possibly also *Pacifastacus leniusculus* where there may be a negative impact especially if the density of eel is high the impact on fisheries can be considered minimal and not a major problem (Moriarty, 1990b; Naismith and Knights, 1994).

7.8.2.7 Developing a stocking strategy.

Appropriate implementation strategies are essential if a stocking programme is to be successful. The issues that must be considered include: source of fish, health of the batch, handling and transportation of fish to stocking site, stocking densities, age or size of seed, timing of stocking and mechanisms of release (see Figure 7.7). All of these aspects must be taken into account at the planning stage of the stocking exercise to maximise the benefits and minimise any potential risks (Cowx, 1998).

Again, prior to developing a stocking strategy it is essential that the carrying capacity of the water body has been evaluated and that the status of the existing eel population has been identified.

First choice should be within-catchment seed, the most cost effective way of obtaining stock is likely through trapping the upstream migrants, alternatively stock can be purchased from a commercial supplier. The glass eel stage, mainly because of its availability is the easiest life stage to stock.

There is limited information on optimum stocking density. It is suggested for warmer and more productive lakes, stocking at about 300 glass eel ha^{-1} and for colder and less productive lakes, stocking rates should be reduced to 100–200 eels ha^{-1} (Moriarty *et al.*, 1990; Wickström, 2001). In rivers stocking densities should be between 1 and 2 eels m^{-2} in low productivity waters, rising to 4–5 eels m^{-2} in warmer or higher productive waters with plenty of bottom cover and/or marginal vegetation and high macro-invertebrate productivity (Knights and White, 1997). The eels should be scattered stocked into suitable habitat to reduce intra-specific competition, at the most appropriate time as related to water temperatures and food availability and not during periods of high flow when small eels can be washed downstream. Consideration also needs to be given to the frequency of the stocking whether the best returns are derived from annual stocking or whether a less frequent stocking regime would produce a greater output.

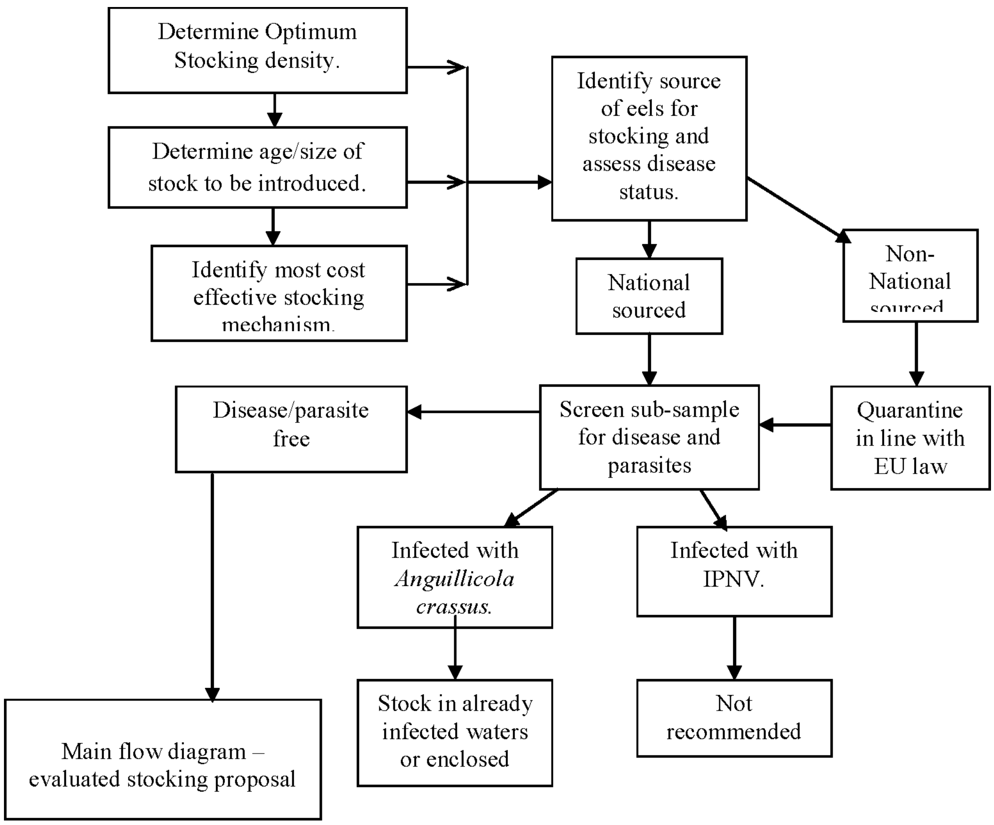


Figure 7.7. Development of a stocking strategy. This diagram is an elaboration of the inner box of Figure 7.6.

7.8.2.8 Evaluate stocking programme.

This juncture in the pre-stocking process is aimed at drawing together all the previous stages undertaken before commencing stocking. It is at this point that the 'whole' picture is reviewed and a final decision made about the entire stocking programme. Any omissions/contradictions/concerns should be identified and resolved. Ultimately the entire stocking programme may be robust but lack of financial backing, opposition by water body owners, lack of supply of seed stock and other factors may result in the programme not being implemented.

7.8.2.9 Considering alternatives to stocking or 'do nothing'.

When stocking is not advised the first step is to return to the management objectives and see if they are still applicable or appropriate to the eel stock situation. Stocking is one tool of many that can be used to manage eels stocks others include removing barriers to migration, reducing or eliminating fishing pressure, restoring and/or enhancing the habitat as well as "do nothing" all of which should have gone through their own risk assessment at the early planning stage.

7.8.2.10 Implement stocking programme and evaluate results.

If the stocking programme is feasible and the risks acceptable then the next stage is to implement the programme. A post-stocking monitoring programme needs to be undertaken to evaluate the success of the programme and if necessary allow amendment of the stocking practices to maximise the chances of achieving the initial objectives of the programme.

7.8.3 Conclusions on stocking strategy

There are several key points that have been identified following the review of stocking practices/methods and include:

- Any stocking programme requires long-term investment and commitment.
- A pre-stocking assessment of the receiving water body must be carried out
- Glass eels/elvers used to stock intra-catchment is the first choice of stock source. Transfer of stock from outside the catchment will require health checks and possibly a period of holding before stocking and as a result increase costs.
- Stocking upstream of barriers to downstream migration is an option for most forms of barrier with the possible exception of hydroelectric dams. If stocking is to be undertaken upstream of hydroelectric stations then by-pass facilities need to be available or arrangements need to be in place to ensure safe out-migration of spawners. Eel passes would need to be constructed, even if stocking was for commercial reasons, to allow for a minimum spawner escapement.
- Post-stocking monitoring is essential and a statistically robust programme should be developed.
- More detailed and long-term research is needed on optimum stocking rates especially in river catchments.

7.9 Conclusions and recommendations on restocking of glass eel as a measure to aid stock recovery

It is concluded that there is no surplus of glass eel on a Europe wide basis. In localised areas there may still be surplus of glass eel over and above the needs of the immediate river basin district. These local surpluses may not persist much longer.

There is enough evidence to suggest that stocking, used judiciously, has a high probability of net benefit in terms of spawner production.

1) There is an urgent need for guidelines giving best practice for restocking programmes.
2) While there is still time and available seed material, a number of restocking programmes should be commenced, in two scenarios:
    - As a concerted short term measure which should produce a quick return in terms of increased spawner output from currently under-stocked but highly productive habitats. This will effectively serve as a pilot programme for
    - Stocking as an insurance policy in some slow growth areas to maintain long term output of spawners.
3) Post-evaluation monitoring is essential for all stocking programmes. Statistically robust programmes should be developed for this purpose.
4) Support programmes are required for ecological assessment of habitat potential for spawner production using restocking in relation to:
    - Quantitative assessment of potential output, and
    - Assessment aimed at identifying sites particularly suited for production of high quality spawning eel.

These programmes will assist in the improvement of guidelines as required at 1 above.

5) While there is insufficient stock available to reach the current Europe wide population biomass targets, effective use of the potential 100 tonnes or more of glass eel currently fished without benefit to spawner output could go a long way to restoring the most depleted local stocks.

Summary, Prospects and Main Recommendations

The Summary, Prospects and Main Recommendations have been included at the very beginning of this report. The usual placement at the end of the main report, preceding voluminous Annexes, would have made them difficult to find.

The 2006 session of the EIFAC/ICES Working Group recommends that the planned Galathea 3 expedition releases a container of pheromone treated rubber dummy eels into the Sargasso Sea, in order to restore the social spawning behaviour, driving the depensatory stock-recruitment relation of this species.

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Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Jan Andersson	Swedish Board of Fisheries Institute of Coastal Research Ävrö 16 SE-572 95 Figeholm Sweden	Tel: +46 491 762841 Fax: +46 491 762845	jan.andersson@fiskeriverket.se
Miran Aprahamian	Environment Agency, NW Region Richard Fairclough House, Knutsford Road, Warrington WA4 1HG United Kingdom	Tel: +441925 653999 Fax: +441925 415 961	miran.aprahamian@environment-agency.gov.uk
Mårten Åström	Swedish Board of Fisheries Institute of Freshwater Research Sötvattenslaboratoriet, SE-178 93 Drottningholm Sweden	Tel: +46 8 6990610 Fax: +46 8 699 06 50	marten.astrom@fiskeriverket.se
Laurent Beaulaton	Inland Living Aquatic Resources Research Unit Cemagref, Agricultural and Environmental Engineering Research Institute 50, av. de Verdun Gazinet 33612 Cestas cedex France	Tel: +33 5 57 890 803 Fax: +33 5 57 890 801	laurent.beaulaton@bordeaux.cemagref.fr
Claude Belpaire	Research Institute for Nature and Forestry Vestiging Groenendaal Duboislaan 14 B-1560 Groenendaal-Hoeilaart Belgium	Tel: +32 2 658 04 11 Fax: +32 2 657 96 82	claude.belpaire@inbo.be
Daniele Bevacqua	Dipartimento di Scienze Ambientali Università degli Studi di Parma Area Parco delle Scienze. 43100 Parma. Italy	Tel: +39 0521905619	daniele.bevacqua@poste.it
Janis Birzaks	Latvian Fish Resources Agency Daugavgrivas 8 LV-104 Riga Latvia	Tel: +371 7612536 Fax. +371 7616946	Janis.Birzaks@latzra.lv

Gerard Castelnaud	Inland Living Aquatic Resources Research Unit Cemagref, Agricultural and Environmental Engineering Research Institute 50, av. de Verdun Gazinet 33612 Cestas cedex France	Tel: +33 5 57 890 803 Fax: +33 5 57 890 801	gerard.castelnaud@cemagref.fr
Thomas Changeux	Conseil Supérieur de la Pêche Immeuble "Le Péricentre" 16, avenue Louison Bobet 94132 Fontenay-sous-Bois France	Tel: +33 1 45 14 36 05 Fax: +33 1 45 14 36 60	thomas.changeux@csp.ecologie.gouv.fr
Eleonora Ciccotti	Dipartimento di Biologia Laboratorio di Ecologia Sperimentale e Acquacoltura Università di Roma "Tor Vergata" Via della Ricerca Scientifica 00133 Rome Italy	Tel: +39 (0)6 7259 5969 Fax: +39 (0)6 7259 5965	ciccotti@uniroma2.it
Willem Dekker (Chair)	Netherlands Institute for Fisheries Research RIVO P.O. Box 68, 1970 AB IJmuiden The Netherlands	Tel: +31 255 564 712 Fax: +31 255 564 644	willem.dekker@wur.nl
Estibaliz Diaz	AZTI - Tecnalia / Itsas Ikerketa Saila Txatxarramendi Ugartea z/g 48395 Sukarrieta (Bizkaia) Spain	Tel: +34 94 6029400 Fax: +34 94 6870006	ediaz@suk.azti.es
Caroline Durif	CEES, University of Oslo/Institute of Marine Research Work address: IMR 5392 Storebø Norway	Tel: +47 56 18 22 50 Fax:+47 56 18 22 22	Caroline.durif@imr.no
Wim van Eijk	Dutch Fish Product Board PO Box 72 2280 AB RIJSWIJK The Netherlands	Tel: +31 70 3369607 Fax: +31 70 3999426	Weijk@pvis.nl
Reinhold Hanel	Leibniz Institute of Marine Sciences Düsternbrooker Weg 20 24105 Kiel Germany	Tel: +49 431 600 4556 Fax: +49 431 600 4553	rhanel@ifm-geomar.de

Detlev Ingendahl	Inland Agency on Ecology, Land and Forestry of Northrhine-Westfalen Heinsbergerstr. 53 57399 Kirchhundem Germany	Tel. +49 2723 77940 Fax: +49 2723 77977	detlev.ingendahl@loebf.nrw.de
Ain Järvalt	Institute of Agriculture and Environment Estonian University of Life Sciences Centre for Limnology Rannu, 61101 Tartu County Estonia	Tel: +372 7 454544 Fax: +372 7 454546	ain.jarvalt@emu.ee
Giulio De Leo	Dipartimento di Scienze Ambientali Università degli Studi di Parma Area Parco delle Scienze. 43100 Parma. Italy	Tel. +39 0521905619 Fax. +39 0521905402	giulio.deleo@unipr.it
Gerd Marmulla	Inland water Resources and Aquaculture Service Fishery Resources Division, Fisheries Department FAO Viale delle Terme di Caracalla 00100 Rome Italy	Tel: +39 0657052944 Fax: +39 0657053020	Gerd.Marmulla@fao.org
Kieran McCarthy	Department of Zoology, National University of Ireland, Galway, University Road, Galway, Ireland	Tel: +353 91 492333 Fax: +353 91 750526	tk.mccarthy@nuigalway.ie
Tomasz Nermer	Department of Fishery Resources, Sea Fisheries Institute ul. Kollataja 1 81-332 Gdynia, Poland	Tel. +48 58 7356211 Fax: +48 58 7356110	nermer@mir.gdynia.pl
Arjan Palstra	Integrative Zoology Institute of Biology Leiden Leiden University PO Box 9511 Kaiserstraat 63 2300 RA Leiden The Netherlands	Tel: (+31) 71 5274955, Fax: (+31) 71 5274900	Palstra@rulsfb.leidenuniv.nl
Mike Pawson	Centre for Environment, Fisheries and Auaculture Science Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom	Tel: +441502523346 Fax: +442502513865	Mike.pawson@cefas.co.uk

Michael Ingemann Pedersen	Danmarks Fiskeriundersøgelser Afdeling for Ferskvandsfiskeri Vejlsovej 39 DK-8600 Silkeborg Denmark	Tel: +45 89 213128 Fax: +45 89 213150	mip@dfu.min.dk
Wojciech Pelczarski	Department of Fishery Resources, Sea Fisheries Institute Kollataja 1, 81-332 Gdynia Poland	Tel: +48 58 7356219 Fax: +48 58 7356110	wpelczar@mir.gdynia.pl
Russell Poole	Aquaculture & Catchment Management Services Marine Institute Newport, Co. Mayo Ireland	Tel: +353 98 42300 Fax: +353 98 42340	russell.poole@marine.ie
Patrick Prouzet	IFREMER LRH Aquitaine Technopole IZARBEL 64210 Bidart France	Tel: 05.59.41.53.98 Fax 05.59.41.53.59	Patrick.prouzet@ifremer.fr
Robert Rosell	Department of Agriculture for Northern Ireland Agricultural and Environmental Sciences Division Newforge Lane Belfast BT9 5PX United Kingdom	Tel: +44 2890 255506 Fax: +44 2890 255004	robert.rosell@dardni.gov.uk
Alan Walker	Centre for Environment, Fisheries and Aquaculture Science Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom	Tel: +441502523541 Fax: +442502513865	a.m.walker@cefas.co.uk
Håkan Westerberg	Swedish Board of Fisheries Box 423 SE 401 26 Gothenburg Sweden	Tel +4631 7430333 Fax +4631 7430444	Hakan.westerberg@fiskeriverket.se
Klaus Wysujack	Federal Research Centre for Fisheries Institute for Fisheries Ecology Wulfsdorfer Weg 204 22926 Ahrensburg Germany	Tel: +49-4102-51128 Fax: +49-4102-898207	klaus.wysujack@ifo.bfa-fisch.de

Annex 2: Working Document

Speed of recovery of the European eel – an attempt to formalise the analysis

Mårten Åström[1] and Willem Dekker[2]

[1]Institute of Freshwater Research, Swedish Board of Fisheries, SE-178 93 Drottningholm, Sweden, marten.astrom@fiskeriverket.se

[2]Netherlands Institute for Fisheries Research RIVO, P.O. Box 68, 1970 AB IJmuiden, The Netherlands, willem.dekker@wur.nl

Introduction

In fishery management one generally assumes that the fish populations in consideration show some kind of non-linear stock-recruitment relationship as illustrated by the solid line in Figure 1. The non-linearity is due to some kind of density dependency in the recruitment process from spawners to young recruits. To complete the life cycle some assumptions are needed on how recruit biomass or density (R) relate to subsequent spawner biomass or density (SSB). In Figure 1 this relation is for simplicity assumed to be linear, and three different levels of mortality rate are illustrated, where higher slope means higher (fishery) mortality rate.

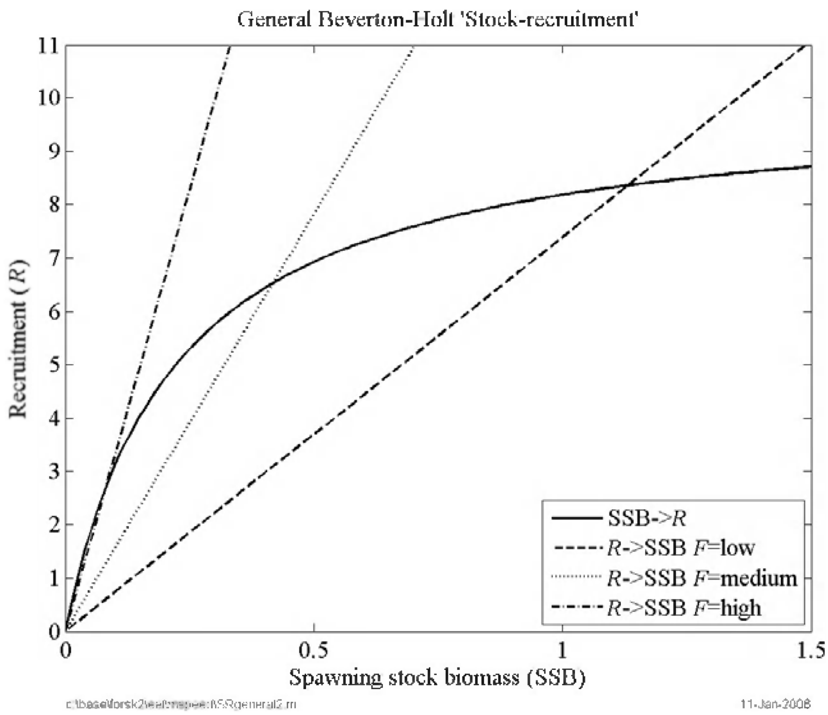

Figure 1. General stock-recruitment relation of the Beverton-Holt type (solid curve), describing how spawning stock biomass (or density) (SSB) relate to recruit production (*R*). The dashed, dotted and dot-dashed lines describe assumed linear relations between recruit biomass (or density) and spawning stock biomass (or density), where higher slope implies higher fishing mortality rate. The intersections between the two types of curves determine equilibrium biomasses (densities).

The two types of curves in Figure 1 can be combined into one single curve for each mortality rate level (Figure 2), showing the recruitment at a particular time ($t + T$) as a function of the recruitment one generation earlier (at time t), where T denote the time it takes to fulfil one generation cycle. Now the equilibrium points are illustrated by the intersections with a 1:1

line. These two graphs do just represent two ways of illustrating the same stock-recruitment recruitment-stock relations. A similar plot might be constructed using the spawning stock biomass on both axes, with the only difference in the scales on the axes. In the mathematical analyses below a simplified recruitment-recruitment relation is used.

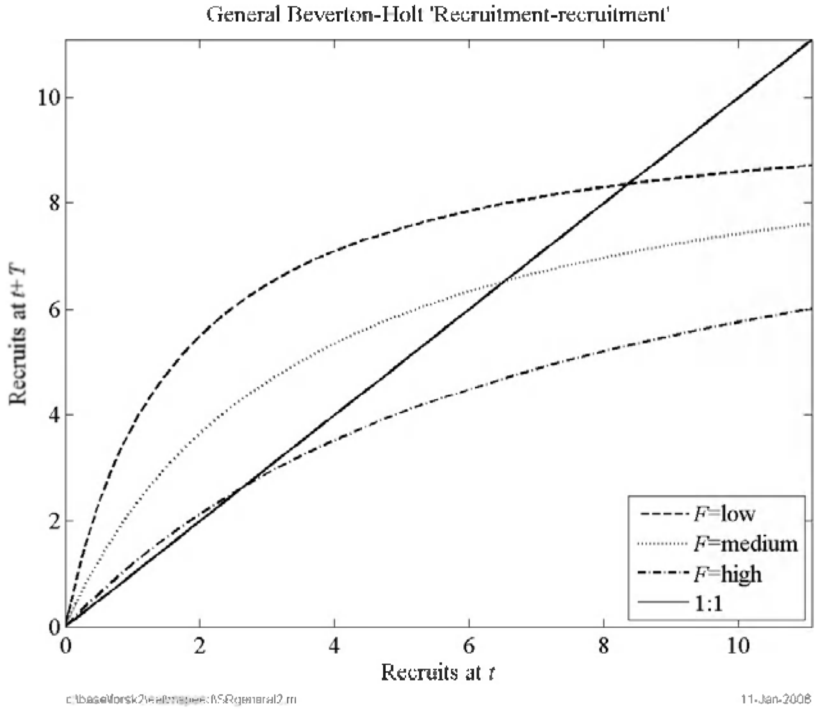

Figure 2. The resulting recruitment-recruitment relation when combining the two types of curves shown in Figure 1. To be able to illustrate the equilibrium biomasses (densities) a 1:1 line (45°) is also depicted (solid line), whose intersections with the curves determine the equilibrium biomasses (densities).

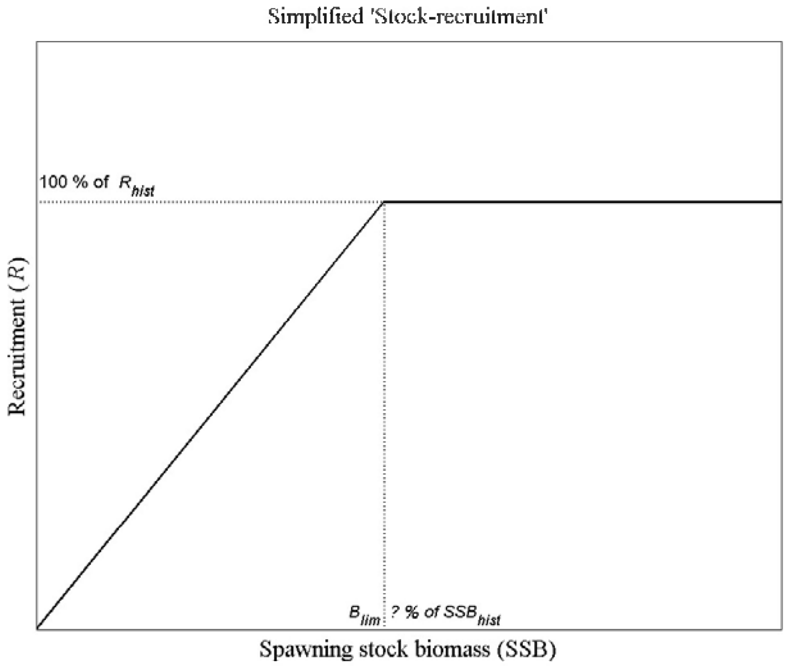

Figure 3. Linearized segmented version of a simple stock-recruitment relation. The solid lines only depict how spawning stock biomass (or density) (SSB) relate to recruit production (*R*). The level of full historic recruitment is indicated as 100% of R_{hist} and the corresponding spawning stock is indicated as B_{lim}.

In the context of fishery management one can almost never expect to have precise enough data to construct a proper non-linear stock-recruitment or recruitment-recruitment curve. Therefore one is generally confined to a simplified version consisting of two linear segments as the one shown in Figure 3 (ICES, 2003). A very general goal in fishery management is to achieve a fishery regime where the spawning stock is large enough so that recruitment is not impaired. In Figure 3 this is represented by the breakpoint between the two linear segments, i.e. where the recruitment is at 100% of its historic level. The spawning stock at this breakpoint is usually taken as the limit biomass, B_{lim}, i.e. the spawning stock biomass that we have to assure is never reached because it is on the limit to disaster. In order to minimize the risk of ending up at B_{lim} a precautionary target biomass B_{pa} is assigned. How much larger than B_{lim} this target reference point (B_{pa}) need to be is dependent on how large the uncertainty of the estimates are.

To be able to express the limit reference point (B_{lim}) in terms of percentage of the historic spawning stock one has also to know how the mortality rates during the life stages between the recruitment and the subsequent spawning relate to the shown stock-recruitment relation. In order words, one has to add the relations between recruit biomass (or density) and the subsequent spawning stock biomass (or density).

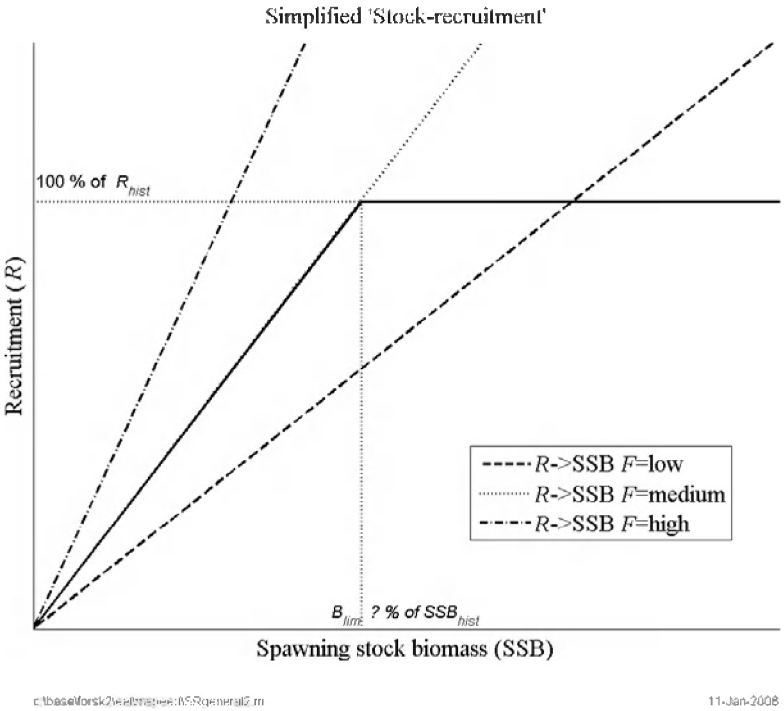

Figure 4. Linearized segmented version of a simple stock-recruitment relation (solid lines) complemented with relations between recruit biomass (or density) and spawning stock biomass (or density) (dashed, dotted and dot-dashed lines). Note that the first part of the dotted line for medium mortality rate coincides with the sloped part of the solid line for the stock-recruitment relation. The level of full historic recruitment is indicated as 100% of R_{hist} and the corresponding spawning stock is indicated as B_{lim}.

If we assume that the dashed line in Figure 4 illustrates a situation with only natural mortality (F = 0), the intersection between this dashed line and the solid line indicates the historic equilibrium, and subsequently B_{lim} and B_{pa} could be expressed in terms of the historic spawning stock biomass (SSB_{hist}) indicated at this equilibrium.

In connection to Figure 4 it should be noted that limit and precautionary reference points with regard to fishery mortality rate can also be defined. The definition of the limit fishery mortality rate reference point (F_{lim}) is the F that drives the spawning stock biomass to B_{lim}, and likewise the precautionary fishery mortality rate is the one driving the spawning stock to B_{pa}. In the following we focus on calculations on how full recruitment of the European eel could be achieved by fishery restrictions, and how long time such full recovery could be anticipated to take. Implicitly we thus only calculate F_{lim}, i.e. how to achieve B_{lim}, and not F_{pa} or B_{pa}, noting that the latter fishery mortality and spawner levels will eventually be needed to safeguard the eel for the future.

General model

Expressing stock-recruitment in the standard way in discrete time, but only in terms of number or biomass of glass eel recruits (cf. Figure 2) we get

$$R_{t+\tau+\tau_{oc}} = R_t e^{(-F\tau_{ex}-M\tau)} g\left(R_t e^{(-F\tau_{ex}-M\tau)}\right). \quad (1)$$

The expression $R_t e^{(-F\tau_{ex}-M\tau)}$ is equal to the spawning stock number or biomass, g is some function expressing the per spawner production of recruits, τ is the time span of the continental stages of the eel, τ_{ex} is the time span of the exploited stages which is a part of the continental stage (i.e. $\tau_{ex} \leq \tau$), τ_{oc} is the time span of the oceanic phase from that the spawners leave the coast until of the new born eels arrive back, M is instantaneous natural mortality rate and F is instantaneous mortality rate due to fishery. Both mortality rates are here expressed in units of per year (i.e. $year^{-1}$). In some situations it can be useful to interpret the natural mortality rate as the result of all mortality rates other than the mortality rate due to the fishery, but this is not further used in the following analyses.

Depending on the precise form of the function g this general stock-recruitment formulation could take, e.g. the classic forms of the Beverton-Holt or the Ricker formulations when recruitment is plotted as a function of the spawning stock (cf. Figure 1). In the following analyses we are only interested in the first part of this curve, i.e. the part where both spawning stock and recruitment are increasing, until the point where the recruitment levels off even if the spawning stock is further increased. As mentioned previously one is in fishery management generally trying to achieve a situation where the spawning stock is large enough so that recruitment is not affected. That is, one want the spawning stock to be so large that recruitment in practice is at, or very close to, its maximum. In the following we will designate such a maximum recruitment level as R_{hist}, denoting historical recruitment unaffected by humans.

At low densities, as is presently the case for the European eel, we can assume that the function g, the per spawner recruit production, is a constant b, equivalent to the expected maximum of the function g, thus giving

$$R_{t+\tau+\tau_{oc}} = R_t e^{(-F\tau_{ex}-M\tau)} b \, . \qquad (2)$$

This model corresponds to the first linear sloped part of Figure 3 and Figure 4 and is the base for all subsequent analyses presented here.

Primary effects of fishery restrictions on future recruitment

If all fishery is closed at the time t, and the fishery previously included the last stage before spawning, there will at the time $t + \tau_{oc}$ first be a gradual increase of the recruitment (cf. Åström 2005) and after a time period of $\tau_{oc} + t_{full} -1$ years (corresponding to the time of the oceanic stage (τ_{oc}), plus the time it takes for the eels to grow from the youngest exploited stage to spawner escapement (t_{full}), minus one year since the first year of increase is also the year $t + \tau_{oc}$), the recruitment can be expected to have increased by a factor of

$$k_{t+\tau_{oc}+t_{full}-1} = \frac{R_{t+t_{full}-1-\tau} e^{(-M\tau)} b}{R_{t+t_{full}-\tau} e^{(-F\tau_{ex}-M\tau)} b} = e^{(F\tau_{ex})} \, . \qquad (3)$$

Or, more generally, if the fishing mortality rate is lowered to some proportion x ($0 \le x \le 1$) of the present fishing mortality rate, the recruitment can after $\tau_{oc} + t_{full} - 1$ years be expected to increase by a factor of

$$k_{t+\tau_{oc}+t_{full}-1} = \frac{R_{t+t_{full}-1-\tau} e^{(-xF\tau_{ex}-M\tau)} b}{R_{t+t_{full}-1-\tau} e^{(-F\tau_{ex}-M\tau)} b} = e^{(F\tau_{ex}\cdot(1-x))} \, . \qquad (4)$$

Note that the recruitment at the time $t+\tau_{oc}+t_{full}-1$ is the result of the survival of the eels recruited at the time $t+\tau_{oc}+t_{full}-1-\tau-\tau_{oc}=t+t_{full}-1-\tau$. What is described by equations (3) and (4) can be regarded as the primary effects of fishery restrictions, i.e. the proportional increase of recruitment, due to increased survival of the already recruited stock. This proportional increase is expressed in relation to what the recruitment should have been without fishery restrictions, of which the latter might bee approximated with the observed recruitment of today. So if expected recruitment at $t + \tau_{oc} + t_{full} - 1$ would have been some proportion $q_{x=1,t+\tau_{oc}+t_{full}-1}$ of the historic recruitment R_{hist} if no fishery restriction had been imposed, with fishery restrictions we will expect that this recruitment has increased to

$$R_{t+\tau_{oc}+t_{full}-1} = R_{t+t_{full}-1-\tau} e^{(-x\cdot F\cdot \tau_{ex} - M\cdot\tau)} b = k_{t+\tau_{oc}+t_{full}-1} R_{t+t_{full}-1-\tau} e^{(-F\cdot\tau_{ex}-M\cdot\tau)} b =$$
$$= e^{(F\cdot\tau_{ex}\cdot(1-x))} R_{t+t_{full}-1-\tau} e^{(-F\cdot\tau_{ex}-M\cdot\tau)} b =$$
$$= e^{(F\cdot\tau_{ex}\cdot(1-x))} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} \approx e^{(F\cdot\tau_{ex}\cdot(1-x))} q_t R_{hist} \quad , \quad (5)$$

after a time of $\tau_{oc} + t_{full} - 1$ years, after the fishery restrictions have been imposed.

The intermediate increase and following full primary effect can be described by

$$R_{t+\tau_{oc}+j} = e^{(F\cdot\min(j+1,\tau_{ex})\cdot(1-x))} q_{x=1,t+\tau_{oc}+j} R_{hist} \approx e^{(F\cdot\min(j+1,\tau_{ex})\cdot(1-x))} q_t R_{hist} , (6)$$

where $\tau_{oc} + j$ is the time since fishery restrictions was imposed, and $0 \le j \le \tau + \tau_{oc}$, the function $\min(j + 1, \tau_{ex})$ simply takes the minimum of the two expressions within the parentheses. Equation (6) is adapted from expressions describing the temporal effects of restrictions of the yellow eel fishery mortality rate from Åström (2005). In this it is implicitly assumed that exploitation includes the last stages before the spawner escapement. Otherwise there would be a period longer than τ_{oc} - 1 before any effects of the fishery restrictions is expected to be seen. This period before any response would correspond to τ_{oc} - 1 plus the time it takes for the eels to grow from the last exploited stage to the spawner escapement.

The results so far are only practically manageable if the expected future recruitment level without fishery restrictions can be expected to be somewhat equal to observed recruitment of today (with the current fishery mortality rate) (i.e. $q_{x=1,t+\tau_{oc}+t_{full}-1} \approx q_t$). This requires that recruitment has been fairly constant at a higher level one generation earlier, which we know it has not been in most of Europe. An extension handling the complication with constantly declining recruitment in the past is presented in a section further below.

Secondary effects of fishery restrictions on future recruitment

We do also want to be able to calculate the secondary effects, i.e. the expected long-term effects of fishery restrictions on the recruitment that results from the increased standing stock caused by the primary effect on recruitment. This secondary effect on recruitment is not expected until the recruits that results from the primary effect reach their spawning and their offspring return to the continent, i.e. after additionally $\tau + \tau_{oc}$ years (i.e. full secondary effects will show $\tau_{oc} + t_{full} - 1 + \tau + \tau_{oc}$ years after the fishery restrictions have been implemented). Note that in the period between that the primary effect has taken full effect (at $t + \tau_{oc} + t_{full} - 1$) and that the secondary effects start to affect the recruitment (at $t + \tau_{oc} - 1 + \tau + \tau_{oc}$) only the primary effects will prevail, and the full potential of the secondary effect will not show until $t + \tau_{oc} + t_{full} - 1 + \tau + \tau_{oc}$ when the recruits resulting from the full effect of the primary step start producing offspring. This means that after fishery restrictions we will first experience a gradual increase in the recruitment, starting at $t + \tau_{oc}$ (again assuming that the last stages before spawner escapement have been exploited) which gets its full (primary) effects at $t + \tau_{oc} + t_{full} - 1$, then recruitment will be constant at that level until $t + \tau_{oc} - 1 + \tau + \tau_{oc}$ when the secondary increase will start based on the first part of the gradual primary increase (according to equation (6)). The plateau before the secondary effects start to show will thus last for $\tau + \tau_{oc}$ - t_{full} years. Given that the fishery restriction is serious enough, the increase will then go on until a new population equilibrium has established.

The recruitment of today can be expressed as a function of recruitment $\tau + \tau_{oc}$ years ago, times the survival to spawning, times the recruit production per spawner, but it can also simply be expressed as some proportion q_t of the average recruitment of historic times (R_{hist}), i.e.

$$R_t = R_{t-\tau-\tau_{oc}} e^{(-F\tau_{ex} - M\tau)} b = q_t R_{hist} . \quad (7)$$

We have European wide estimates of some of the involved parameters (time spans and mortality rates from Dekker 2000), with the most obvious exceptions regarding the parameter for recruit production per spawner (b) and the recruitment at a particular time (R_t) in numbers, biomass or in terms of proportions of average historic recruitment levels. In the following we present a crude indirect way of estimating these parameters, and formulate expressions to describe the anticipated secondary effects of fishery restrictions.

First we try to find an estimate of $R_{t-\tau-\tau_{oc}}$, the recruitment that was the base for the spawner escapement of today, in terms of the average of historic levels of recruitment. Since 1979 the recruitment to continental Europe has been declining rapidly. Recruitment indices suggest that the recruitment has on average been declining at a constant yearly instantaneous rate (see below) that we here call D. The recruitment each year can then be estimated from the recruitment n years back in time by

$$R_t = R_{t-n} e^{-Dn} , \quad (8)$$

and by rearranging this equation, recruitment n years back can be estimated from present recruitment as

$$R_{t-n} = R_t e^{Dn} \quad (9)$$

From this relationship and the knowledge of the current recruitment in terms of a proportion of historic recruitment we can estimate the approximate recruitment level that was the base for the current spawner population as

$$R_{t-\tau-\tau_{oc}} = R_t e^{(D\cdot(\tau+\tau_{oc}))} = q_t R_{hist} e^{(D\cdot(\tau+\tau_{oc}))} . \quad (10)$$

Rearranging equation (7) and then inserting equation (10) we get the opportunity to estimate the recruit production per spawner as

$$b = \frac{q_t R_{hist}}{R_{t-\tau-\tau_{oc}} e^{(-F\tau_{ex} - M\tau)}} = \frac{q_t R_{hist}}{q_t R_{hist} e^{(D\cdot(\tau+\tau_{oc}) - F\tau_{ex} - M\tau)}} = e^{(F\tau_{ex} + M\tau - D\cdot(\tau+\tau_{oc}))} . \quad (11)$$

Now we can express the possible secondary effects of fishery restriction on future recruitment, expected to show its full potential one generation ($\tau + \tau_{oc}$ years) after the full primary increase of the spawning stock and the subsequent increase of the recruitment (as expressed in equation (5))

$$\begin{aligned} R_{t+\tau_{oc}+t_{full}-1+\tau+\tau_{oc}} &= R_{t+\tau_{oc}+t_{full}-1} e^{(-xF\tau_{ex} - M\tau)} b = \\ &= e^{(F\tau_{ex}\cdot(1-x))} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} e^{(-xF\tau_{ex} - M\tau)} e^{(F\tau_{ex} + M\tau - D\cdot(\tau+\tau_{oc}))} . \end{aligned} \quad (12)$$

Equation (12) can recursively be reiterated several times, i.e. the full right hand side of the equation is repeatedly inserted as the new recruitment (R) on the right hand side and then multiplied with the survival expression $e^{(-xF\tau_{ex} - M\tau)}$ and the expression for the recruit production per spawner $e^{\left(F\tau_{ex}+M\tau-D\left(\tau+\tau_{oc}\right)\right)}$. Two generations after full primary effect on recruitment we thus expect the recruitment to be

$$\begin{aligned} R_{t+\tau_{oc}+t_{full}-1+2\cdot(\tau+\tau_{oc})} &= R_{t+\tau_{oc}+t_{full}-1+1\cdot(\tau+\tau_{oc})} e^{\left(-xF\tau_{ex}-M\tau\right)} b = \\ &= R_{t+\tau_{oc}+t_{full}-1} e^{\left(-xF\tau_{ex}-M\tau\right)} b e^{\left(-xF\tau_{ex}-M\tau\right)} b = R_{t+\tau_{oc}+t_{full}-1} e^{\left(-xF\tau_{ex}-M\tau\right)\cdot 2} b^2 \\ &= e^{\left(F\tau_{ex}\cdot(1-x)\right)} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} e^{\left(-xF\tau_{ex}-M\tau\right)\cdot 2} e^{\left(F\tau_{ex}+M\tau-D\cdot(\tau+\tau_{oc})\right)\cdot 2} = \\ &= e^{\left(F\tau_{ex}\cdot(1-x)\right)} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} e^{\left(F\cdot\tau_{ex}\cdot(1-x)-D\cdot(\tau+\tau_{oc})\right)\cdot 2}. \end{aligned} \tag{13}$$

In this way we can estimate how recruitment changes after an arbitrary number of eel generations. We find that T number of generations (each of $\tau + \tau_{oc}$ years) after the primary increase we expect the recruitment to be

$$\begin{aligned} R_{t+\tau_{oc}+t_{full}-1+T\cdot(\tau+\tau_{oc})} &= R_{t+\tau_{oc}+t_{full}-1} e^{\left(-xF\tau_{ex}-M\tau\right)\cdot T} b^T \\ &= e^{\left(F\tau_{ex}\cdot(1-x)\right)} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} e^{\left(F\tau_{ex}\cdot(1-x)-D\cdot(\tau+\tau_{oc})\right)\cdot T}. \end{aligned} \tag{14}$$

From the observation that the expression in the exponent that is multiplied with T need to be larger than zero to induce a long-term population increase, we can find the breakpoint between long-term (secondary) increase in the recruitment or continued the decline depending on the severity of the fishery restrictions. This breakpoint is found when the expression in the exponent equals zeros, i.e. when

$$F\tau_{ex}\cdot(1-x) = D\cdot(\tau+\tau_{oc}), \tag{15}$$

or more generally, from the middle section of equation (14),

$$\ln b = xF\tau_{ex} + M\tau. \tag{16}$$

Solving equation (15) for the allowed proportion of present fishery mortality rate (x) we get

$$x_{max} = \frac{F\tau_{ex} - D\cdot(\tau+\tau_{oc})}{F\tau_{ex}} = 1 - \frac{D(\tau+\tau_{oc})}{F\tau_{ex}}, \tag{17}$$

or from equation (16) in more general terms

$$x_{max} = \frac{\ln b - M\tau}{F\tau_{ex}}, \tag{18}$$

which express which value of the proportion of present fishery mortality rate (x) that give no long-term increase or decrease in recruitment. The index "*max*" indicates that this is the maximum value that x should take in order to stop further decline, so the allowed proportion of present mortality rate has to take values below x_{max} to induce a long-term recruitment increase (i.e. $x < x_{max}$). Note that with x-values only closely below x_{max} the recovery time will be very long, and at equivalence ($x = x_{max}$) by definition infinite, i.e. recruitment at status quo at the presently very low level. For x-values above x_{max} future recruitment is expected to continue to decline.

This makes it obvious that also the time perspective has to be analysed. From equation (14) we can find how many eel generations after the primary increase that will be needed to restore the recruitment to its full level of 100% of historic levels for a given level of fishery restrictions (x). We then replace the left hand side of equation (14) with R_{hist} and solve for T, giving

$$T_{R_{hist}} = \frac{F\tau_{ex} \cdot (x-1) - \ln q_{x=1,t+\tau_{oc}+t_{full}-1}}{F\tau_{ex} \cdot (1-x) - D \cdot (\tau + \tau_{oc})}. \quad (19)$$

Note that although (x-1) is always negative (or zero), the natural logarithm of a quantity less than one (q) is also always negative, giving a parameter space with positive solutions. We can also from equation (14) get more general expressions for the number of generations needed for full recovery like

$$T_{R_{hist}} = \frac{\ln R_{hist} - \ln R_{t+\tau_{oc}+t_{full}-1}}{\ln b - xF\tau_{oc} - M\tau} = \frac{F\tau_{ex}(x-1) - \ln q_{x=1,t+\tau_{oc}+t_{full}-1}}{\ln b - xF\tau_{ex} - M\tau}. \quad (20)$$

Note that the full time it takes to reach back to historic average levels of recruitment thus is $t_{R_{hist}} = \tau_{oc} + t_{full} - 1 + T_{R_{hist}} \cdot (\tau + \tau_{oc})$. Note also that in a more general setting the per spawner recruitment production (b) is supposed to decrease the closer we get to the desired recruitment level due to density dependence, further increasing the time required. At the same time we clearly see from equation (20) that decreasing the instantaneous natural mortality rate (M) would also decrease the time to recovery. However, the possibilities to decrease the natural mortality rate are much more restricted than our capability to affect the fishery mortality rate (F). To a large extent this depends on how anthropogenic activities affect the natural mortality rate. Again the results so far are only practically manageable if recruitment has been constant in the past (a prerequisite for $q_{x=1,t+\tau_{oc}+t_{full}-1} \approx q_t$). An extension handling this complication is presented in a section further below.

Parameter estimates

From Dekker (2000) we find that the average of the total time span of the continental stage in northern Europe is 16 (18?) years ($\tau = 16$), the average of the exploited life stage is 6 years ($\tau_{ex} = 6$), the instantaneous natural mortality rate is 0.14 per year ($M = 0.14$) and the cumulated fishery mortality is 3.25 ($F \cdot \tau_{ex} = 3.25$), which suggests that the average instantaneous fishery mortality rate per exploited year is 0.54 ($F = 0.54$). In the following we also assume that the oceanic stage, from when spawners leave the continent until the next generation of glass eels enter the coast, lasts for about two years ($\tau_{oc} = 2$). The time it takes before the primary effects gets their full effect on spawner escapement, corresponds to the time it takes for the eels to grow from the youngest exploited stage to the spawner escapement. So if glass eels are exploited this time would be expected to be close to the total time of the continual stages, i.e. $t_{full} = \tau = 16$ years. If, on the other hand, only silver eels are exploited, this time would be less than a full year, say $t_{full} = 0.5$ years. When yellow (and silver) eels are exploited $t_{full} = \tau_{ex} = 6$ years, which is the example that will be further explored below.

We have recent (2004) estimates of q of about 2.5% of the average recruitment of the 1960–1970s (Willem: from where?). The latter is here taken as an approximation of the parameter R_{hist}. Using the standardized (percentage of average for 1979–1994) recruitment indices from three of the longest recruitment series with true glass eels (Den Oever, Ems and Loire, data from ICES, 2005) we can get a rough estimate of the rate of decline in the recruitment since 1977 and until 2004 (only to 2001 in the case of Ems). The instantaneous rate of decline (D) of the recruitment indices is estimated to be D=0.1538 year^{-1}, (see Figure 5), using the formula $I_t = e^{a-D \cdot t}$, or in practice $\ln(I_t) = a - D \cdot t$ in a regression analysis ($R^2 = 0.486$, $p<0.001$), where I_t indicates the three recruitment indices, the parameter D is the instantaneous rate of decline of the indices and the parameter a is of no further interest.

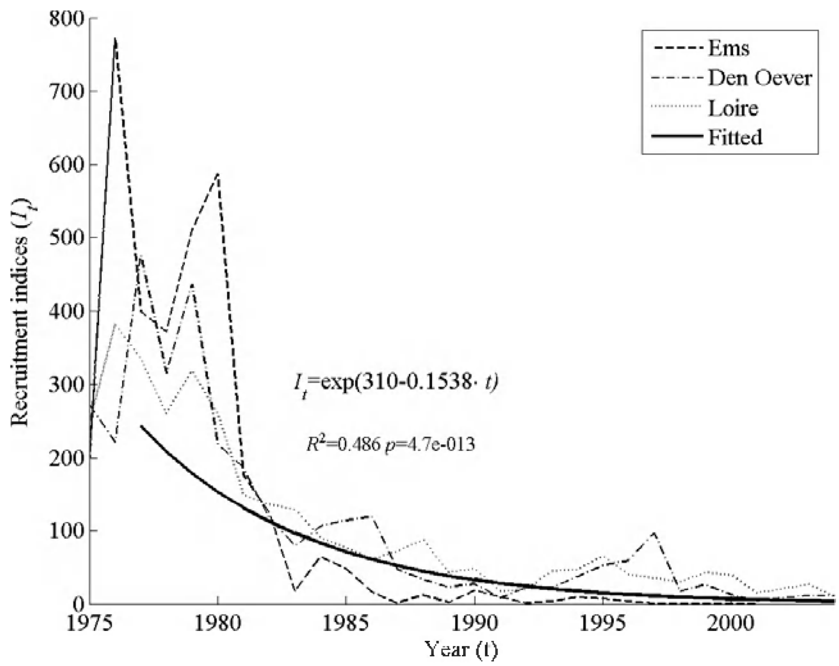

Figure 5. Standardized recruitment indices of Ems, Den Oever and Loire (various broken line), and estimated decline rate (thick solid line), with estimated equation and some regression statistics indicated.

Numerical examples

Equipped with the parameter values from the previous section we can now give some numerical examples on the recovery process and the time perspectives of it, given the simplifying assumption that the recruitment that has been the base for the current stock of eels of different ages has been fairly constant, e.g. equating $q_{x=1,\, t+\tau_{oc}+t_{full}-1}$ with q_t.

We start with the resulting estimates of the recruitment base of the current stock according to equation (10) ($R_{t-\tau-\tau_{oc}}$ = 0.40·R_{hist}) and the recruit production per spawner according to equation (11) (b = 15.2). Note that this per spawner recruit production concerns the number or biomass of recruits that enter the coastal waters of Europe and northern Africa, not the initial birth rate per spawner in the Sargasso Sea, and that we have not separated between the sexes. In practise the latter means that we for simplicity are only considering females, and implicitly assume a fairly constant sex ratio over time.

Primary effects

From equation (5) we find that the primary effects of completely closing the fishery (x = 0) would be to get around 64% of historic recruitment (0.64·R_{hist}) after 7 years ($\tau_{oc} + t_{full}$ -1 = 2 + 6 – 1). This primary effect will then prevail for another 12 years ($\tau + \tau_{oc} - t_{full}$ = 16 + 2 - 6) until the first signs of the secondary effect start to show after in total 19 years ($\tau_{oc} + t_{full} - 1 + \tau + \tau_{oc} - t_{full}$), and the full potential of the combination of the primary and the secondary effects will show 25 years after the fishery restriction have been applied ($\tau_{oc} + t_{full} - 1 + \tau + \tau_{oc}$). The general relationship between the resulting proportions of historic recruitment (q) as a consequence of different levels of fishery restrictions (expressed as the proportion of present fishery mortality rate allowed (x)) is shown in Figure 6.

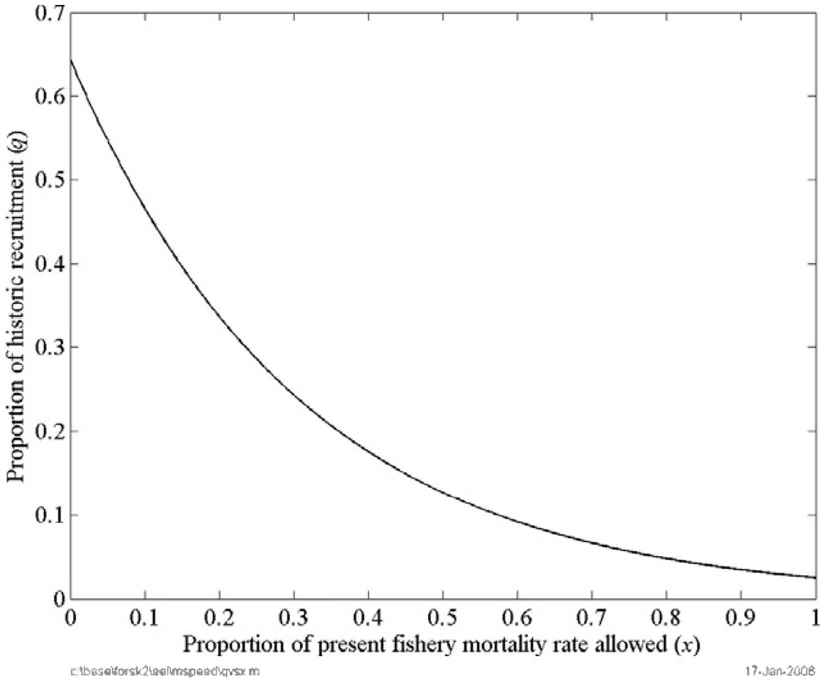

Figure 6. Illustrating how the allowed proportion of present fishery mortality rate is expected to affect the recruitment level 7 years later (i.e. primary effect), expressed as proportion of historic average recruitment. The long-term goal for the recovery of the European eel is 100% of average historic recruitment (R_{hist}), i.e. $q = 1$.

Secondary effects

Entering the parameter estimates presented above into equation (17) we find that present fishery mortality rate has to be decreased below 14.8% if any long-term recovery should be expected (x_{max} = 0.148) after the primary increase.

Moving on to the time perspectives, we find according to equation (19) that if fishery would be completely closed (x = 0) then recruitment would be expected to return to historic levels (R_{hist}) after about $t_{R_{hist}}$ = 23 years. This is because according to equation (19) full recovery will take $T_{R_{hist}}$ = 0.91 generations, after the initial 7 years for the full primary effect. Generation time is here estimated to be 18 years (see above). Note that this result is not exact since the increase will in reality not be continuous but rather reaching plateaus and every plateau level will be intervened with lower recruitment (see below). Because of this we should in general round the number of generations up to the nearest larger integer value, thus in our case giving $T_{R_{hist}}$ = 1 generation, and accordingly in total $t_{R_{hist}}$ = 25 years until full recovery.

Both these results are sensitive to e.g. the estimate of D. An alternative estimate of D could be done including more recruitment series that reflects the continuous decline since the late 1970's, although this increases the variation around the estimates. Thus using the standardized (percentage of average recruitment for 1979–1994) recruitment indices from Ems, Gironde (catch per unit effort in the estuary), Viskan, Shannon, IJzer, Nalon, Vilaine, Den Oever and Loire (data from ICES, 2005), we can get another rough estimate of the rate of decline in the recruitment since 1977 and until 2004 (only to 2001 in the case of Ems and only between 1979 and 2002 for Gironde). The instantaneous rate of decline (D) of the recruitment indices is then found to be D=0.1488 year^{-1}, (see Figure 7).

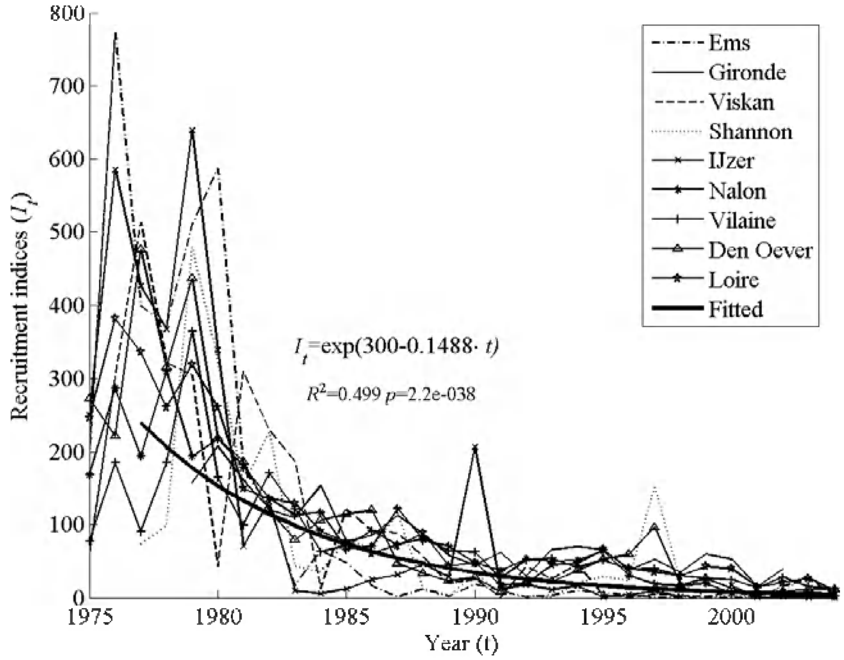

Figure 7. Standardized recruitment indices of Ems, Gironde (CPUE in estuary), Viskan, Shannon, IJzer, Nalon, Vilaine, Den Oever and Loire (various types of lines according to legend) , and estimated decline rate (thick solid line), with estimated equation and some regression statistics indicated.

Then from equation (17) we get x_{max} = 0.176 for D = 0.1488, i.e. that recruitment is expected to show long-term recovery only with fishery mortalities rates below 17.6% of the present level. The number of generations needed for returning to historic recruitment levels with completely closed fishery (x = 0) then becomes $T_{R_{hist}}$ = 0.77, thus giving a total recovery time of about $t_{R_{hist}}$ = 21 years. Again rounding the number of generations up gives 1 full generation, and accordingly in total 25 years. But with 10% of present fishery mortality rate (x = 0.1) complete recovery would take about 63 years (or 79 years when rounding up). The general relationship between the time (not rounded up) needed for full recruitment recovery ($1.0{\cdot}R_{hist}$), as a function of the allowed proportion of the present fishery mortality rate (according to equation (19) and adding the 7 years needed for the full primary effect) is shown in Figure 8 for the two different estimates of the previous decline rate.

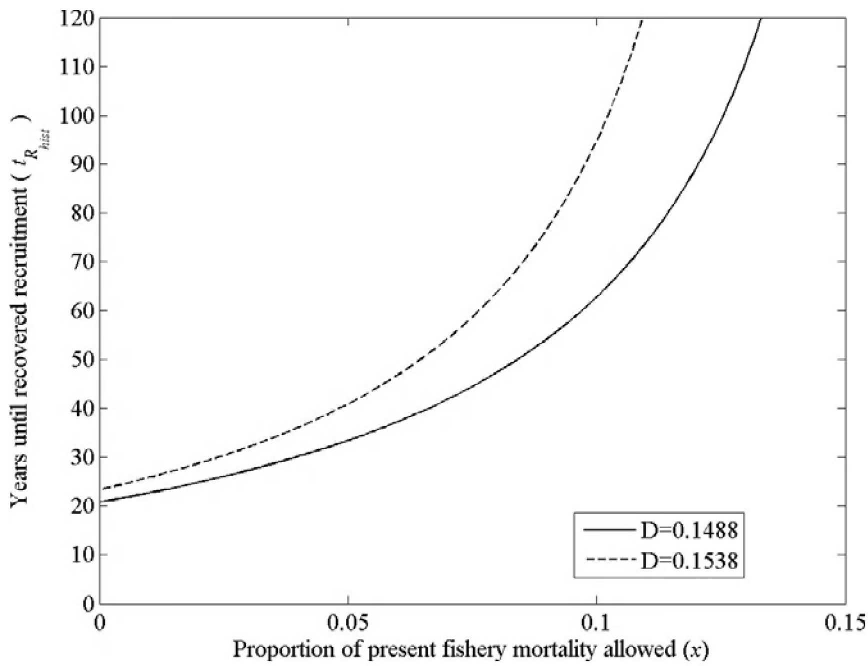

Figure 8. The time required for full recruitment recovery ($t_{R_{hist}}$) as a function of the allowed proportion of present fishery mortality rate (*x*) according to equation (19) (without rounding up), for two different estimates of the instantaneous rate of decline of the past recruitment (*D*).

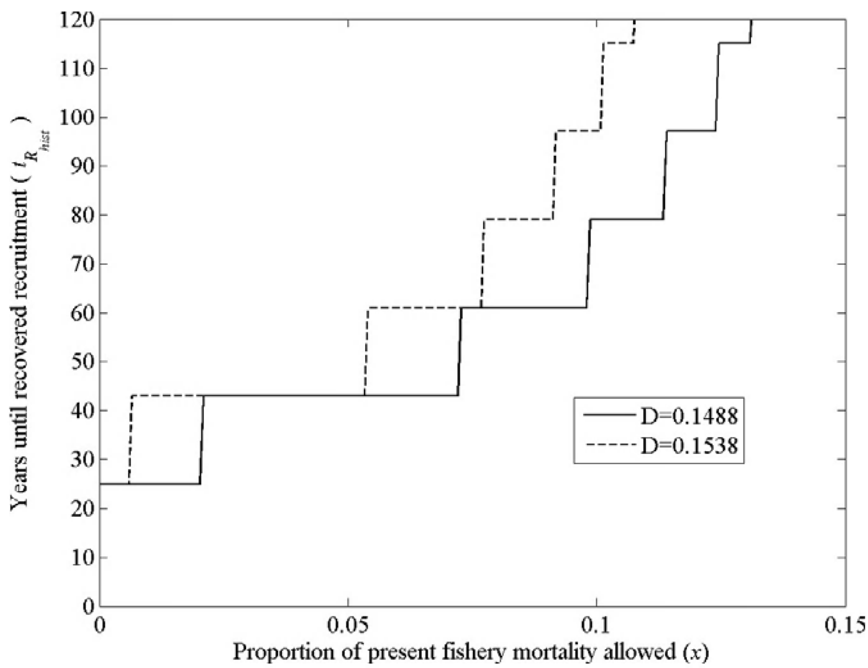

Figure 9. The time required for full recruitment recovery ($t_{R_{hist}}$) as a function of the allowed proportion of present fishery mortality rate (*x*) according to equation (19) (with rounding up to the closest larger integer), for two different estimates of the instantaneous rate of decline of the past recruitment (*D*).

To give a little more realistic view of the time perspectives for full recruitment recovery ($1.0 \cdot R_{hist}$) Figure 9 is based on equation (19) but rounding the number of generations up to the closest larger integer, and adding the 7 years needed for the full primary effect.

Expected recruitment over time

As stated above Figure 8 or even Figure 9 does not describe the recovery process completely correct. We have several times mentioned the hidden assumption of constant past recruitment. However, if we should be able to expect any primary effect of fishery restrictions there has to have been a history of reduced recruitment due to fishery. Thus we have to assume a difference between past recruitment and the most recent, just before the fishery restrictions. In Figure 10 the time course of the expected recruitment after fishery restrictions is shown, expressed as the proportion of historic recruitment. In this figure proportional recruitment before fishery restrictions is calculated according to equation (10), based on the observation of current recruitment at 2.5%, although this latter recruitment level is never realised in the figure. Even though the effects of fishery on past recruitment is not shown in the figure the deep drops in recruitment in this figure is due to the effects of fishery, or more specifically that fishery restrictions do not take full primary effects until all previously fished year classes have matured. Note in Figure 10 that although the plateaus increase for every generation the minimum recruitment values stay very low for very long time after fishery restrictions has been imposed.

Note that although the parameter D plays an important role for the results because it enters in the estimate of the parameter describing the recruit production per spawner (b), the past continuous decline of recruitment has still explicitly not been taken into consideration in the prospect for future recruitment. So all the above results are certainly overly optimistic.

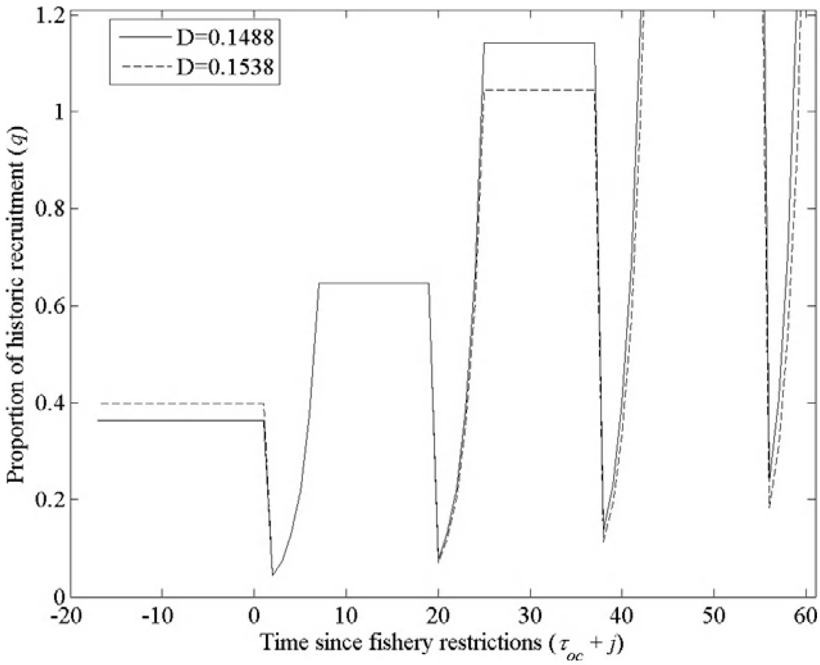

Figure 10. The expected proportion (q_t) of the historic recruit (R_{hist}) plotted as function of time since fishery restrictions ($\tau_{oc} + j$). In this case completely closed fishery is assumed ($x = 0$). Previous decline in recruitment is not taken into account, except for the sharp drop just as fishery restriction is implemented.

Declining recruitment

The exercise with the observed decline in recruitment indices (equations (9) and (10)) can also be used to take this decline into account when calculating the primary and the secondary effects of fishery restrictions. If we start with an observation that the current recruitment is a proportion q_t of the historic recruitment (R_{hist}), we can calculate the expected future recruitment without fishery restrictions some time later using the estimate of the instantaneous rate of decline of the recruitment (D) in the following way

$$R_{t+\tau_{oc}+t_{full}-1} = R_t e^{-D\cdot(\tau_{oc}+t_{full}-1)} = q_t R_{hist} e^{-D\cdot(\tau_{oc}+t_{full}-1)} = q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist}\,. \quad (21)$$

This decline of expected recruitment is due to the observed decline in past recruitment some ($\tau + \tau_{oc}$) years earlier, i.e. from year $t - \tau - \tau_{oc}$ until year $t - \tau + t_{full}$, which we assume will affect future spawning escapement and then susequent recruitment. From equation (21) we see that we can simply express q at a particular time in terms of q_t, in the following way

$$q_{x=1,t+\tau_{oc}+t_{full}-1} = q_t e^{-D\cdot\left(\tau_{oc}+t_{full}-1\right)}\,. \quad (22)$$

Inserting equation (22) in equation (5) instead of the last approximate part of that equation, we get

$$R_{t+\tau_{oc}+t_{full}-1} = e^{\left(F\cdot\tau_{ex}(1-x)\right)} q_{x=1,t+\tau_{oc}+t_{full}-1} R_{hist} = e^{\left(F\cdot\tau_{ex}(1-x)-D\cdot\left(\tau_{oc}+t_{full}-1\right)\right)} q_t R_{hist}\,, \quad (23)$$

which represents the expected recruitment, due to the primary effects of fishery restrictions, for the first year when this effect is fully expressed. However, with declining past recruitment we can no longer expect there to be a plateau with constant recruitment at that level until the secondary effects kick in, but rather a continuous decline from the level that has just been reached.

With our numerical example, with $q_t = 0.025$ and $x = 0$, i.e. closed fishery, we then find that

$R_{t+t_{oc}+t_{full}-1} = 0.220$, i.e. 22% of R_{hist} with $D = 0.1538$, or

$R_{t+t_{oc}+t_{full}-1} = 0.227$, i.e. 23% of R_{hist} with $D = 0.1488$.

So instead of the previously expected primary recovery to 64% of R_{hist} (irrespective of the estimate of D) when the recruitment decline was not incorporated, we now find that the recovery due to the primary effects of fishery restrictions can in reality be expected to be only 22 to 23% of the average historic level of recruitment, when the past recruitment decline is taken into account.

At the time step before the secondary effects start to show (when the first gradual increase of recruitment give rise to new recruits) we would expect recruitment due to the primary effect to have declined to

$$R_{t+\tau_{oc}+\tau+\tau_{oc}-1} = e^{\left(F\cdot\tau_{ex}\cdot(1-x)-D\cdot\left(\tau_{oc}+\tau+\tau_{oc}-1\right)\right)} q_t R_{hist}\,. \quad (24)$$

With our numerical example the recruitment at that time would amount to 3.5% of R_{hist} with $D = 0.1538$ or 3.8% with $D = 0.1488$.

In order to illustrate the expected development of the recruitment over time due to both the primary and the secondary effects we first define the following expression for the proportion of the historic recruitment for the time period before any effects of fishery restrictions can be seen

$$q_{t-\tau_{oc}-\tau+i} = q_t e^{D(\tau_{oc}+\tau-i)} \text{ for } 0 \le i \le \tau_{oc} + \tau + \tau_{oc} - 1, \quad (25)$$

which is a back calculation from the knowledge of present proportion of historic recruitment (q_t) and the decline rate (D), valid from $t - \tau_{oc} - \tau$ to $t + \tau_{oc} - 1$. Then after fishery restrictions have been implemented at time t the expected proportional recruitment $\tau_{oc} + j$ time steps later is expressed as

$$q_{t+\tau_{oc}+j} = q_{t+\tau_{oc}+j-\tau-\tau_{oc}} e^{\left(-F\cdot\left(\tau_{ex}-\min(j+1,\tau_{ex})\cdot(1-x)\right)-M\tau\right)} e^{\left(F\cdot\tau_{ex}+M\tau-D\cdot(\tau+\tau_{oc})\right)}, \quad (26)$$

where $0 \le j \le \infty$, and getting the input for the q's on the right hand side first from equation (25) and then from the results from equation (26) itself in accordance with the time indexing. The results of these equations are best illustrated in a plot of q vs. time.

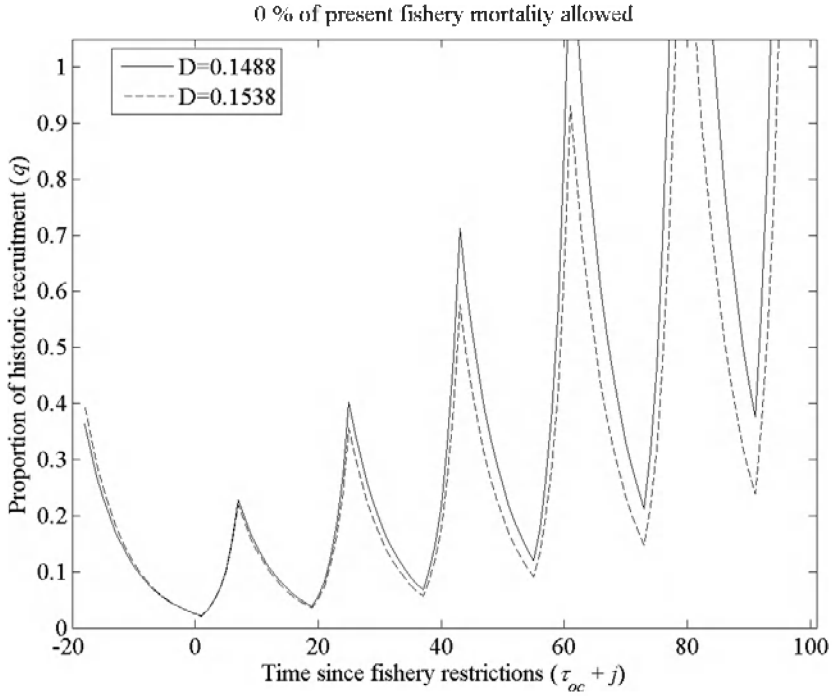

Figure 11. The expected proportion (q) of the historic recruit (R_{hist}) plotted as function of time since fishery restrictions (τ_{oc}+ j). In this case completely closed fishery is assumed (x = 0). Previous decline in recruitment is here taken into account, according to the two different estimates of the instantaneous rate of decline (D).

From Figure 11 we see that expected time to full recovery (q = 1.0) gets very long when previous recruitment decline is taken into account, somewhere between 61 years, for D = 0.1488, to 78 years, for D = 0.1538, even when fishery is completely closed (x = 0). Note however, that even if full recruitment is reached "already" after 61 years of closed fishery (for D = 0.1488), after that recruitment drops sharply to only $0.21 \cdot R_{hist}$ at 73 years after the implementation of the fishery closure. The expected bottom notations of the recruitment do not remain safely above the historic recruitment levels until after the last bottom notation of $0.66 \cdot R_{hist}$ at 109 years after fishery closure, for D = 0.1488. For the higher decline rate it takes even longer (145 year).

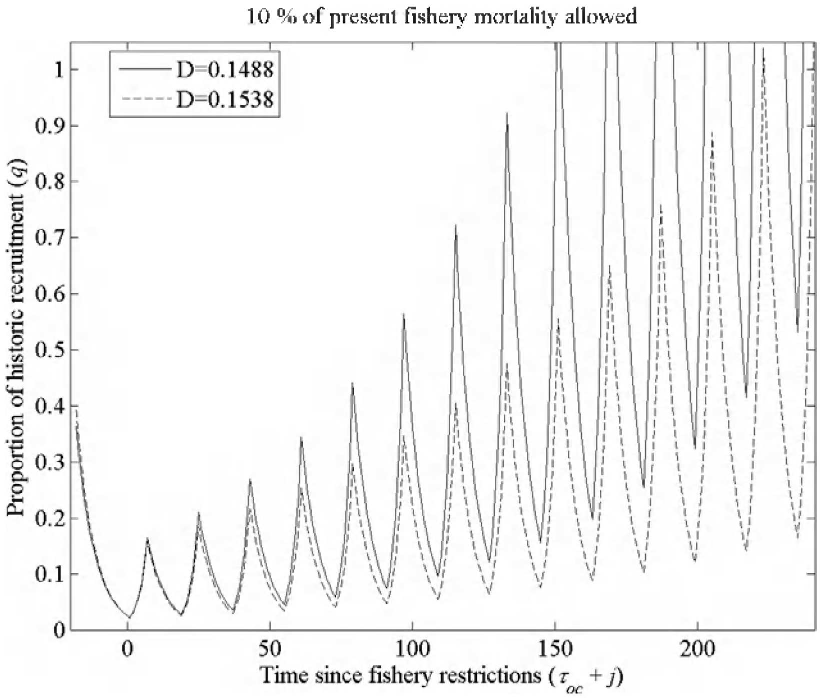

Figure 12. The expected proportion (q) of the historic recruit (R_{hist}) plotted as function of time since fishery restrictions (τ_{oc} + j). In this case it is assumed that 10% of the present fishery mortality rate (F) is allowed (x = 0.1). Previous decline in recruitment is here taken into account, according to two different estimates of the instantaneous rate of decline (D).

Figure 12 is illustrating the expected recovery process if 10% of the present fishery mortality rate is allowed, i.e. if only some very restricted fishery would be allowed. We note that time until full recruitment recovery is now expected to be somewhere between 151 and 223 years (for D = 0.1488 and D = 0.1538, respectively). Again even after full recruitment has been reached the recruitment is expected to drop very low some years later, for D = 0.1488 recruitment is expected to drop to about $0.20{\cdot}R_{hist}$ at 163 years after fishery restrictions, and for D= 0.1538 recruitment is expected to drop to $0.16{\cdot}R_{hist}$ at 235 years after fishery restrictions has been implemented.

It should be noted that the prerequisite on the fishery mortality rate ($x < x_{max}$), in order to allow for a long-term recovery according to equations (17) or (18), is valid also when the past recruitment decline is incorporated (see Figure 13).

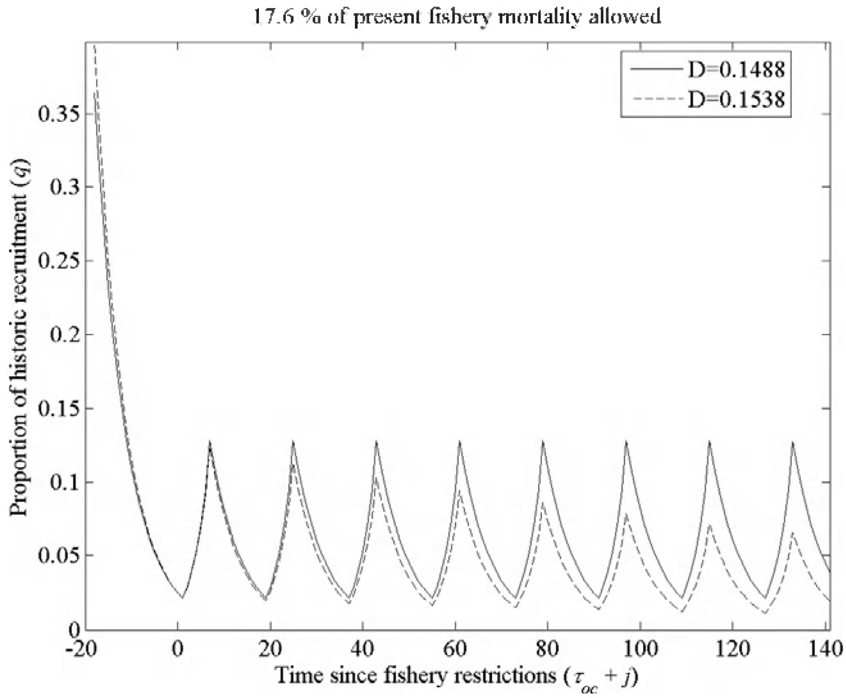

Figure 13. Illustration that the prerequisite on the fishery mortality rate (x_{max}), according to equations (17) or (18), is still valid when the past recruitment decline is incorporated. The proportion of present fishery mortality rate (*F*) allowed is set to x_{max} = 0.176 so that the situation with D = 0.1488 show no long-term recovery in recruitment after the initial increase due to the primary effect, and for D above that level a long-term decrease is evident. Note the change of scale on the y-axis.

If we assume that as much as 60% of present fishery mortality rate is allowed (x = 0.60) (Figure 14), we see a rapid decline only interrupted by very small signs of temporal recovery. Such a fishery regime should not be mixed up with allowing 40% of the present spawners to escape, because 60% of present fishery mortality rate imply only 14% of the spawner escapement that would be possible with the current stock (when the full primary effect is reached) (this is calculated with the equation $p = e^{-xF\tau_{ex}}$, where p is the proportion of presently possible spawner escapement due to the primary effect (modified from Åström, 2005)). To achieve 40% of (presently possible) spawner escapement due to the full primary effect, fishery mortality rate would need to be lowered to 28% of the present (x = 0.28). Still according to Figure 15 this would lead to further long-term decline in recruitment, intertwined with temporary small tops of recovery, well below 10% of historic average recruitment. So if the proportion of present fishery mortality rate allowed (x) is not lowered well below x_{max} we might as well spend our time writing the final necrologue over the European eel. The two x_{max}-values presented here (x_{max} = 0.176 and x_{max} =0.148) corresponds to 56 and 62% of presently possible spawner escapement. In this context it should be mentioned that fishery mortality rate usually is supposed to be proportional to the fishery effort, although this recently has been questioned.

It has to be noted that even these very sad scenarios are probably optimistic regarding the time perspective needed for full recovery of the recruitment, since for the real eel population the recruit production per spawner (b) is expected to decrease when the desired recruitment level (R_{hist}) is approached, due to density dependent processes. In the above analyses b is assumed to be constant irrespective of the population density.

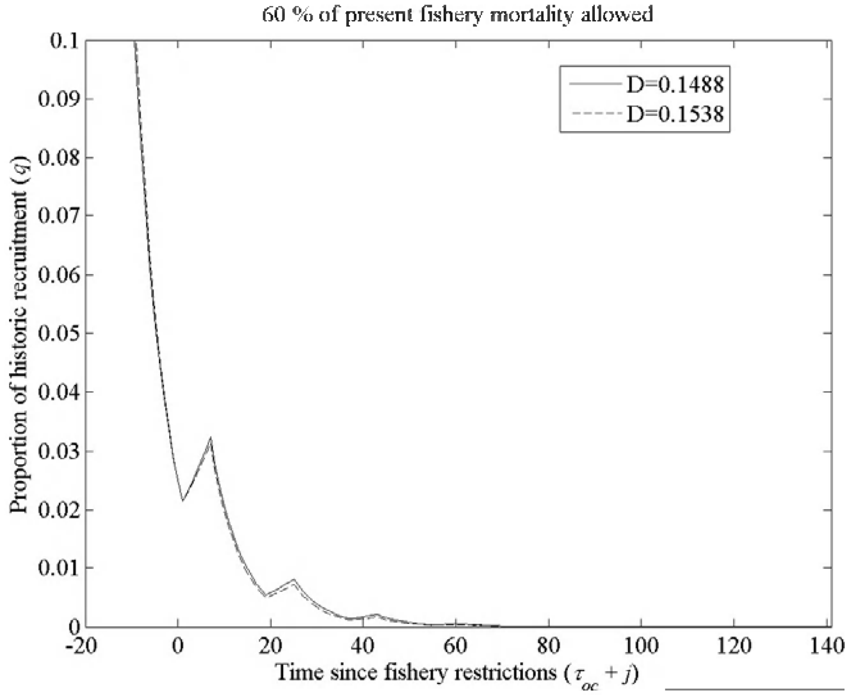

Figure 14. The expected proportion (q) of the historic recruit (R_{hist}) plotted as function of time since fishery restrictions (τ_{oc} + j). In this case it is assumed that 60% of the present fishery mortality rate (F) is allowed (x = 0.6). Previous decline in recruitment is taken into account. Note the change of scale of the y-axis.

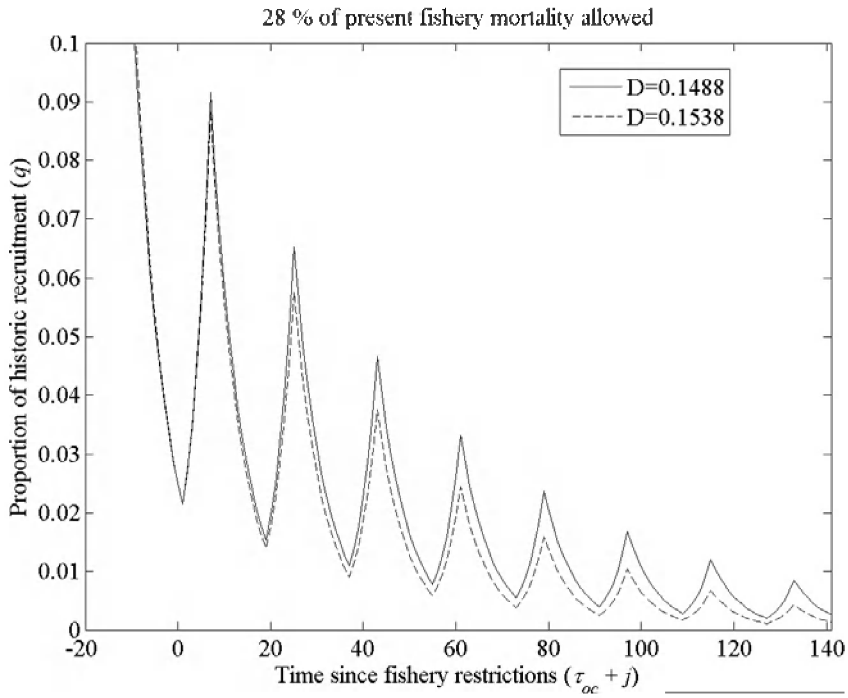

Figure 15. The expected proportion (q) of the historic recruit (R_{hist}) plotted as function of time since fishery restrictions (τ_{oc} + j). In this case it is assumed that 28% of the present fishery mortality rate (F) is allowed (x = 0.28), which corresponds to 40% of presently possible spawner escapement due to the full primary effect. Previous recruitment decline is taken into account. Note that the maximum of the y-axis only represents 10% of historic average recruitment.

There are some indications that the eel might be in a situation with depensation in the stock-recruitment relationship (Dekker, 2004; ICES, 2005), i.e. that recruitment is declining faster than the spawning stock, when the spawning stock has reached below a certain level. Depensation has not been taken into account in the present analyses. If the eel is experiencing depensation the prospect for recovery is even worse than what is described in these analyses, in the sense that the eel population size might at present be below the point from where the decline can be reversed. This can occur if the recruit production is so low that it is below the lowest level that can be achieved for the mortality rates (i.e. only natural mortality). If the last 25 years of decline reflects depensation, this also implies that the estimate of the recruit production per spawner (b) according to equation (11) reflects a past situation with higher b than can be expected for the depleted spawning stock of today. On the other hand, depensation means that recruit production per spawner (b) actually first increases when the spawning stock is increased from very low values, making it still meaningful to at least try to save the European eel.

Sensitivity analyses

In order to get an idea of the robustness of the presented results some kind of sensitivity analyses is needed. We start with how the primary recruitment increase is affected by a 1% coordinated change of the three involved parameter (F, τ_{ex} and q_t) to create two scenarios around the basic scenario we have already seen, one "worst" scenario where all three parameters are decreased by 1% and one "best" scenario where the parameters are increased by 1% (Figure 16).

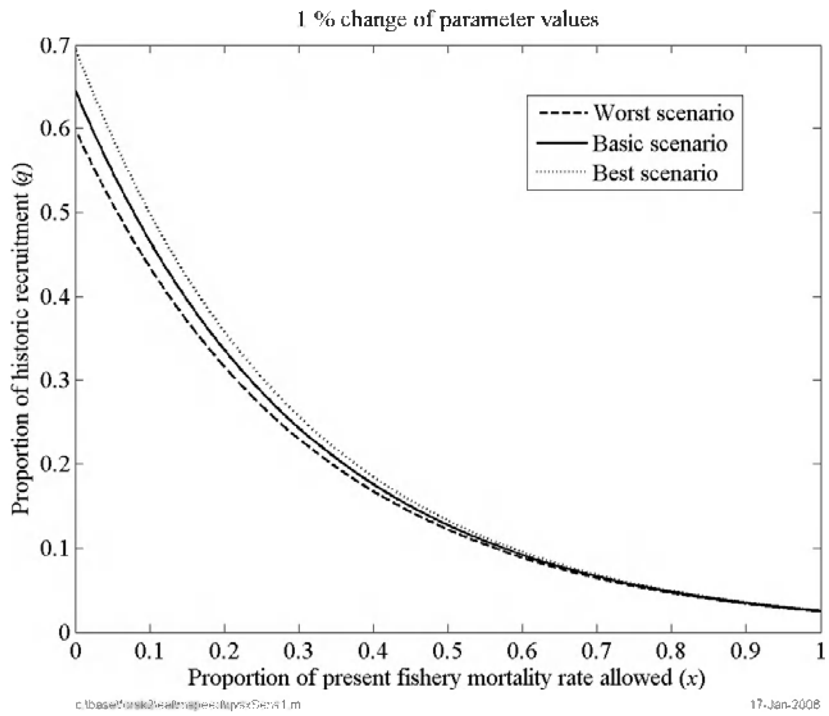

Figure 16. Sensitivity of the primary effect of fishery restrictions of scenarios with combinations of 1% change of the three parameters F, τ_{ex} and q_t. For the "worst scenario" the parameters have all been decreased by 1% compared to the basic scenario, and for the "best scenario" they have all been increased by 1%.

Next we look at the sensitivity of the calculations of the maximum allowable proportion of the present fishery mortality rate (x_{max}) to the precision in the parameter estimates. From Table 1 we see the anticipated effects of changing all the involved parameters by 1% each in a coordinated way to create two new scenarios beside the basic case we have already seen. By decreasing F and τ_{ex} by 1% and increasing D, τ and τ_{oc} by 1% we create a worst case scenario from which we see that allowing more than 11% of the present fishery mortality rate is very likely to prevent long-term recovery of the eel recruitment. Perturbing the parameters the other way around creates a best-case scenario where the breakpoint for the proportion of fishery mortality rate that allow for long-term recovery is around 20%. From Table 2 we see a very dramatic effect of changing all the involved parameter by as much as 5%. With the “worst case” scenario it is clear that not even complete closure of all fishery is certain to lead to a long-term increase in the recruitment. With the “best-case” scenario the breakpoint between long-term recovery and decline is around 30% of present fishery mortality rate.

Table 1. Sensitivity analyses of the estimates of x_{max} (the maximum allowable proportion of present fishery mortality rate) according to scenarios with combinations of 1% changes of each parameter given in the left side of the head of the table.

	F	τ_{EX}	*D* (9 or 3 indices)	τ	τ_{OC}	X_{MAX} (D_0= 0.1448)	X_{MAX} (D_0= 0.1538)
Worst case	0.5363	5.94	0.1503/0.1553	16.16	2.02	0.1422	0.1134
Basic case	0.5417	6.0	0.1488/0.1538	16.0	2.0	0.1759	0.1482
Best case	0.5471	6.06	0.1473/0.1523	15.84	1.98	0.2082	0.1816

Table 2. Sensitivity analyses of the estimates of x_{max} (the maximum allowable proportion of present fishery mortality rate) according to scenarios with combinations of 5% changes of each parameter given in the left side of the head of the table.

	F	τ_{EX}	*D* (9 or 3 indices)	τ	τ_{OC}	X_{MAX} (D_0= 0.1448)	X_{MAX} (D_0= 0.1538)
Worst case	0.5146	5.7	0.1562/0.1615	16.8	2.1	0 (-0.0068)	0 (-0.0406)
Basic case	0.5417	6.0	0.1488/0.1538	16.0	2.0	0.1759	0.1482
Best case	0.5688	6.3000	0.1414/0.1461	15.2	1.9	0.3254	0.3027

It is also of interest to analyse the relative contribution of each parameter to the resulting variable x_{max}. This can be illustrated by calculating the elasticity of the focal variable to each of the parameters (Caswell, 2001). If we are interested in the relative effect of the parameter F on x_{max}, then the technical definition of the elasticity of x_{max} with respect to F is

$$e_F = \frac{F}{x_{\max}} \frac{\partial x_{\max}}{\partial F}. \tag{27}$$

The elasticity gives the proportional change in x_{max} resulting from a proportional change in the parameter in question. When calculating the elasticity of x_{max} with respect to one of the parameters all other parameters are kept constant according to the basic scenario. In Figure 17 the elasticity of x_{max} is illustrated for all parameters entering the definition of x_{max} (equation (17)). All parameters except τ_{oc} have similar proportional effects on x_{max} from a proportional change of their value. Thus the importance of the precision of the estimate of the time of the oceanic stage (τ_{oc}) is much less important than the precision of all other parameters.

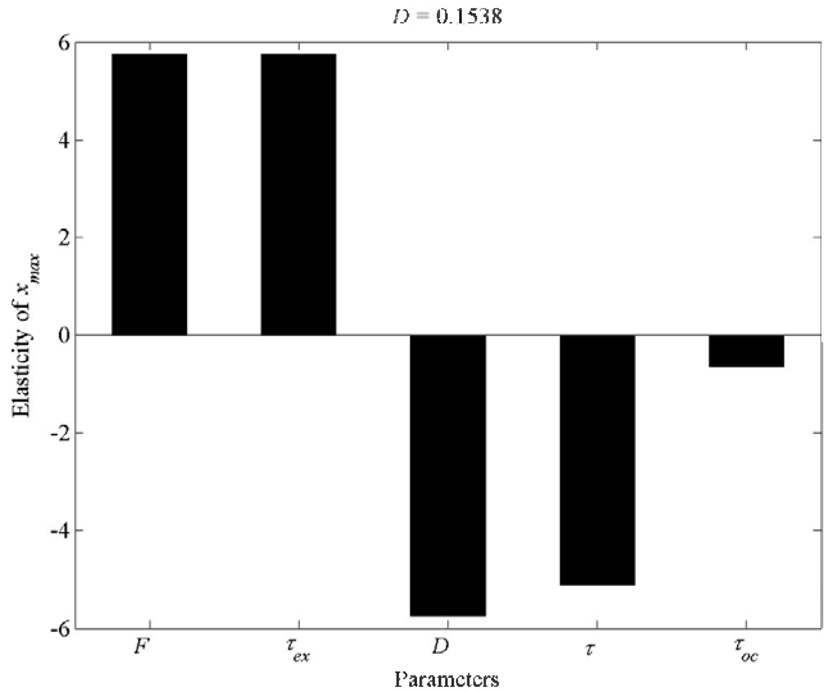

Figure 17. Elasticity of x_{max} for each of the parameters in equation (17), using the basic set of parameter values.

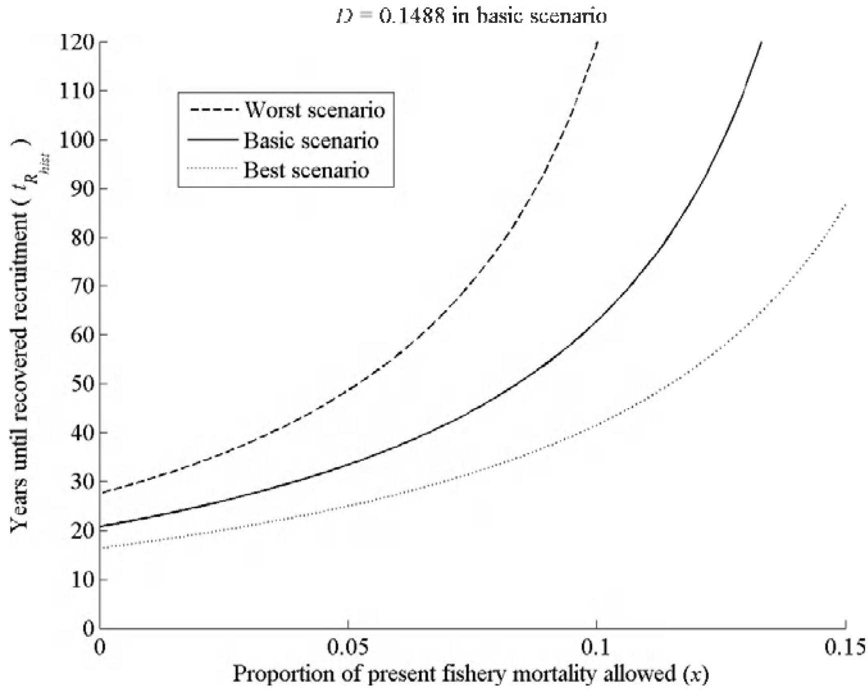

Figure 18. Sensitivity of the estimates of recovery time to 1% changes in parameter values for three scenarios with D= 0.1488 in the basic scenario.

Figure 18 and Figure 19 illustrate the sensitivity of the estimates of recovery time $t_{R_{hist}}$ to changes in parameter values, and Figure 20 and Figure 21 show the equivalent graphs when rounding the number of generations up to the nearest larger integer. The scenarios represent changes of each parameter by 1% in a coordinated way to create a worst case and a best case scenario around the already presented basic scenario. For the worst case scenario the parameters τ, τ_{oc} and D were increased by 1% and the parameters F, τ_{ex}, q_t and t_{full} were decreased by 1%. For the best case scenario the parameters were changed in the opposite directions. From these figures it is clear that not even the "best" scenarios give a very optimistic picture of the time perspectives of the recovery of the eel stock. They also point out that there are great risks associated with management strategies allowing any fishery mortality.

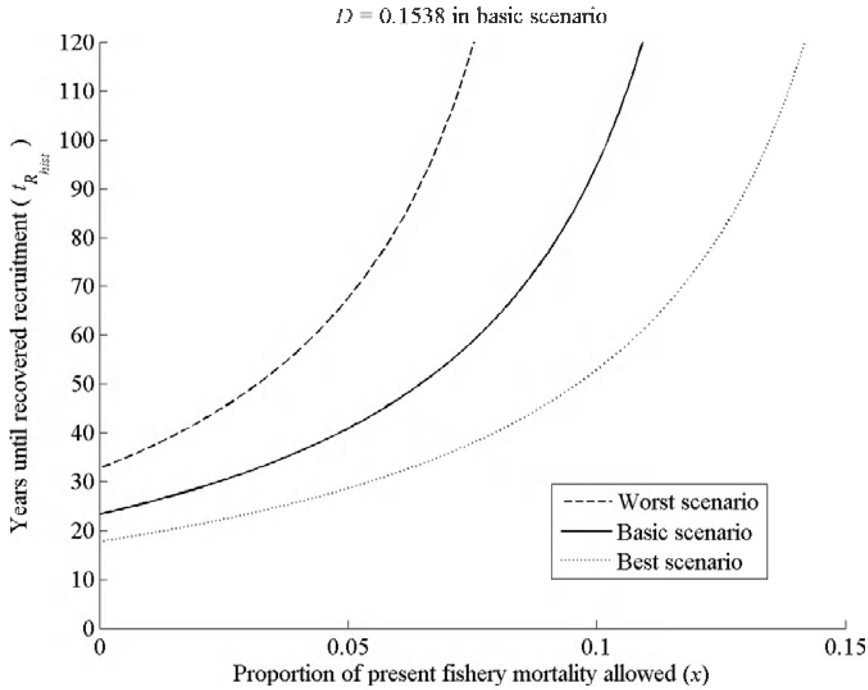

Figure 19. Sensitivity of the estimates of recovery time to 1% changes in parameter values for three scenarios with D= 0.1538 in the basic scenario.

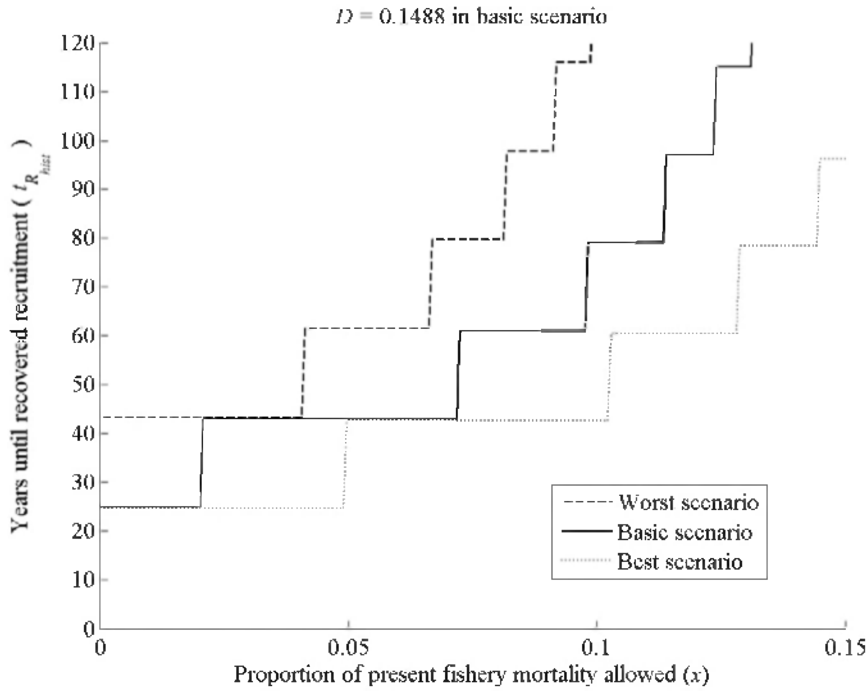

Figure 20. Sensitivity of the estimates of recovery time (rounded up) to 1% changes in parameter values for three scenarios with D= 0.1488 in the basic scenario.

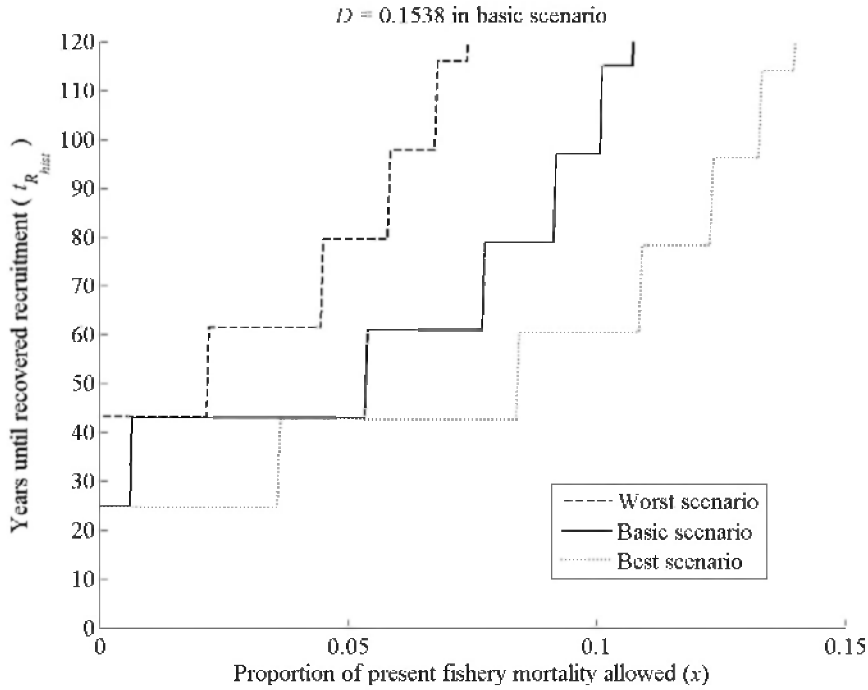

Figure 21. Sensitivity of the estimates of recovery time (rounded up) to 1% changes in parameter values for three scenarios with D= 0.1538 in the basic scenario.

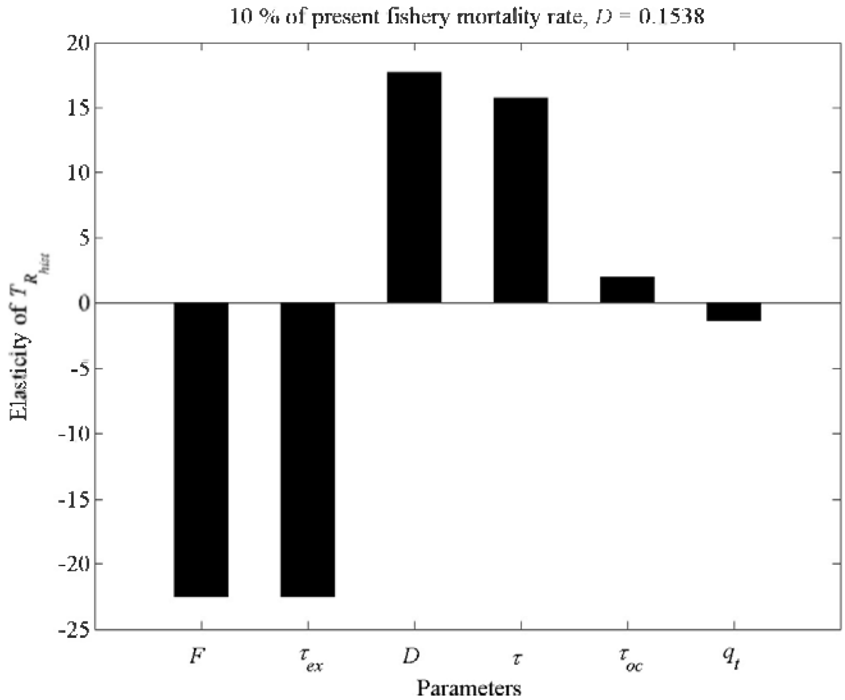

Figure 22. Elasticity of the number of generations needed for full recovery $\left(T_{R_{hist}}\right)$ for each of the parameters affecting that variable, using the basic set of parameter values.

The relative importance of the parameters for the resulting number of generations needed for full recovery ($T_{R_{hist}}$) is illustrated with its elasticity with respect to the parameters defining it (Figure 22). Proportional change of the parameters associated with fishery exploitation (F and τ_{ex}) has the largest proportional effects on $T_{R_{hist}}$. The length of the oceanic stage (τ_{oc}) and the estimate of the current recruitment in terms of the proportion of historic recruitment (q_t) have the smallest proportional effects on $T_{R_{hist}}$. In between, but still with rather large effect, comes the estimate of the past decline rate in the recruitment (D) and the estimate of the total time span of the continental stage (τ).

Figure 23 and Figure 24 illustrate the effect of the three different scenarios of parameter values on the expected recovery process over time since implementation of fishery restrictions, including the effect of the past recruitment decline. These scenarios were created in the same way with coordinated 1% changes of the parameters as for Figure 18, Figure 19, Figure 20 and Figure 21.

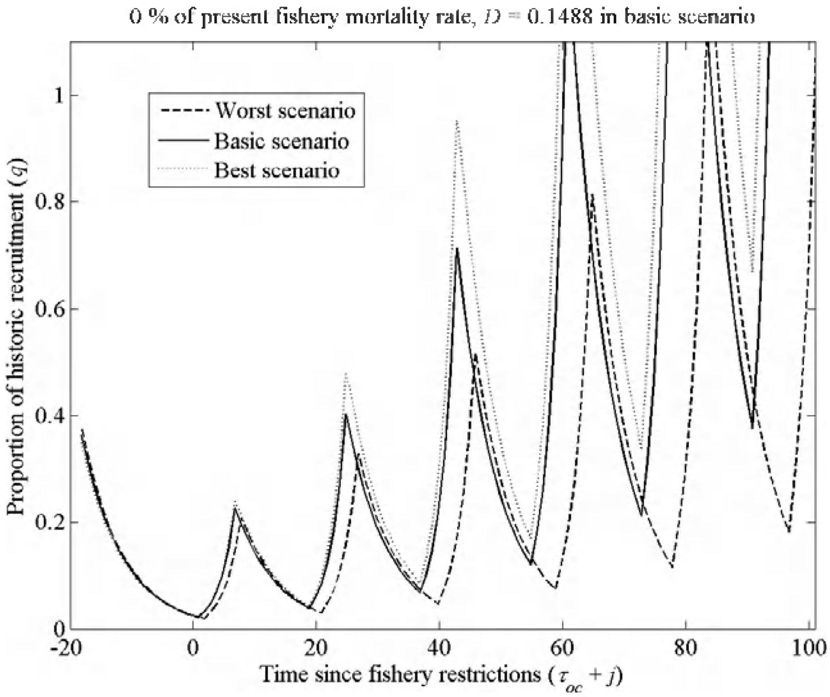

Figure 23. Sensitivity of the expected proportion (q) of the historic recruitment over time since fishery restrictions for three parameter scenarios with 1% changes of the parameters, with D = 0.1488 in the basic scenario.

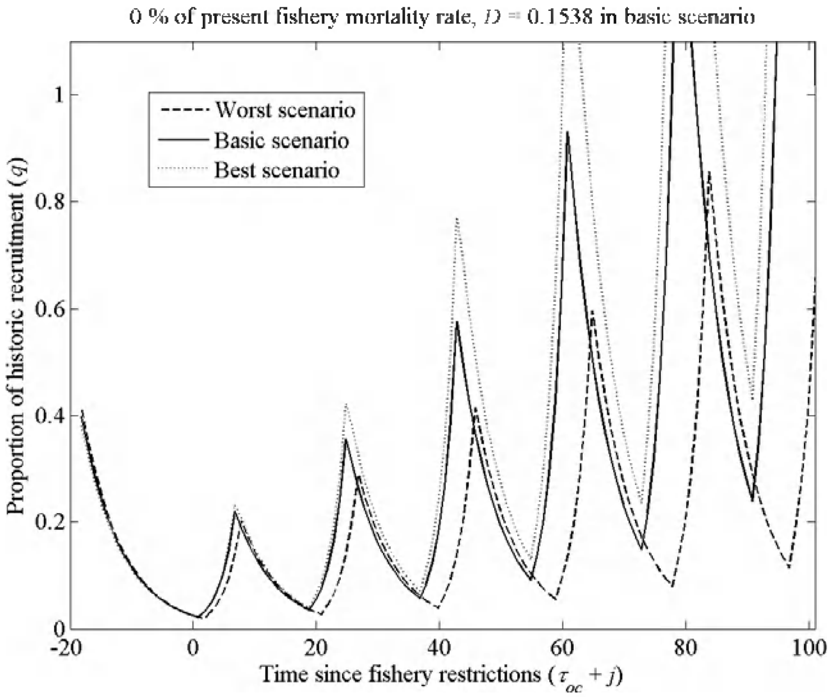

Figure 24. Sensitivity of the expected proportion (q) of the historic recruitment over time since fishery restrictions for three parameter scenarios with 1% changes of the parameters, with D = 0.1538 in the basic scenario.

Conclusions

- The eel is a slow growing animal; recovery of the stock will take considerable time, in the order of 20–200 years
- The length of the recovery period is strongly linked with the reduction in (anthropogenic) mortality achieved in executing a recovery plan. With only small reductions in mortality rates, no long-term recovery can be expected at all.
- Following an initial increase in spawner escapement due to a reduction in mortality in the exploited life stages, a prolonged period is expected, equal in length to the unexploited (undersized) life stage, in which no further recovery of spawner escapement is expected. This stable period should not be interpreted as a sign of no further success of the mortality reduction.
- Even when an initial increase in spawner escapement is observed, it can not be taken for granted that this will give a further long-term increase, as this depends on the level of the mortality reduction.

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Håkan Wickström contributed to this paper in various ways through several discussions and with comments on the text.

References

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Annex 3: Eel stock and fisheries reported by country – 2005

In preparation to the Working Group, participants of each country have prepared a so-called Country Report, in which the most recent information on eel stock and fishery are presented. These Country Reports aim at presenting the best information, which does not necessarily coincide with the official status. This Annex reproduces the Country Reports in full detail.

Participants from the following countries provided an (updated) report to the 2006 meeting of the Working Group:

- Norway
- Sweden
- Estonia
- Latvia
- Poland
- Germany
- Denmark
- Netherlands
- Belgium
- Ireland
- United Kingdom
- France
- Spain
- Italy

For practical reasons, this report presents the country reports in electronic format only (http://www.ices.dk/reports/ACFM/2006/WGEEL/Annex%203.pdf). In the printed version, these can be found on an enclosed CD.

Report on the eel stock and fishery in Norway 2005

NO.A. Authors

Caroline Durif, Asbjørn Vøllestad
University of Oslo
PO Box 1066, Blindern 0316 Oslo
Norway
Tel. +47 56 18 22 50. Fax: +47 56 18 22 22
Caroline.Durif@imr.no

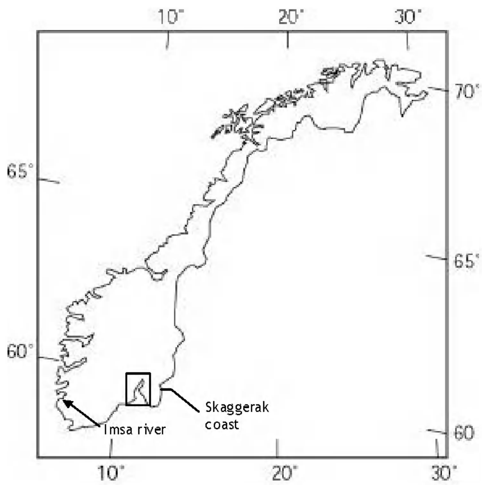
Jakob Gøsæter
Institute of Marine Research
Flødevingen Research Station, 4817 His,
Norway

NO.B. Introduction

Norway has abundant rivers and lakes (12% of the country is covered by lakes, rivers, swamp/marsh areas; 144 river systems with a catchment area ≥ 200 square km). 1104 river systems, in varied degrees, are regulated to produce hydroelectric power but 341 river systems are permanently protected against being exploited for the production of electric energy

The larger rivers of Norway are found in the east, where the country's longest river, the Glåma, has a course of 610 km (380 mi). With its tributaries, the Glåma drains about one-eighth of Norway's area. In northern Norway, the longest river is the Tana. Flowing north into the Barents Sea, it forms part of the frontier with Finland, and it is renowned as the country's most important salmon-fishing river.

The length of the continental coastline is 25 148 km (including fjords and bays). In total the Norwegian shoreline adds up to 83 281 km (including fjords, bays and islands).



NO.C. Fishing capacity

There is no tradition for eel consumption or harvesting in Norway, so fishing remains very limited. There are no official statistics available on number of fishermen. Eel fishing is single person operations. Small boats, usually with approx 100 fyke nets per boat. Working through summer along the coast (along the south and west coast).

NO.D. Fishing effort (number of nets, their usage, etc)

No official statistics – but log-books from a number of fishermen have been collected since 1975. Data have not been analyzed.

NO.E. Catches and landings

1) **Catch of glass eel -** Not allowed in Norway.

2) **Re-stocking quantities -** No stocking of eel in Norway.

3) **Catch of yellow and silver eel -** The official catch data consists of annual totals only. Almost all is yellow eels from coastal areas – the few tons of silver eels captured in fresh water are included as yellow eels. There is a minimum legal size of between 37 (silver eels) – 40 cm (yellow eels).

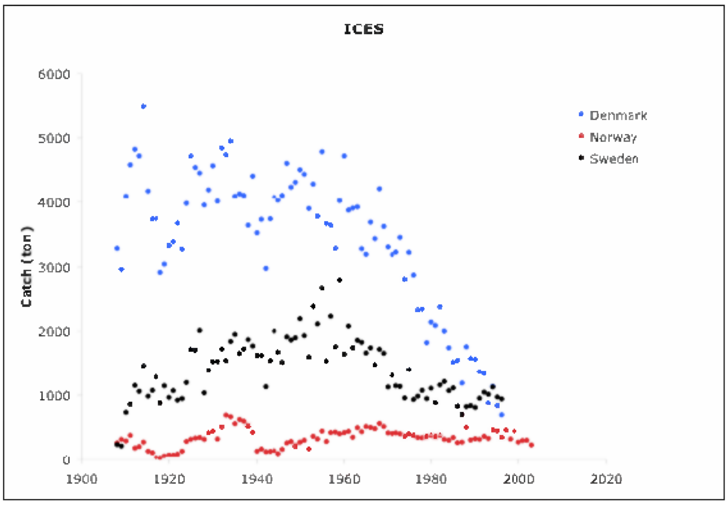


Figure 1.

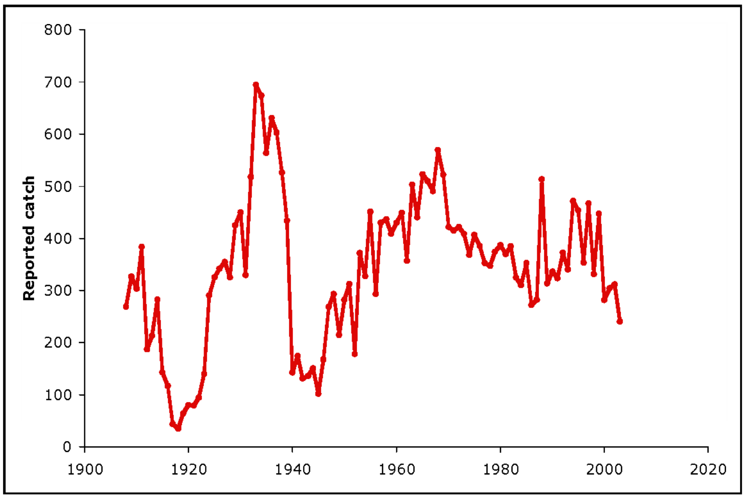


Figure 2. Long-term variation in reported catch (Norwegian official statistics as reported to ICES).

4) **Aquaculture production -** There are 15 registered companies for eel aquaculture, but most of them have ceased eel farming. Nonetheless, as there is no glass eel fishery or import, eels are caught at the yellow stage (none under 40 cm) and grown to a larger size.

5) **Catch of Recreational Fisheries -** A small unregulated fishery by recreational fishermen. No data.

NO.F. Catch per Unit of Effort

Logbooks from fishermen in the Skaggerak region are available since 1975, although data collection was discontinued. Data has not yet been adequately analyzed.

Preliminary results show that there is negative relationship between CPUEs and total effort. However, total effort has remained more or less constant over the years. CPUEs show a lot of variation but they have decreased since the 1970s. Although since the 1980, there has not been a significant decrease in the total catch, even after adjusting for effort. These results need further analyses and details from the fishermen's reports must be checked before these results are confirmed.

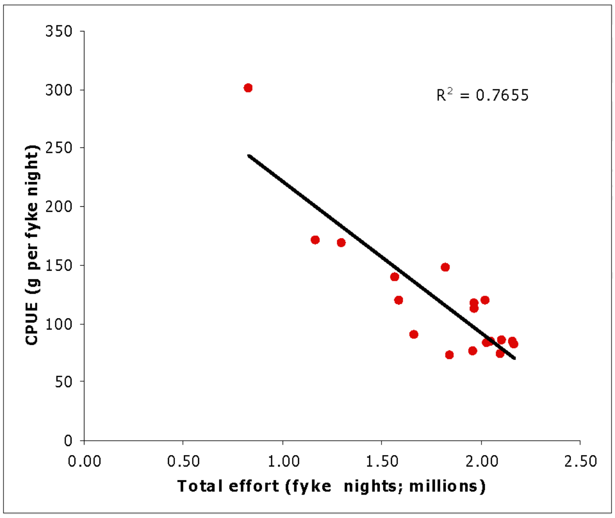


Figure 3. Data from fishermen logbooks. Relationship between CPUE and total effort (fyke nights * 10^6).

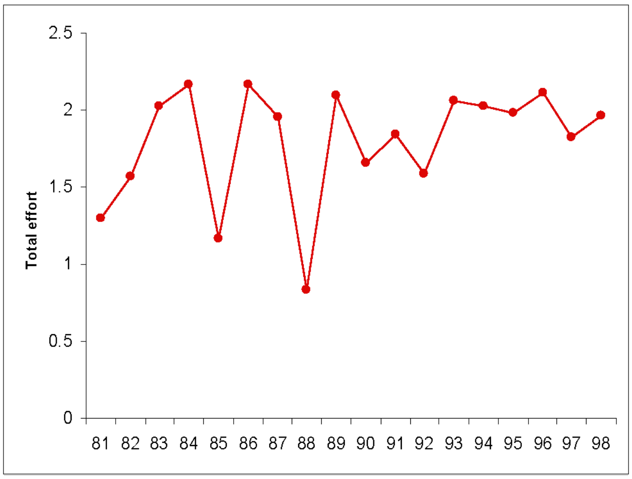


Figure 4. Data from fishermen logbooks. Total effort (fyke nights * 10^6)

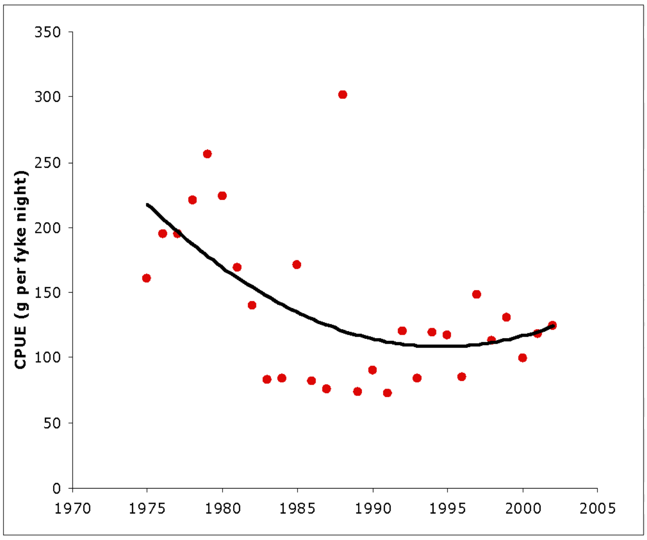


Figure 5. CPUE from fishermen logbooks for the period 1975- 2002. CPUE (g per fyke night).

NO.G. Scientific surveys of the stock

1) **Recruitment surveys** – only in the Imsa river (since 1975) – has been reported regularly to ICES (Wickstrøm, Moriarty or Dekker) by Asbjørn Vøllestad. Only elvers are reported here; they are counted every day. Large ascending eels are counted but not included in the data.

Table 1. Trap data from the river Imsa.

Year	Recruitment	Silver eels
1975	42945	5201
1976	48615	3824
1977	28518	5435
1978	121818	4986
1979	2457	2914
1980	34776	3382
1981	15477	2354
1982	45750	3818
1983	14500	3712
1984	6640	3377
1985	3412	4427
1986	5145	3733
1987	3434	1833
1988	17500	4274
1989	10000	2107
1990	32500	2196
1991	6250	1347
1992	4450	1394
1993	8625	681
1994	525	
1995	1950	
1996	1000	
1997	5500	
1998	1750	
1999	3750	
2000	1625	1749
2001	1875	4580
2002	1375	1850
2003	3775	2824
2004	375	2076
2005	1550	1894

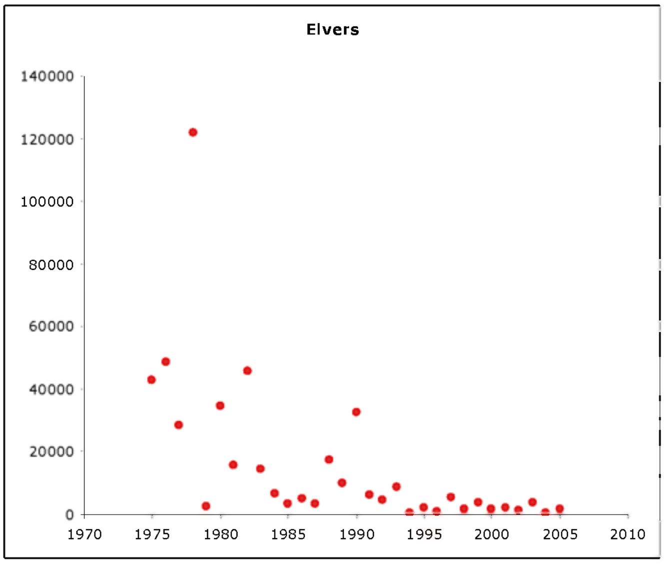


Figure 6. Total number of ascending elvers (number in trap) between 1975 and 2005 in the river Imsa.

2) **Yellow eel surveys** – A monitoring program in the Skagerrak coast has been initiated in the early 1900s. It consists of a series of beach seine (14 mm stretched mesh) hauls conducted once a year in September/October. The gear and sampling procedures are standardized. Initially, in 1919 and 1920, 87 stations were monitored of which 33 are still sampled. During the last 25 years, between 70 and 80 stations have been sampled yearly. Altogether 280 stations were visited.

Table 2. Sampling areas, sampling periods and number of stations taken during different time spans.

Area no	Area name	Sampling started	Number of stations >70 years	50 - 69 years	30 - 49 years	<30 years	Total stations	Present stations
1	Torvefjord	1919 -	2			3	5	5
2	Topdalsfjord	1920 -	3		5	11	19	8
3	Høvåg - Steindalsfjord	1919 -	7	2	6	9	24	9
4	Bufjorden - Grimstad	1919 -	2			3	5	5
5	Flødevigen	1919 -	2	1	1	8	12	2
6	Lyngør - Dybvåg	1962 -			4	4	8	5
7	Sandnesfjord, Risør	1919 -	7		1	1	9	8
8	Søndeledfjord, Risør	1919 -	5		9	11	25	8
9	Risør skerries	1919 -	2			5	7	4
10	Stølefjord, Kragerø	1919 -	2		1	2	5	2
11	Kilsfjord, Kragerø	1919 -	3		2	2	7	4
12	Hellefjord, Kragerø	1919 -		1	3	5	9	3
13	Soppekilen, Kragerø	1919 -	2	2	1	1	6	3
14	Grenlandsfjords	1953 -			9	11	20	10
15	Sandefjord	1962 -			5	8	13	6
16	Nøtterø - Tjøme	1936 -		5	2	4	11	7
17	Holmestrand area	1936 -		6	2	4	12	7
18	Vestfjord, Inner Oslofjord	1936 –		6	3	14	23	11
19	Drøbakk area	1936 -		4	1	5	10	5
20	Hvaler	1936 -		6	2	7	15	8

Table 3. Mean catch per beach seine sweep (number of eels) and coefficient of determination (R2) for a time-trend analysis using splines with l = 100.

Area no	Area	Mean catch	SE	R^2
1	Torvefjord	0.260	0.018	0.26
2	Topdalsfjord	0.444	0.024	0.44
3	Høvåg - Steindalsfjord	0.343	0.013	0.34
4	Bufjorden - Grimstad	0.172	0.248	0.17
5	Flødevigen	0.150	0.029	0.15
7	Sandnesfjord, Risør	0.143	0.026	0.14
8	Søndeledfjord, Risør	0.249	0.020	0.25
9	Risør skerries	0.154	0.010	0.15
10	Stølefjord, Kragerø	0.246	0.035	0.25
11	Kilsfjord, Kragerø	0.177	0.027	0.18
12	Hellefjord, Kragerø	0.257	0.022	0.26
13	Soppekilen, Kragerø	0.139	0.028	0.14
14	Grenlandsfjord	0.425	0.080	0.43
15	Sandefjord	0.096	0.033	0.10
16	Nøtterø - Tjøme	0.160	0.026	0.16
17	Holmestrand area	0.267	0.037	0.27
18	Vestfjord, Inner Oslofjord	0.389	0.068	0.39
19	Drøbak area	0.237	0.033	0.24
20	Hvaler	0.280	0.029	0.28

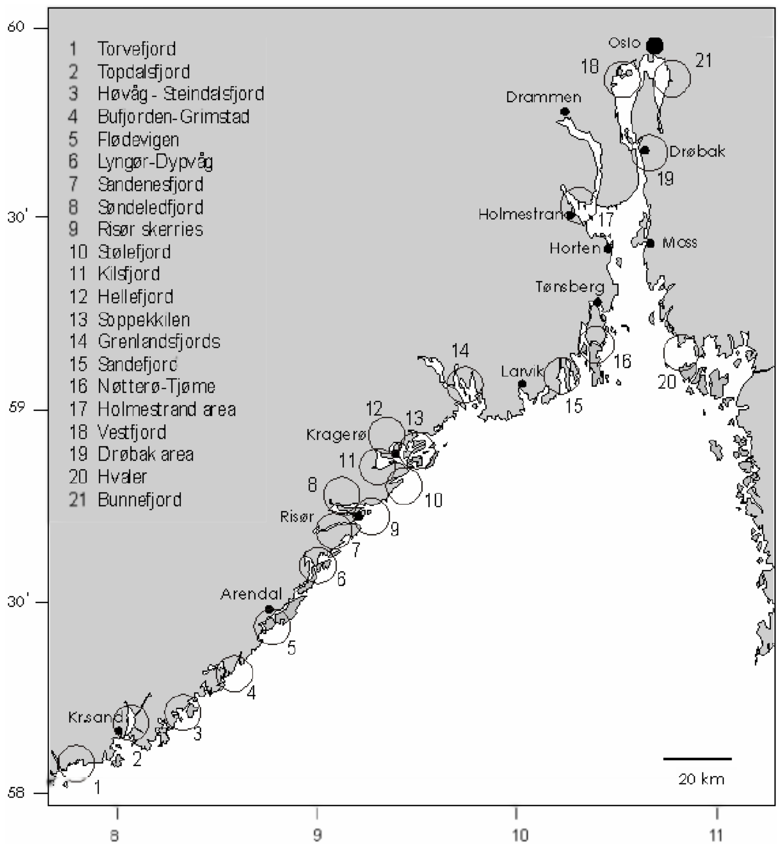


Figure 7. Map of Skaggerak sampling areas stations. Only areas still sampled are shown.

The stations that have been sampled every year from 1919 onwards were pooled to calculate averages of the observed catch data as well as the predicted trends. The mean trend was based on predicted values from the non-linear spline functions. In order to pool data across areas we standardized both observed catches and trends. An alternative trend function was calculated following the cumulated sums (Ibanez *et al.*, 1993). Both of these two independent trend analyses give almost the same result, therefore they can be trusted.

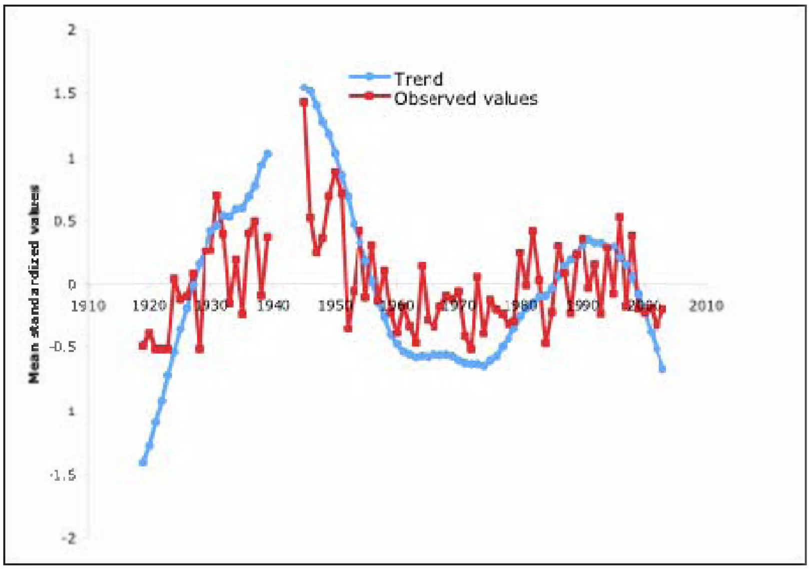


Figure 8. Observed catch data and predicted time trend.

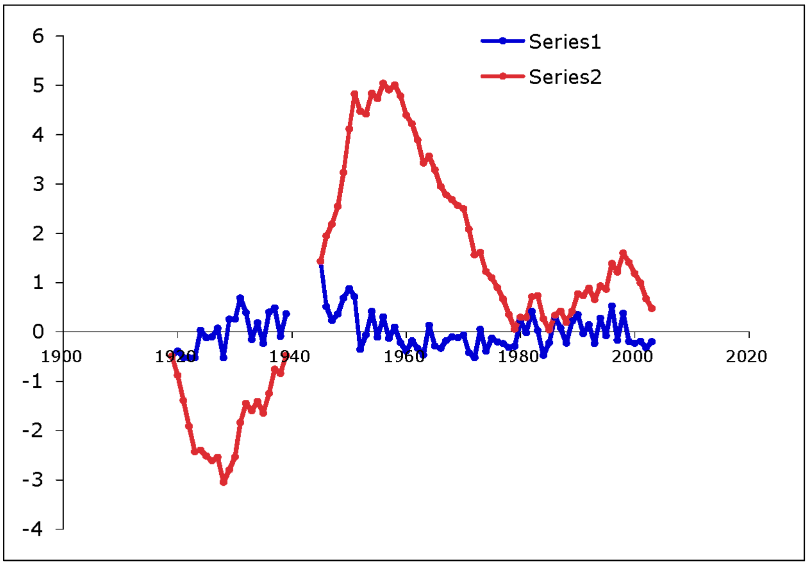


Figure 9. Alternative trend analysis using a cumulated function, following Ibanez *et al.* (1993). Series 1 is the original catch data (standardized), while series 2 is the trend function.

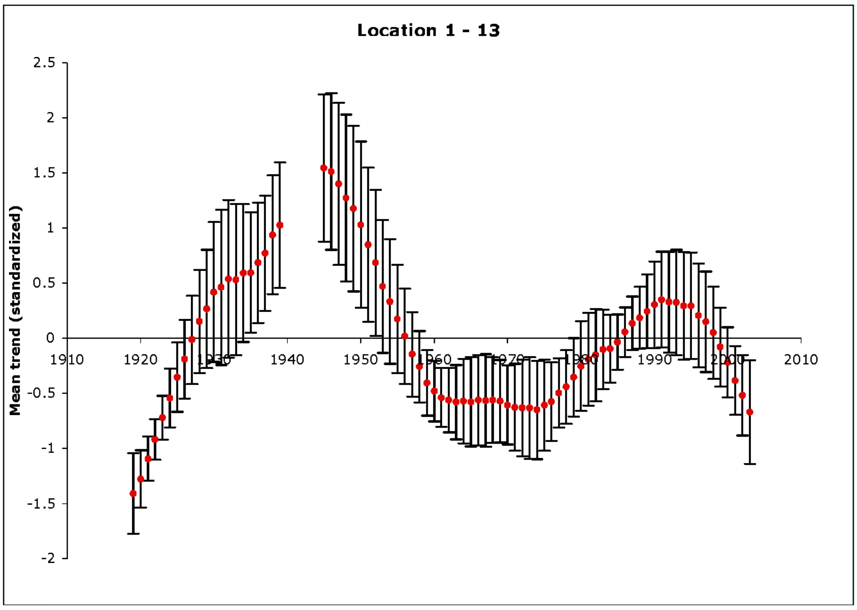


Figure 10. Estimated trend with 2SE as variance measures.

3) **Silver eel surveys** – This corresponds to data from the river Imsa (since 1975). Silver eels are caught in a Wolf Trap at the river's mouth. Eels are counted every day. Data is missing 1994 and 1999.

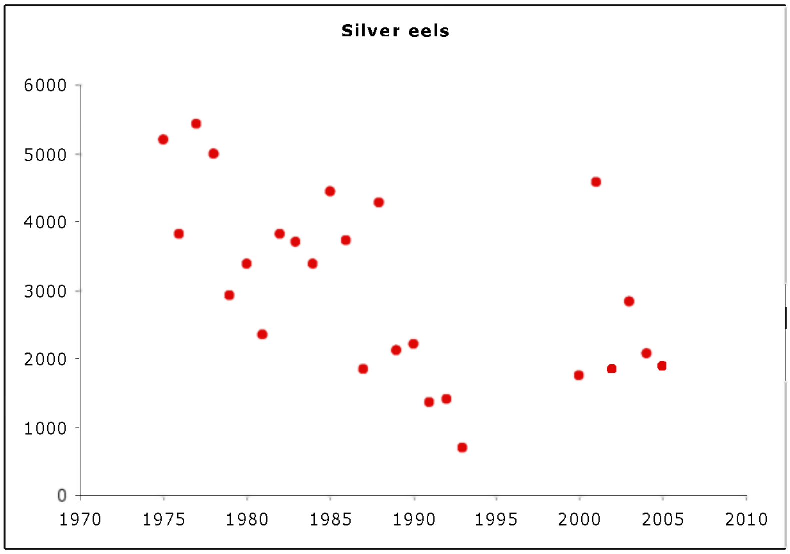


Figure 11. Total number of descending silver eels (number in trap) between 1975 and 2005 in the river Imsa.

NO.H. Catch composition by age and length

The only relevant data is work done by Asbjørn Vøllestad, data on brackish water eels in the Oslo fjord – published a long time ago.

NO.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity

There is no standardized sampling. There may be some eel data available but nothing is easily available to be summarized.

NO.J. Other sampling. Cormorants, etc.

Probably nothing relevant.

Report on the eel stock and fishery in Sweden 2005

SE.A. Authors

Håkan Wickström
Swedish Board of Fisheries, Institute of Freshwater Research
SE-178 93 DROTTNINGHOLM, Sweden
Tel. +46 8 6990607. Fax: +46 8 6990650
hakan.wickstrom@fiskeriverket.se

Jan Andersson, Swedish Board of Fisheries, Institute of Coastal Research

Joakim Hjelm, Swedish Board of Fisheries, Institute of Marine Research

Johan Modin, Swedish Board of Fisheries, Institute of Coastal Research

Stefan Sjögren, Swedish Board of Fisheries, Institute of Freshwater Research

Håkan Westerberg, Swedish Board of Fisheries, HQ

Mårten Åström, Swedish Board of Fisheries, Institute of Freshwater Research

This report was completed in January 2006; most data are from 2005 and some from 2004.

SE.B. Introduction

Eel fisheries in Sweden occur in most coastal waters from the Norwegian border in Skagerrak to about 61°N in the Baltic Sea. In the beginning of the 20th century eel fishery was practised also along the northern most parts of the Baltic Sea. There is also a considerable eel fishery in a number of freshwater lakes. Both yellow and silver eels are fished, but there is no tradition (it is also against the law) to catch glass eels or elvers. The Government manages and controls the fishery in most marine areas and in the five largest lakes using a few management instruments like minimum legal size, gear restrictions etc. There is also a substantial fishery for eels in privately owned waters both in coastal areas as in freshwater. In most lakes, except the five largest ones, the Government has almost no jurisdiction to regulate the fishery for any species. In most fisheries the eels are fished in combination with other species. Depending on the type of water (fresh or brackish, west or east coast etc.) species as pike-perch, perch, pike, cod, turbot, whitefish and flounders are important by-catch in the eel fisheries, though not worth enough alone for a viable fishery without eel as the main target species. The distribution of the commercial Swedish eel fishery could be simplified as follows:

SE.B.1. The present division in eel fishing areas

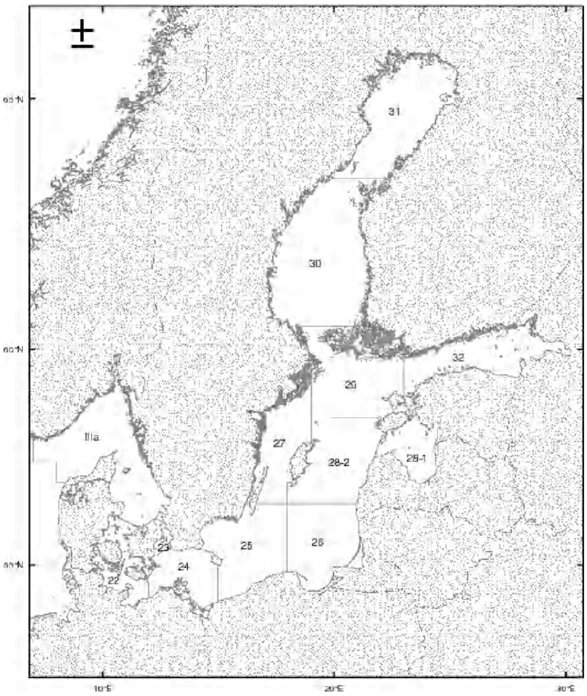


Figure SE.1 ICES Subdivisions in the Baltic area

SE.B.1.1.

The Swedish West Coast from the Norwegian border (59°N, 11°E) to Öresund (56°N, 13°E), i.e. 320 km in Skagerrak and Kattegat (ICES Subdivisions 20 and 21).

Along this open coast there is an important fishery for yellow eels. Accordingly the minimum legal size is as small as 370 mm. Mostly fyke nets (single or double) are used, but also baited pots during certain periods of the year. The landings in this fishery are reported through the EU-logbook system as well as from contract notes delivered from authorised wholesaler to the Board of Fisheries. During the last six years the annual commercial catch of mostly yellow eels was about 210 tons.

SE.B.1.2.

Öresund, i.e. a 110 km long Strait between Sweden and Denmark (ICES Subdivision 23).

In this area both yellow and silver eels are caught using fyke nets and some large pound nets. The northern part of Öresund is the last place where silver eels originating from the Baltic Sea could be caught before they disappear into the open seas. In recent time about 50 tons of yellow and silver eels were caught annually by Swedish fishermen in Öresund. As Öresund is shared with Denmark special rules apply, among other things a very small minimum legal size (350 mm).

SE.B.1.3.

The Swedish South Coast from Öresund to about 56°N, 15°E.

This is a 315 km long coastal stretch of which more than 50 % is an open and exposed coast (ICES Subdivisions 24 and 25). Silver eels caught in a traditional fishery using large pound nets dominate the catch. This is the “Swedish Eel Coast” where there are a lot of activities, restaurants and tourism based on the eel and the eel fishery. Some yellow eels are also caught, mainly in the archipelagos to the east. The minimum legal size for yellow eels is 600 mm in this area. In recent years about 98 tons of yellow and silver eels were caught annually by commercial fisheries in this area.

SE.B.1.4.

The Swedish East Coast from about 56°N, 15°E to 59°30’N, 18°50’°E.

Along this 450 km long stretch both silver and yellow eels are fished using both fyke nets and large pound nets. Also in this area 600 mm is the minimum legal size for yellow eels. About 115 tons of yellow and silver eels are caught annually in this area.

SE.B.1.5.

Freshwater lakes.

There are sparse stocks of eels in most drainage basins all over Sweden except in the high mountain areas. However, nowadays most eels are fished with pound nets in Lakes Mälaren, Vänern and Hjälmaren. A number (at least 17) of smaller lakes, mainly situated in the southern part of the country, add another 25 % to the catch in the large lakes. In total about 100 tons of eels are caught annually by the commercial eel fishery in lakes. In the five largest lakes where the Government has jurisdiction 600 mm is the minimum legal size for yellow eels. For silver eels no size limit applies.

The fishery in freshwater is probably to a large extent based on stocked eels since the natural

immigration to these lakes should be small today. Stocking material is either yellow eels in the size of 0.1 kg that has been caught on the Swedish West Coast or imported newly pigmented eels. In the three large lakes Vänern, Mälaren and Hjälmaren the fishermen must have a permit from their respective County Board to fish with fyke nets as soon they are deeper than 1,5 m. With that they are also obliged to leave catch statistics to the Board of Fisheries on a monthly basis. In the smaller lakes the professional fishermen fish in privately owned waters but as they have a fishing license they have to deliver catch statistics but only on a yearly basis. The fishing is usually carried out from small boats with a length of 5–6 m.

Eel fishing may also occur in additional lakes and some streams where traps have been built. The extent of this fishery is totally unknown, but it is probably of very little importance today. The recreational fishing of eel in small freshwaters is probably of even smaller importance, even if long line fishing exists in some lakes.

Besides what is described above there is a more or less unknown and uncontrolled fishery by non-commercial fishermen, by recreational fishers using professional fishing gears and by true anglers. This fishery has been estimated four times since 1990 by using questionnaires and amounts according to the most recent poll in 2005 to 491 tons of which 388 came from the sea and 103 from freshwater (Fiskeriverket, 2005). As the estimates for eel are based on very few replies the uncertainties are large.

The commercial catch of eels in Sweden in 2004 was then about 473 tons from the sea and 100 tons from freshwater, i.e. about 573 tons in total. The recreational catch adds another 491 tons making a grand total of about 1000 tons. A very recent correction of the estimate of the recreational catch is discussed in SE.E.5. In short the new estimate of the recreational catch is 249 tons only. Thus the grand total might be about 800 tons.

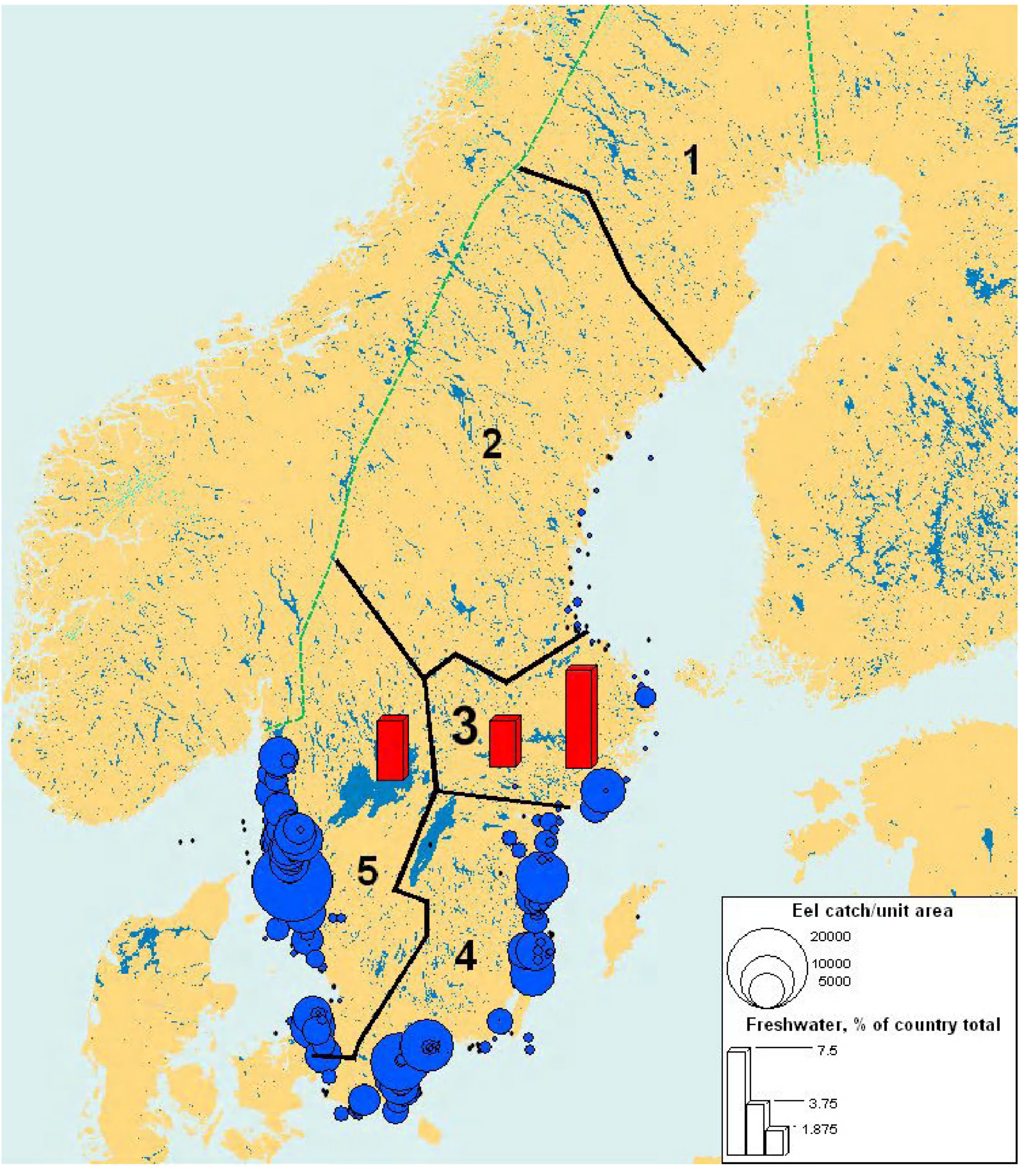


Figure SE.2. The commercial catch in year 2004 expressed per unit area (squares of 1 minute latitude * 1 minute longitude). The catch from the major Swedish lakes is given as their respective percentages of the total Swedish catch. The River Basin Districts are schematically indicated (as 1–5).

SE.B.2. River Basin Districts (RBD)

The Water Framework Directive subdivides Sweden into 5 separate River Basin Districts, of which two extend to some importance beyond our borders (Figure SE.2). These are the RBD nos.:

1) **Bottenvikens vattendistrikt** (or BBAY) shared with Finland (small part to the north). This RBD includes all drains to **the northern part of the Gulf of Bothnia**. Eels do occur in this RBD, but are nowadays quite rare. Drainage area: 154 702 km^2.

2) **Bottenhavets vattendistrikt** (or BSEA) that drains into **the southern part of the Gulf of Bothnia**. Eels occur also in this area. During the early 20th century there was a substantial eel fishery in the southern parts of this RBD. At the present time the commercial catches are small. Drainage area: 146 667 km^2.

3) **Norra Östersjöns vattendistrikt** (or NBAL) drains **the central parts of Sweden**, including two of the five largest lakes in Sweden. Eels and eel fisheries are quite abundant in this RBD and in addition to a reduced natural recruitment both lakes and coastal areas are frequently stocked with imported elvers. Drainage area: 44 212 km^2.

4) **Södra Östersjöns vattendistrikt** (“**the Southern Baltic Sea**”) (or SBAL) drains a large part of southern Sweden and includes a vast number of lakes with eel and also the coastal waters where there was and still is an important and traditional fishery for silver eels. Several lakes are stocked annually also in this RBD. Drainage area: 59 939 km^2.

5) **Västerhavets vattendistrikt** (“**the North Sea**”) (or WEST) shared with Norway (to a minor part). This RBD includes the large Lake Vänern and numerous lakes and streams were eels still are quite abundant. Several lakes are stocked annually in this RBD. Drainage area: 73 330 km^2.

The main parts of the eel fisheries in Sweden are concentrated to RBD 3, 4 and 5. However, the catch of silver eels along the coast of RBD 4 is known to come from eels that have lived and grown in almost any part of the Baltic Basin.

SE.C. Fishing Capacity

SE.C.1. Coastal waters

Table SE.a. Number fishermen by RBD with eel landings (all gears)

	BBAY	BSEA	NBAL	SBAL	WEST	ALL
1999	0	27	37	162	176	402
2000	3	28	35	135	139	340
2001	0	27	27	134	142	330
2002	1	23	28	118	149	319
2003	1	29	28	134	139	331
2004	1	31	29	127	134	322
2005	0	30	33	143	137	343
mean	1	28	31	136	145	341

Reliable information on fishing capacity can only be presented as the number of individual fishermen reporting catches in the official statistics. The numbers in Table SE.a do not consider the size of the reported catch of the individual fisherman or which life stage is the primary target. The Southern Baltic and the West Coast (North Sea) RBD´s were the dominating districts with equal shares in 1999–2005.

SE.C.2. Freshwater

From the inland eel fishery, statistics exists from all fishermen that have fishing licenses or a permit to use deeper fyke nets and pound nets in Lakes Vänern, Mälaren and Hjälmaren. There are no companies operating in the lakes but the fishing is carried out by single fishermen or in very few cases by two fishermen together. The number of fishermen in the lakes that reported catch of eels is shown below, per lake or group of lakes and per RBD.

Table SE.b

LAKE	VÄNERN	MÄLAREN	HJÄLMAREN	OTHER LAKES	TOTAL
Number of fishermen	23	32	28	21	104

RBD	3	4	5	TOTAL
Number of fishermen	61	10	33	104

SE.D. Fishing Effort

SE.D.1. Coastal waters

The official catch statistics at the present do not give reliable information on the effort in the fishery for eel.

SE.D.2. Freshwater

In the eel fisheries in the three lakes mentioned above, the type of net used varies both between and within lakes. There is no other information than that the nets are deeper than 1, 5 m. The nets have a leader which may be 50-300 m long and the depth of the nets varies between 3 and 20 m.

The temporal resolution of the statistics is on a daily basis in the larger lakes and on a yearly basis in the smaller lakes. The maximum number of all kinds of fyke nets used in 2004 is shown in the table below.

Table SE.c

LAKE	VÄNERN	MÄLAREN	HJÄLMAREN	OTHER LAKES	TOTAL
Number of net permits	118	167	171	133	589

During 2004 the following number of pound nets ("bottengarn") were used on a daily average in four of our lakes.

Table SE.d

LAKE	NUMBER OF POUND NETS USED (DAILY AVERAGE OVER THE YEAR)
Vänern	49
Vättern	5
Mälaren	76
Hjälmaren	81
Total	212

The abundance of fyke nets is largest in the shallow Lake Hjälmaren, which area is about 20% of the area of Lake Vänern and 40% of the area of Lake Mälaren.

SE.E. Catches and Landings

SE.E.1.

Not valid as there are no glass eel fisheries in Sweden (neither viable nor legally allowed).

SE.E.2. Restocking

Restocking inland and coastal waters with glass eels, elvers, bootlace or medium-sized yellow eels, in order to improve the local eel fishery practised since many years in Sweden, in order to improve the local eel fishery. Already in the beginning of the 20th century elvers were imported from England (via Hamburg, Germany). Since the beginning of the 1970's a more regular restocking programme has been in operation. From the beginning mostly medium-sized yellow eels from the Swedish West Coast were used but the proportion of imported and quarantined elvers has slowly increased. Most of the costs are covered by the Government using different funds destined for fish stock management (e.g. funds imposed by the water-rights courts), but also the commercial fishermen's association and local societies make a substantial contribution. In 1998 ca. 1,1 million € was spent on restocking while only about 0,5 million € was spent in 2005. A database over the amounts of stocked eels in separate water bodies is under construction. During 2000–2005 the following quantities (preliminary data) of eels were restocked:

Table SE.e. Restocked quantities per RBD in 2000–2005.

RBD	2000		2001		2002		2003		2004		2005		Total	
	G (pcs)	M (kg)	G (pcs)	M (kg)	G (pcs)	M (kg)	G (pcs)	M (kg)	G (pcs)	M (kg)	G (pcs)	M (kg)	G (pcs)	M (kg)
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	32 000	0	111 460	0	138 850	0	71 819	0	354 129	0
3	249 955	24 183	183 820	13 550	374 390	5 388	377 210	6 724	114 292	4 200	185 496	3 662	1 485 163	57 707
4	156 560	33 298	136 560	21 031	259 633	15 330	148 860	16 118	231 480	12 493	286 778	1 924	1 219 871	100 194
5	723 839	3 238	317 330	4 344	407 336	2 570	0	1 960	497 608	1 679	189 780	292	2 135 893	14 083
Not defined	205 455	0	209 176	0	311 969	0	3 736	0	69 626	0	0	0	799 962	0
Total	1 335 809	60 719	846 886	38 925	1 385 328	23 288	641 266	24 802	1 051 856	18 372	733 873	5 878	5 995 018	171 984

Today "glass eels" (G) implies quarantined and pre-grown elvers of about one gram each and the medium-sized yellow eels (M) are about 90 gram each.

SE.E.3. Catch of yellow and silver eel

SE.E.3.1. Landings (data from contract notes)

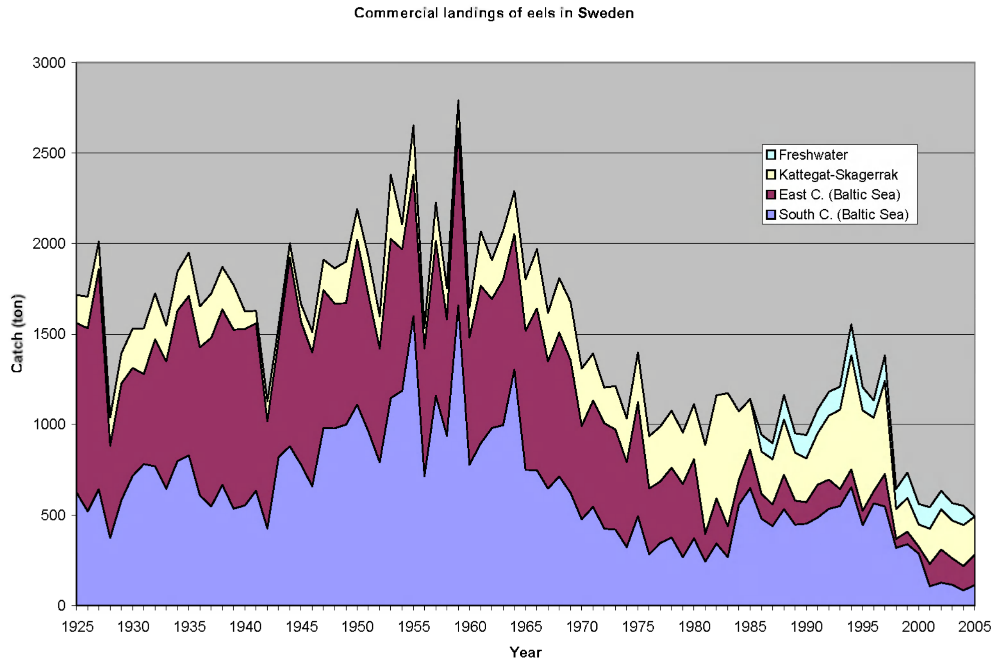


Figure SE.3. Commercial landings of eel in Sweden (Kattegat-Skagerrak corresponds to RBD 5, data come from the contract notes). The data behind this figure is given in the Appendix (Table SE.m).

SE.E.3.1. Freshwater

In inland waters the catch statistics is reported and stored at the Swedish Board of Fisheries. No distinction is made of different life stages of the eels caught. A recent sample from the commercial catch in 6 lakes showed that about 80% were silver eels and 20% yellow or half-silver. The average size was 0,96 kg with a range from 0,25 to 2,5 kg. Eels do silver at different sizes in different lakes. Yearly catches for the period 2000–2004 is shown below.

Table SE.f. Commercial catch in freshwater (tons)

Year	Vänern	Mälaren	Hjälmaren	Other lakes	Total
2000	22	38	20	34	114
2001	25	38	23	32	118
2002	22	34	18	29	103
2003	23	31	16	26	96
2004	23	38	18	28	107
2005	na	~42	~18	na	na

The catches have varied fairly little during the period.

SE.E.3.2. Freshwater per RBD

RBD 1. There are no data or catches reported from freshwater in this district. This is in accordance with the low natural recruitment to this remote part of Sweden and to the fact there are no regular restocking activities in operation. There are more than 15 157 lakes with a total area of 9919 km^2 in this RBD.

RBD 2. Eels do occur in this area, but there is only a small fishery for them. There are no data from freshwater available. There are more than 12 132 lakes with a total area of 10 212 km^2 in this RBD.

RBD 3. From this district there are catch data from four lakes, Mälaren, Hjälmaren, Sottern and Öljaren. The total reported catch was 56,7 tons in 2004. There are more than 2474 lakes with a total area of 3375 km^2 in this RBD.

RBD 4. In this district there are catch data from nine lakes. In total 8,4 tons were caught in 2004. There are more than 3970 lakes with a total area of 4899 km^2 in this RBD.

RBD 5. There are commercial eel fisheries in five lakes in this district. The main part comes from the huge Lake Vänern (5650 km^2) with 22,9 tons and the total reported catch was 37,2 tons in 2004. There are more than 4900 lakes with a total area of 9734 km^2 in this RBD.

SE.E.3.3. Coastal waters

Total eel catches reported to the log-book system averaged 493 tons in 1999–2005. As the system allows reports of undefined eel catches, the relation between life stages is not exactly known. It is estimated that the shares are equal for yellow- and silver eel. The duty to present logbooks was not mandatory for fishing on private waters until 2005. This implies that catches in the Baltic Sea silver eel fishery is underestimated. The degree of underestimation is not known.

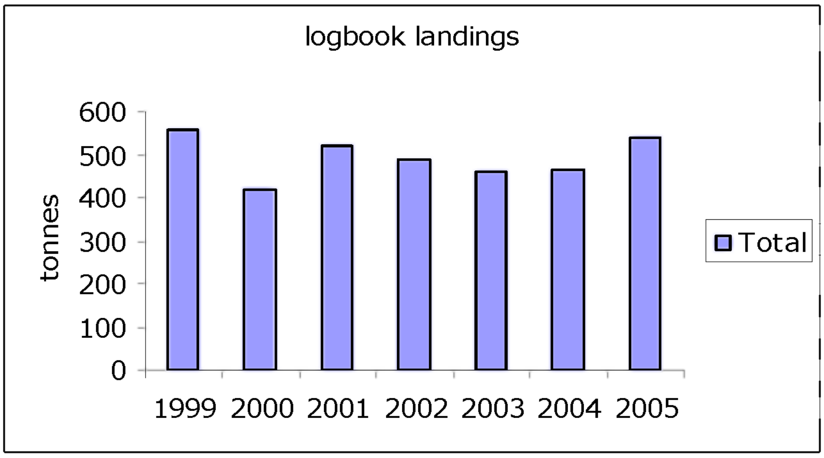


Figure SE.4. Total catches in the Swedish eel fishery as reported in logbooks in 1999–2005.

When catches are separated on RBD´s, the dominance for the Southern Baltic and the West Coast districts is evident (see Figure SE.5). The catches in Southern Baltic RBD is dominated by silver eel from pound nets, while the catches from the West coast RBD concerns mainly fyke net catches of yellow eel.

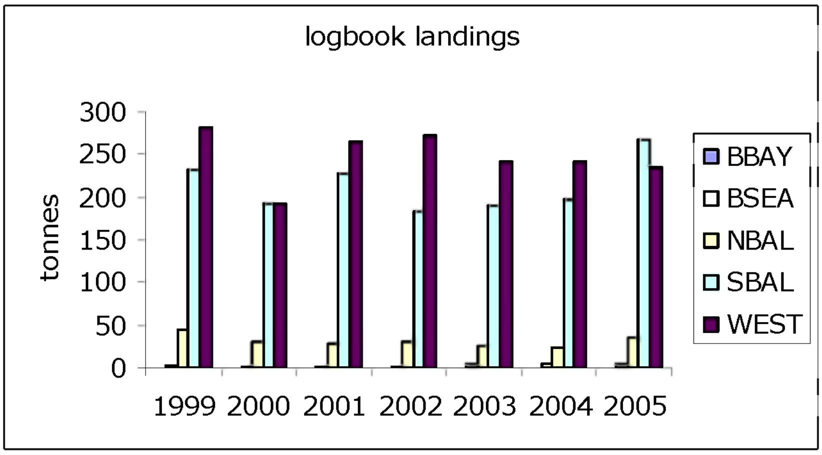


Figure SE.5. Total logbook landings separated on RBD´s in 1999–2005.

SE.E.4. Aquaculture

Different sources reported slightly diverging results for the Swedish aquaculture industry:

Table SE.g. Production of eels in aquaculture from 1983 in Sweden. (SCB 1 and SCB 2 denote one official (SCB 2) and one "unofficial" (SCB 2) version (SCB 2005)

Aquaculture production (tons/year)	Data source		
	*SCB 1	*SCB 2	FAO Fishstat
1983	2	2	2
1984	12	15	12
1985	41	47	41
1986	51	59	51
1987	90	104	90
1988	203	233	203
1989	166	190	166
1990	157	179	157
1991	141	160	141
1992	171	195	171
1993	169	192	169
1994	160	182	160
1995	139	158	139
1996	161	184	161
1997	189	215	189
1998	204	232	204
1999	222	253	222
2000	273	311	273
2001	200	228	200
2002	167	190	167
2003	170	194	170
2004		158	

*SCB (Statistics Sweden) is the official source of statistics in Sweden.

SE.E.5. Recreational Fisheries

In addition to commercial fisheries, the sports/recreational/household fisheries contribute significantly to the total landings of eel. The recreational fisheries have been studied in four surveys, most recently in 2005, by means of questionnaires (Fiske 2005-Report by the

Swedish Board of Fisheries and Statistics Sweden). Although biased when it comes to the representativeness in the collected data (those who do fish tend to answer questionnaires whereas those who do not fish do not bother) the amount of eel caught by sport/recreational/household fishery in the whole country is estimated to 491±218 tonnes per year- about the same amount as the commercial fisheries.

The results and conclusions from this study have recently been subject for a provisional recalculation. It seems that due to the problems mentioned above the recreational catch of eels was overestimated with 97%. The new and corrected results are shown below.

Table SE.h.

Fishing district	Skagerrak & Kattegat	The Sound	S. Baltic Sea	Middle Baltic Sea	The Gulf of Bothnia	Others	Total
Corresponding RBD	5	4	4	~3	~1-2	na	
Corrected estimated catch (kg)	18 283	19 765	60 549	81 597	3 364	65 840	249 398

Adding up these 249 tons of eel from recreational fisheries to the commercial catch ends in a total Swedish catch of about 800 tons.

SE.F. Catch per Unit of Effort

SE.F.1. Freshwater

In inland eel fisheries CPUE data can be calculated on a yearly basis in respective lake, but the dataset is not accessible at the moment. As the type of nets may shift over time it may, however not seem to be very meaningful to do that. In Lake Mälaren and Hjälmaren for example the fishermen tend to replace fine mesh fyke nets, which catches pike, pikeperch and perch in addition to eel, with nets with a coarser mesh size to be able to fish for pikeperch more effectively. The data has never been used for stock assessment as the fishery is based mainly on stocked individuals.

SE.F.2. Marine areas

Selected companies have provided detailed catch statistics from the pound net fishery for silver eel in the Baltic Sea since the late 1950´s. The trend in CPUE is negative in the longest time series, corresponding to a 50% decrease if recent years are compared to the highest levels in the early 1960´s. The series starting in the early 1970´s are diverging, although the changes over time are small (Figure SE.6)

Fishing for eel with fyke nets is of minor importance compared to pound nets on the Swedish coast of the Baltic Proper. Nevertheless it operates in a rather conservative way since several decades and long time series exist from a few companies. Since determination of life stage by the fishermen may have been influenced by market demands rather than being based on biology, catch per unit effort is presented together for yellow- and silver eel. The CPUE was stable in both areas over the years (Figure SE.7). In the southern part of the county of Östergötland yellow eel became less abundant in the mid-1990´s, but a larger proportion of silver eels compensated this decrease. In the northern county of Kalmar, silver eel became more abundant in fyke net catches in the early 1990´s. In this area the silver eel catches in 2005 were the biggest ever recorded in fyke nets, and fishers all over the area reported good catches.

From 1990 the minimum legal size for landing of yellow eel was raised in two steps from 53 to 60 cm. This may had an influence on the CPUE in fyke nets. The mean weight for yellow eel landings was close to 600 g in recent years.

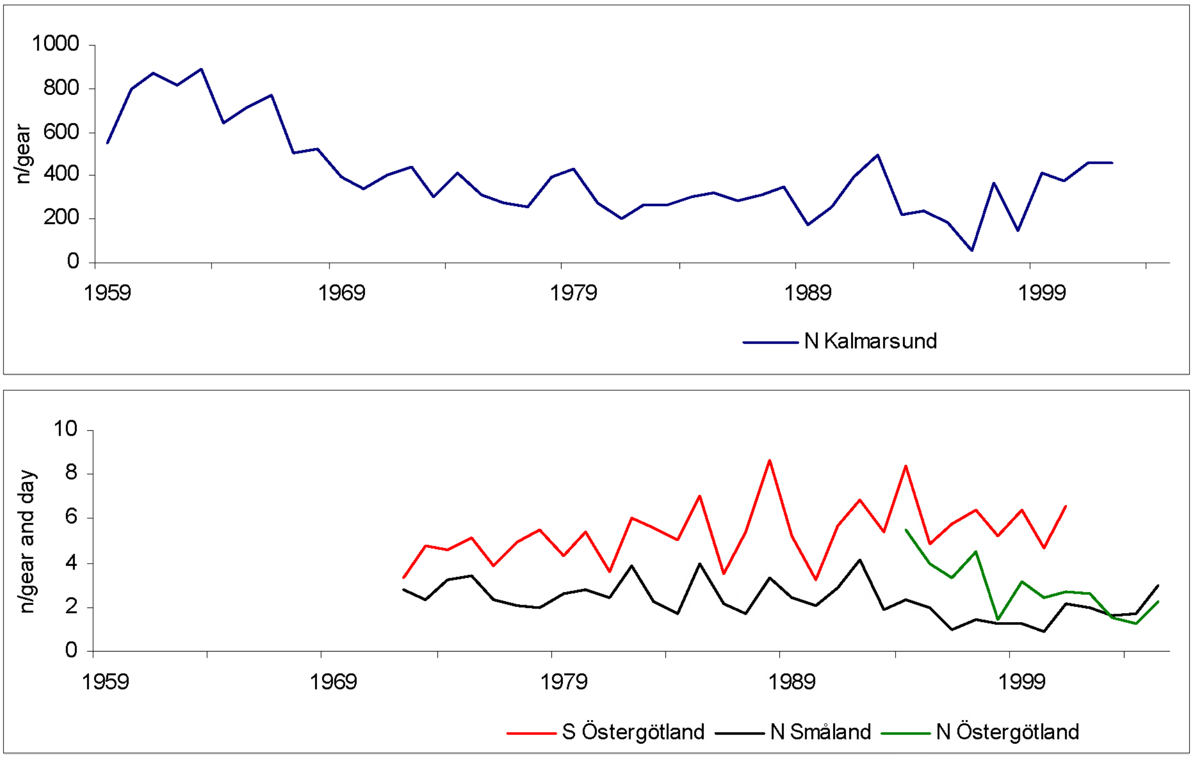


Figure SE.6. Time trends in pound net catches of silver eel in four subareas in Swedish RBD 4 (Southern Baltic). The subareas are all located in ICES subdivision 27 on the Swedish coast of the Baltic Proper.

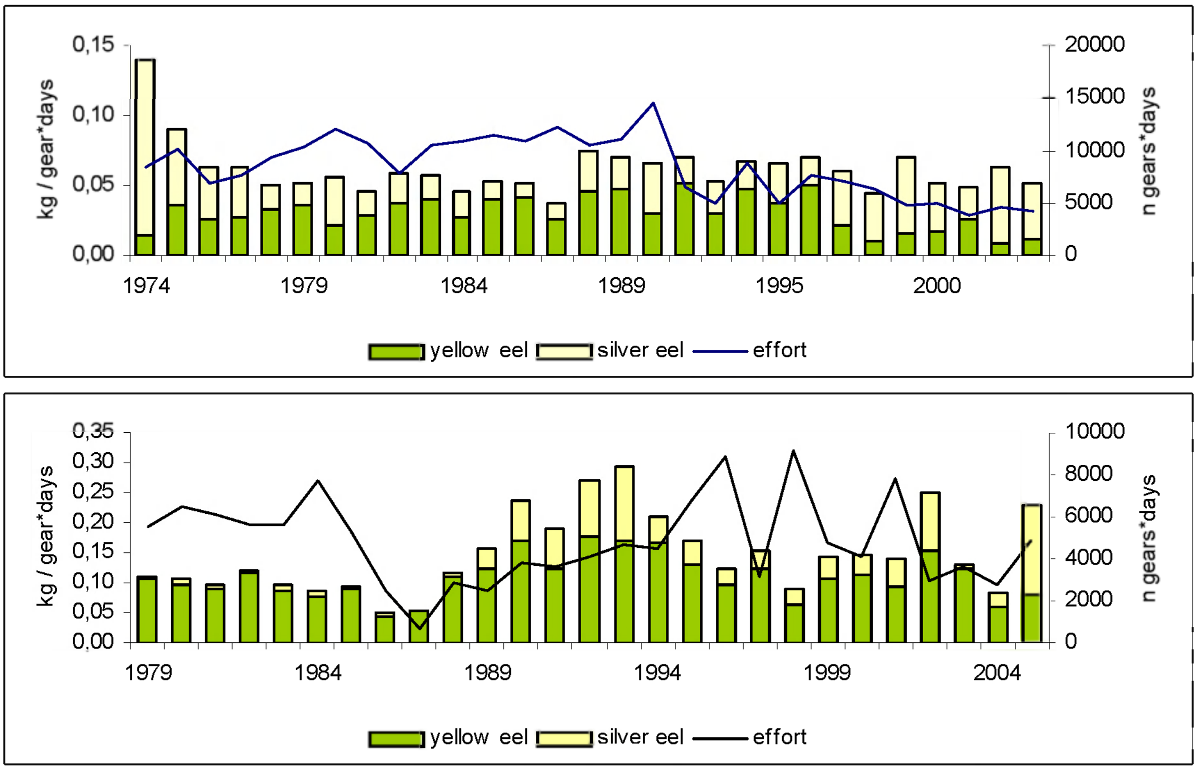


Figure SE.7. Time trends in CPUE and effort for fyke net catches of silver and yellow eel in two subareas in Swedish RBD 4 (Southern Baltic). The subareas are all located in ICES subdivision 27 on the Swedish coast of the Baltic Proper. Southern part of the county of Östergötland (upper) and northern part of the county of Kalmar (lower).

SE.G. Scientific surveys of the stock

SE.G.1.1. Recruitment surveys/ascending young eels

Recruitment of young eels (from glass eels and elvers to quite large bootlace eels) in Swedish waters is monitored in eel passes (equipped with collecting boxes) at the most downstream hydropower dam in a number of rivers along the Swedish coasts. Eels caught are weighed (or counted) before being released in upstream areas. Data from the most reliable eel passes, four in the Baltic Sea and four in Skagerrak-Kattegat, are given in the table below (see Wickström, 2002 for a more complete description).

During the last years the recruitment has generally been low or very low compared to historical levels until the 1960'. So far unexplained, there are sudden peaks in the amount of ascending eels during certain years and in different rivers. In e.g. River Kävlingeån there was an unusually high catch in 2004 when all the remaining rivers were still very low.

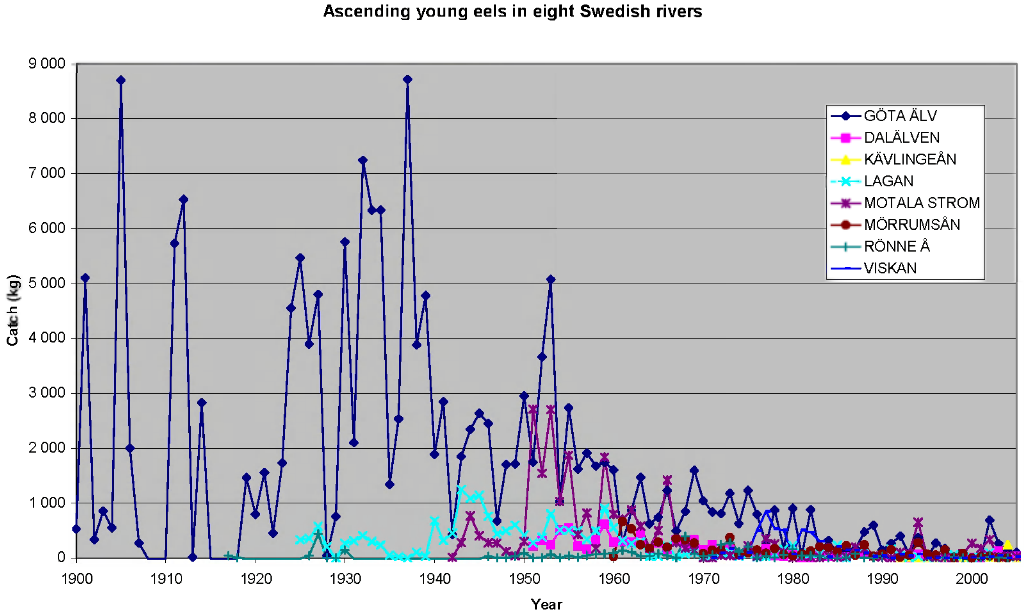
Additional recruitment series on glass eels come from an experimental trawl fishery (with an IKMWT) in the intake channel for cooling water at the Ringhals Nuclear Power Plant (in Kattegat) and from the ICES-IBTS (formerly YFS) using an MIK-trawl in Skagerrak-Kattegat (c.f. SE.G.1.2).

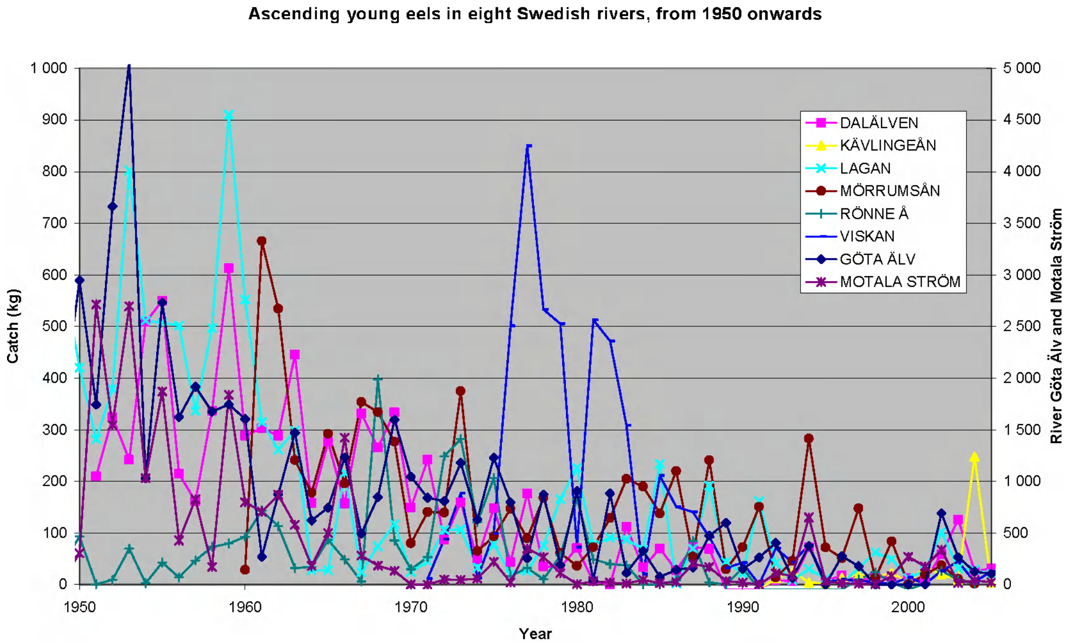
Table SE.i. Amounts (kg) of ascending young eels caught in eight rivers along the Swedish coasts.

RIVER	DALÄLVEN	MOTALA STRÖM	MÖRRUMSÅN	KÄVLINGEÅN	RÖNNE Å	LAGAN	VISKAN	GÖTA ÄLV
YEAR/RBD	RBD 2	RBD 4	RBD 4	RBD 4	RBD 5	RBD 5	RBD 5	RBD 5
1900								530,0
1901								5100,0
1902								340,0
1903								858,0
1904								552,0
1905								8700,0
1906								2000,0
1907								275,0
1908								-9,0
1909								-9,0
1910								-9,0
1911								5728,0
1912								6529,0
1913								20,0
1914								2828,0
1915								-9,0
1916								-9,0
1917					45,0			-9,0
1918					4,5			-9,0
1919					-9,0			1465,0
1920					-9,0			800,0
1921					-9,0			1555,0
1922					-9,0			455,0
1923					-9,0			1732,0
1924					-9,0			4551,0
1925					-9,0	331,3		5463,0
1926					49,0	357,8		3893,0
1927					445,0	581,1		4796,0
1928					0,0	211,9		47,0
1929					0,0	4,5		756,0
1930					147,0	268,0		5753,0
1931					-9,0	316,0		2103,0
1932					-9,0	408,0		7238,0
1933					-9,0	303,5		6333,0
1934					-9,0	236,0		6338,0
1935					-9,0	53,5		1336,0
1936					-9,0	24,5		2537,0
1937					-9,0	0,5		8711,0
1938					-9,0	106,5		3879,0
1939					-9,0	36,0		4775,0
1940					-9,0	684,0		1894,0
1941					-9,0	321,0		2846,0
1942		14,0			-9,0	454,0		427,0
1943		283,0			-9,0	1248,0		1848,0
1944		773,0			-9,0	1090,0		2342,0
1945		406,0			-9,0	1143,0		2636,0
1946		280,0			29,7	766,5		2452,0
1947		272,5			5,8	440,8		675,0
1948		120,0			6,0	494,7		1702,0
1949		43,0			39,4	603,6		1711,0
1950		304,5			93,5	419,9		2947,0

1951	210,0	2713,0			1,0	281,8		1744,0
1952	324,0	1543,5			9,1	379,1		3662,0
1953	241,5	2698,0			70,0	802,4		5071,0
1954	508,5	1030,0			2,7	511,3		1031,0
1955	550,0	1871,0			42,6	506,9		2732,0
1956	215,0	429,0			14,1	501,6		1622,0
1957	161,5	826,0			46,8	336,1		1915,0
1958	336,7	172,0			73,2	497,2		1675,0
1959	612,6	1837,0			80,0	910,5		1745,0
1960	289,0	799,0	29,0		93,0	552,4		1605,0
1961	303,0	706,0	665,5		143,7	314,8		269,0
1962	289,0	870,0	534,8		113,0	261,9		873,0
1963	445,4	581,0	241,2		32,5	298,1		1469,0
1964	158,0	181,6	177,8		34,7	27,5		622,0
1965	276,4	500,0	292,3		87,1	28,0		746,0
1966	157,5	1423,0	196,3		48,5	216,5		1232,0
1967	331,8	283,0	353,6		6,6	24,4		493,0
1968	265,5	184,0	334,8		398,0	74,4		849,0
1969	333,7	135,0	276,8		85,7	117,1		1595,0
1970	149,8	2,0	80,4		29,8	24,7		1046,0
1971	242,0	1,0	141,1		53,3	45,3	12,0	842,0
1972	87,6	51,0	139,9		249,0	106,2	88,0	810,0
1973	159,7	46,0	375,0		282,3	107,1	177,0	1179,0
1974	49,5	58,5	65,4		120,7	33,6	13,0	631,0
1975	148,7	224,0	93,3		206,7	78,4	99,0	1230,0
1976	44,0	24,0	147,2		17,1	20,2	501,0	798,0
1977	176,4	353,0	89,6		32,1	26,4	850,0	256,0
1978	35,1	266,0	168,4		10,8	75,8	532,6	873,0
1979	34,3	112,0	61,4		56,1	165,9	505,2	190,0
1980	71,2	7,0	36,5		165,7	226,0	72,5	906,0
1981	6,8	31,0	72,8		49,2	78,0	513,1	40,0
1982	0,5	22,0	129,0		40,0	90,8	472,0	882,0
1983	112,1	12,0	204,6		37,6	87,8	308,4	113,0
1984	33,9	48,0	189,9		0,5	68,0	20,7	325,0
1985	69,7	15,2	138,1		0,0	234,1	211,5	77,0
1986	28,4	26,0	220,3		8,6	2,5	150,9	143,0
1987	73,5	201,0	54,5		84,8	69,8	140,9	168,0
1988	69,0	169,5	241,0		4,9	191,7	91,9	475,0
1989	-9,0	35,2	30,0		0,0	44,0	32,7	598,0
1990	-9,0	21,0	72,5		32,0	21,6	42,1	149,0
1991	-9,0	2,0	151,0	-9,0	-9,0	161,3	0,4	264,0
1992	9,6	108,0	14,0	12,5	-9,0	42,2	70,3	404,0
1993	6,6	89,0	45,7	25,8	-9,0	8,7	43,4	64,0
1994	71,9	650,0	283,0	4,0	-9,0	30,7	76,1	377,0
1995	7,6	32,0	72,4	2,9	-9,0	11,6	5,5	0,0
1996	17,5	14,0	51,9	13,5	-9,0	2,8	10,0	277,0
1997	7,5	8,1	148,0	19,4	10,4	31,7	7,6	180,0
1998	14,7	5,5	12,9	15,3	24,0	62,6	5,0	0,0
1999	15,5	85,0	84,2	22,2	4,2	49,5	1,8	0,0
2000	12,4	270,1	1,0	5,0	-9,0	13,0	14,1	0,0
2001	8,2	177,5	19,3	34,5	1,8	26,8	1,8	0,0
2002	58,6	338,8	37,4	19,3	27,0	102,0	26,2	693,0
2003	126,1	19,0	11,0	9,7	9,1	31,7	45,1	266,0
2004	26,4	42,0	1,5	248,3	2,0	29,0	5,0	125,0
2005	30,9	24,8	na yet	3,4	na yet	20,5	25,8	105,0

The ascent in River Viskan is totally dominated by elvers arrived as glass eels the same year. Also in River Lagan there is a considerable proportion of "glass eels" but in the remaining rivers there is a mix of year-classes, with eels up to more than 300 mm in TL. The value -9,0 implies no data available. Not available = na.





SE.8 a&b. Long-term trends in the catches of young eels at various places along the Swedish coast. The lower panel is a magnified version of the upper one from 1950 onwards.

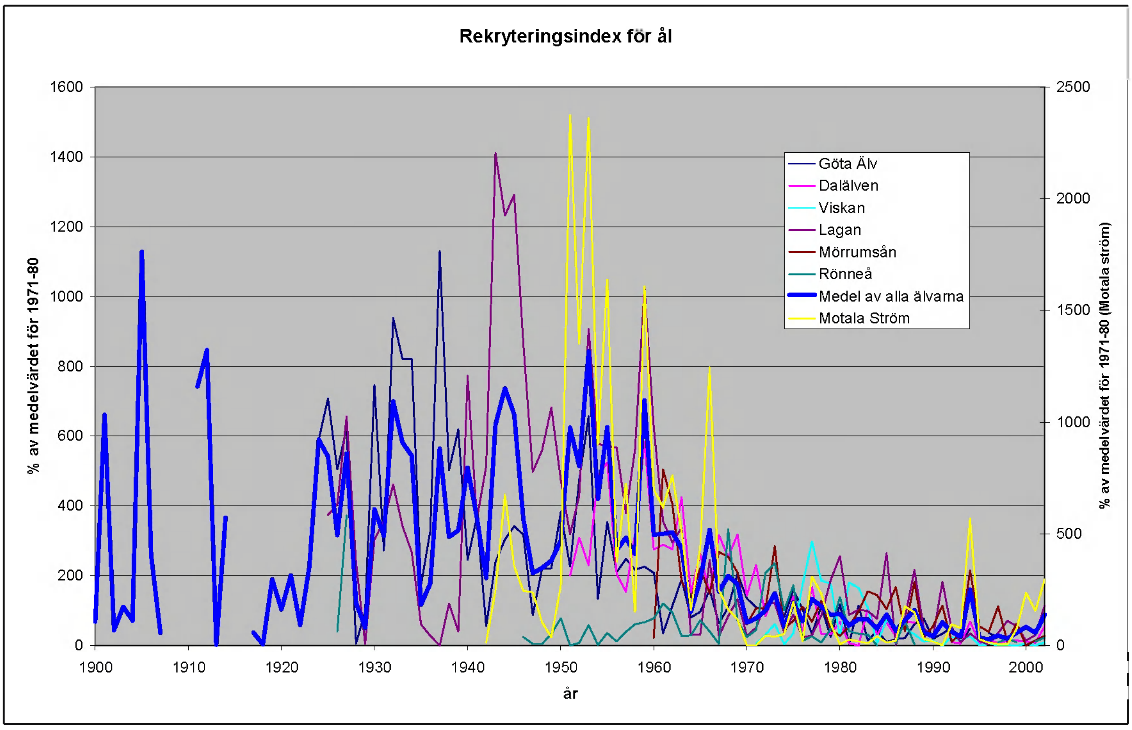


Figure SE.9. Recruitment indices from seven Swedish rivers. Data are presented as percentages of the averages for 1971 to 1980 in the same rivers, respectively.

SE.G.1.2. Recruitment surveys/marine data

The abundance of glass eels in the open sea (Kattegat and Skagerrak) are surveyed by trawling with either an Isaacs-Kidd Midwater trawl (IKMT) or with a modified Methot-Isaacs-Kidd Midwater trawl (MIKT). The former trawl is used in a fixed position in the intake canal for cooling water to the condensers at the Ringhals Nuclear Power Station (e.g. Westerberg, 1998 a,b). The latter method is used from R/V Argos during the ICES-International Young Fish Survey (since 1993 called the International Bottom trawl Survey (IBTS Quarter 1) (Hagström and Wickström, 1990).

When the glass eels have settled they and larger eels can be monitored on soft and shallow bottoms using a "Drop Trap" technique (Westerberg *et al.*, 1993). This was successfully done during a number of years but is now a resting series. This approach made it possible to roughly estimate the total recruitment of young eels to the Swedish coast.

From all three methods recruitment series could be compiled:

Recruitment of glass eel to the Swedish west coast is monitored at the intake of cooling water to the nuclear power plant at Ringhals in the Kattegat (Figure SE.10 and Table j). The time of arrival of the glass eels to the sampling site varies between years, probably due to hydrographical conditions, but the peak in abundance normally occurred in late March to early April. Abundance has decreased by 90% if recent years are compared to the peak in the early 1980`s.

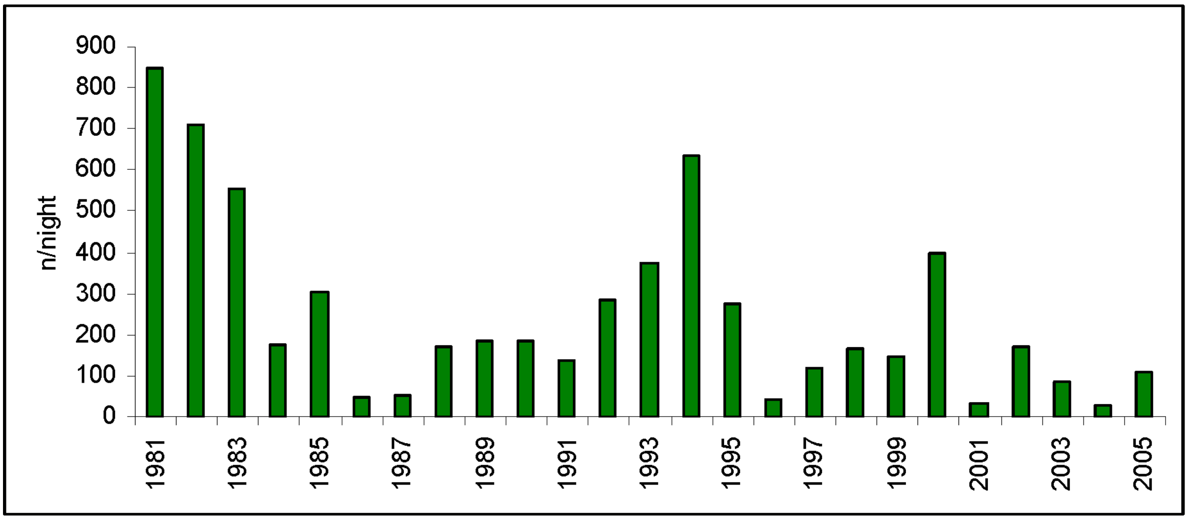


Figure SE.10. Time trend in glass eel recruitment at the Ringhals nuclear power plant on the Kattegat coast in Swedish RBD 5 (Västerhavet).

Table j. Annual indices of glass eel recruitment at the intake canal for cooling water to reactors 1 and 2 at the Ringhals nuclear power plant. Mean of weekly means of numbers of glass eels collected with a modified Isaacs-Kidd midwater trawl during March and April (weeks 9-18). Data were corrected for variations in water flow.

week no	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3	3													1											
4	0							17			1			4					0						
5	4							8		15	14	18	30	5	4	0	0	1	0	74	2	27	6		20
6								28		27	13	56	45	7	11	0	1	1	0	142	0	86	5	1	12
7								6		22	9	85	331	7	41	0	22	9	8	267	3	154	2	2	62
8	1							34		57	3	44	57	8	48	11	3	50	12	115	5	327	5	0	22
9	187		51			3		36	342	185	3	160	55	3	172	0	68	125	62	344	5	117	5	1	15
10	199	24				2		80	372	150	15	471	118	7	224	4	200	100	121	377	3	200	10	3	10
11	250	130	528	176		4		19	129	150	88	290	130	610	333	13	198	8	72	533	22	366	44	3	39
12	374	806	835	289	14	6	2	16	107	145	42	469	535	400	569	25	60	177	158	214	24	530	53	18	162
13	1886	1258	265	122	109	1	0	72	291	251	110	562	495	1430	331	60	42	220	2	479	16	59	185	35	153
14	2093	1335	469	181	0	3	31	149	121	351	138	151	403	1236	625	33	77	448	314	942	22	185	192	65	162
15	1849		878	112	878		141	603	67	284	414	298	540	1145	91	128	201	237	377	154	45	184	151	55	202
16			925		476		69	416	42	120	254	142	527	619	64	73	49	96	79	299	25	53	74	90	286
17	804		477	171	350		6	127		37	193	231	564	278	80	56	44	202	141	257	128	8	84	32	66
18	0					297	114				124	55					230	31				9	46	8	10
mean 9-18	849	711	553	175	305	45	52	169	184	186	138	283	374	636	277	44	117	164	147	400	32	171	84	31	110

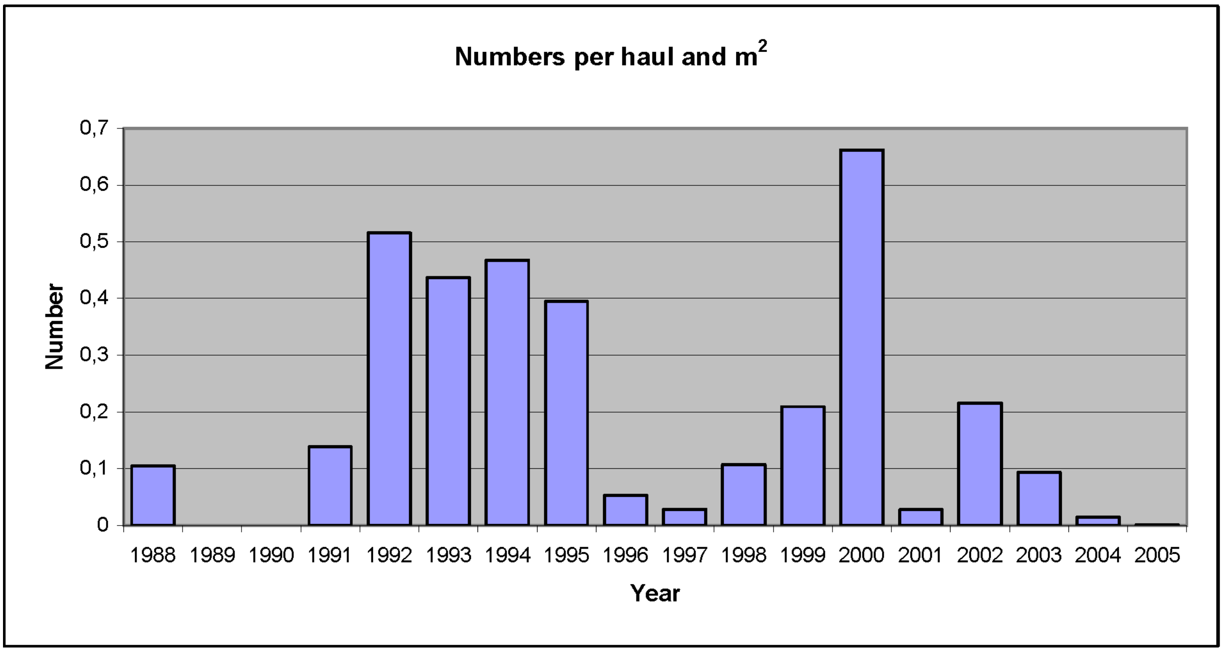


Figure SE.11. Catch of glass eels by a modified Methot-Isaacs-Kidd Midwater trawl (MIKT) in the Skagerrak – Kattegat 1988, 1991-2005 ***(2005 is 0,000192).***

SE.G.1.3.

Another way of estimating the occurrence of young eels ascending in smaller streams is by electro-fishing (Degerman, 1985; Fiskeriverket & Laxforskningsinstitutet, 1999; CEN, 2002). Normally this is done with salmonids in focus with eels as secondary product or spin-off.

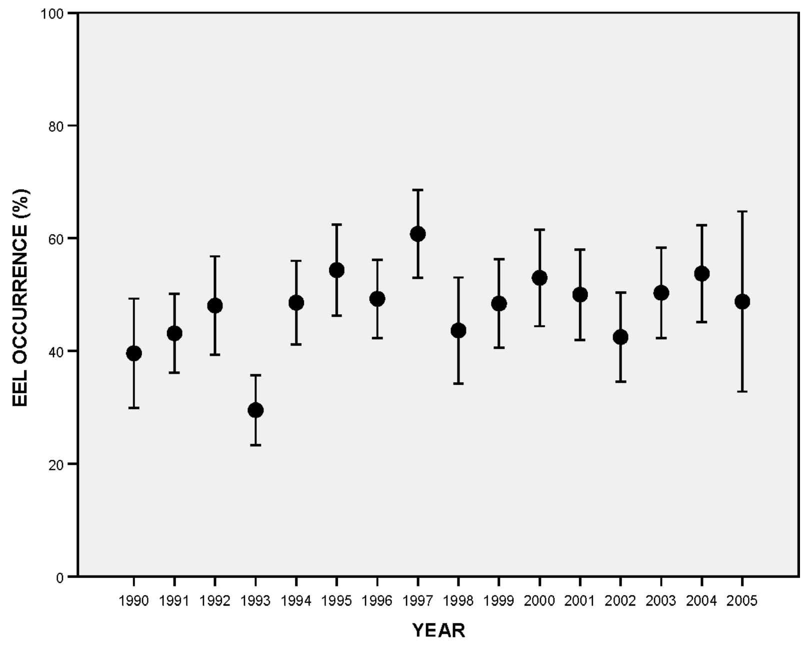


Figure SE.12. Proportion of electro-fished stations (%) with eel occurrence (+/- 95% CI).

The stations in Halland County (Swedish West Coast) that were fished in 1990–2000 are situated from 0 to 100 m asl. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register).

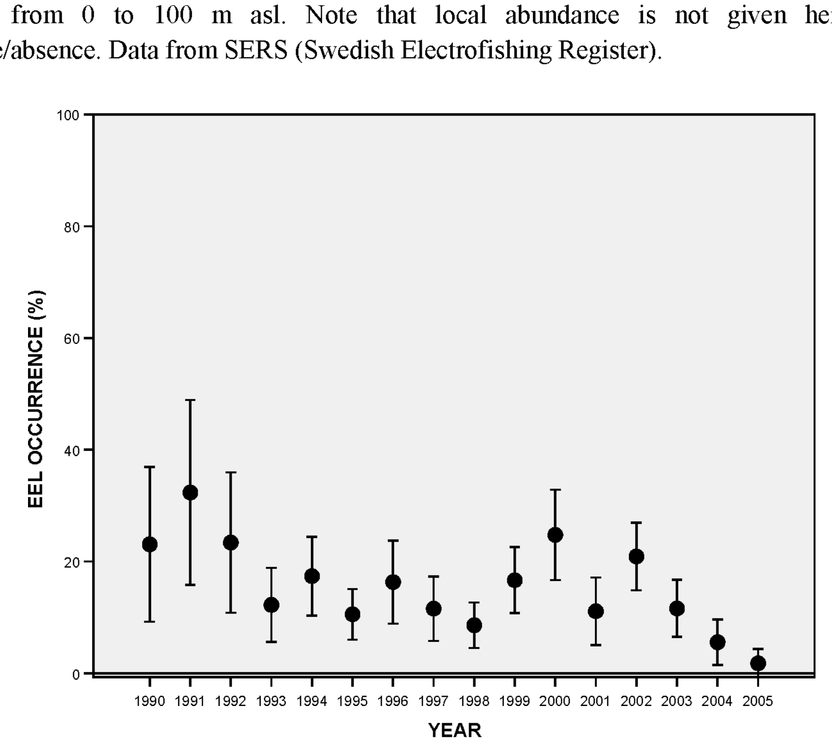


Figure SE.13. Proportion of electro-fished stations (%) with eel occurrence (+/- 95% CI).

Stations that were fished in 1990–2000 in this figure are situated from 0 to 100 m asl in six counties along the Baltic Sea Coast. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register).

SE.G.2. Yellow eel surveys

SE.G.2.1. Yellow eel surveys in coastal waters

The coastal fish communities on the Swedish West Coast are monitored by standardised fishing with fyke nets in shallow water (2–5 m). Yellow eel was among the dominating fish species in August most years. Barsebäck in the SW part of the area belongs to RBD 4 (the Southern Baltic Sea), other areas to RBD 5 (the North Sea). The trend for the longest time series from Vendelsö in N Kattegat is significantly positive. A negative tendency for the Barsebäck area was not significant. In the other areas the period of sampling was too short to be examined for biologically significant trends. The magnitude of CPUE though, was similar to that in the longer series.

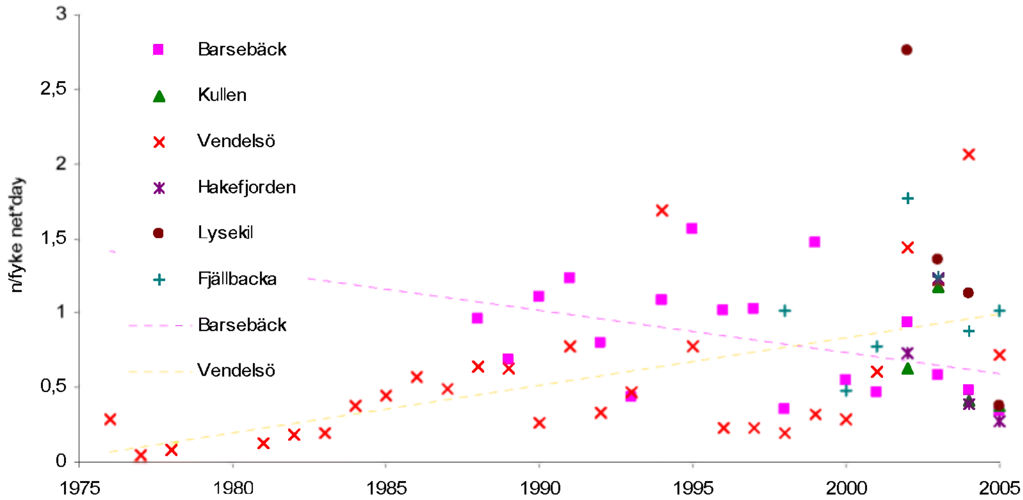


Figure SE.14. Time trend in the yellow eel catches in coastal fish monitoring with fyke nets in August on the Swedish West Coast. RBD 4 (the Southern Baltic Sea) (Barsebäck) and RBD 5 (the North Sea) (others).

The inter-annual variations in CPUE were influenced by water temperature at the time of sampling, but no time trends in temperature were observed for the period with available data (1988–2005).

SE.G.2.2. Yellow eel surveys in freshwater

There are no routine stock surveys for yellow eels in freshwater. The nearest equivalents are the surveys dedicated to stocked populations of eels. These are mostly performed in smaller lakes but also at one site in the large lake Mälaren where glass eels were stocked in both 1980 and 1997. The aim is to follow the development and individual growth of young eels stocked in nature. The eels that were stocked in 1997 were marked with Alizarin Complexone. Such marked eels are now dominating the local eel population.

SE.G.3. Silver eel surveys

There are no regular silver eel surveys in Sweden. However, in 2003 the Institute of Freshwater Research collected large samples from the commercial fisheries in eight lakes and at two sites where most silver eels try to leave the Baltic Sea, i.e. in the Sound (Öresund). In 2005 and 2006 silver eels from additional sites along the Baltic Coast were and are collected. All these eels are now analysed with respect to e.g. their fat content and to their chemical background (by otolith microchemistry). This extensive study might together with a scheduled tag-recapture study be the baseline for recurrent sampling of silver eels.

The Coastal Institute is sampling the commercial catch with the purpose to collect length and age data. This is done within the DCR (Data Collection Regulation Programme). See also SE.H below.

SE.H

SE.H.1 Catch composition by age and length in coastal areas.

Sampling for length in commercial fyke net catches in subdivision 20, 21, 23 and 25 show a similar size composition of yellow eels. Sizes in the interval 40–50 cm were most abundant. More intense sampling in subdivision 27 in the central Baltic Proper demonstrates populations with considerably higher mean length and with single individuals reaching almost 90 cm in length. Silver eel lengths from the central Baltic coast span from 52 to 89 cm, peaking close to

80 cm. Thus there is a considerable overlap in size for yellow- and silver eels in fyke net catches in this area.

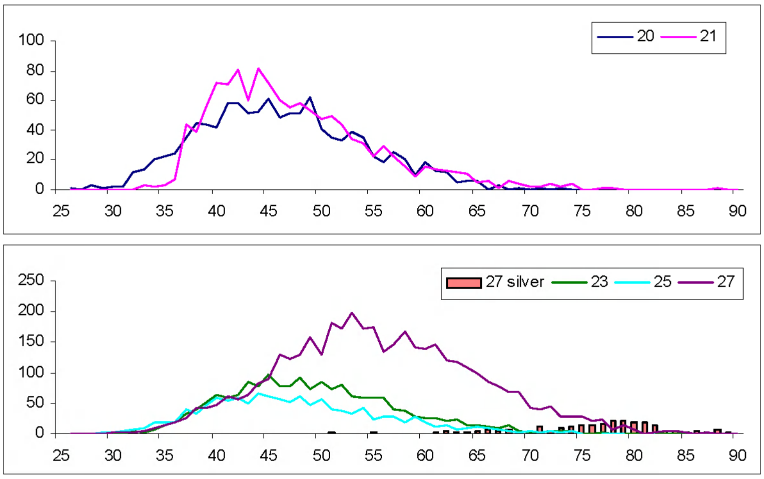


Figure SE.15. Length composition of yellow and silver eel from commercial fyke net catches in numbers for samples collected in 2002–2005 in RBD 5 (ICES SD 20-21) and RBD 4 (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

Preliminary results from age readings of yellow eel samples from fyke nets collected in 2004 indicate a considerable difference in length at age between samples from the western and southern part of the Swedish coast (subdivisions 20–25) and the samples from the central Baltic Proper (SD 27) (see Figure SE.16). An eel was 4–10 cm longer at the age of ten in SD 27 than in the other areas. It should be mentioned though, that no statistical analysis has yet been performed. Mean length at age from individual samples is listed in Appendix, Table SE.k together with standard deviations.

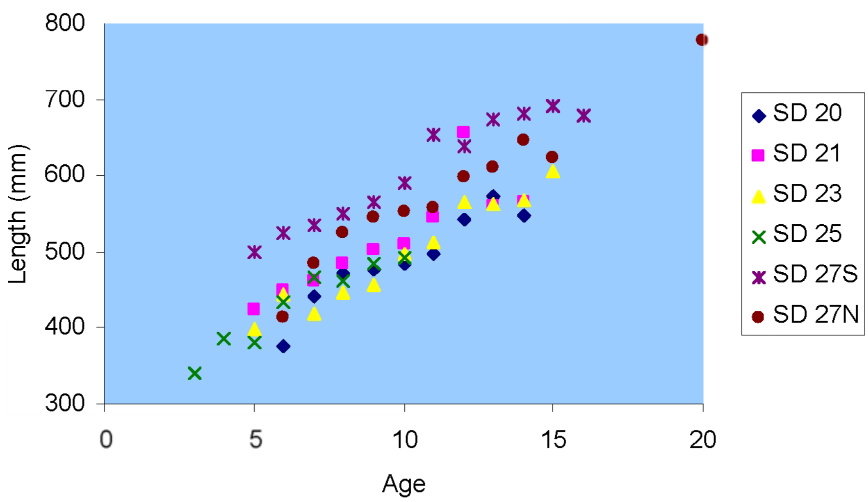


Figure SE.16. Length at age of yellow eel from commercial fyke net catches in samples collected in 2004 in RBD 5 (North Sea) (ICES SD 20-21) and RBD 4 (ICES SD 23, 25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

Estimated total instantaneous mortality rates, based on age distribution of yellow eel catches in 2004, varied between 0,4 and 0.7 in six samples from RBD´s 4 and 5. The highest mortalities were observed in the southern areas of SD 23 and 25. The estimated mortality rates were derived from the slope of numbers per year class in individual samples, starting from the most abundant year class (see Table SE.k and Figure SE.17). The samples from subdivisions 20, 21 and 23 were collected from commercial landings (legal size 35–37 cm), while the samples from subdivisions 25 and 27 in the Baltic Proper (legal size 60 cm) were collected from unsorted catches in commercial fisheries of sizes above and below the legal limit.

Table SE.k. Slope of the logarithm of numbers per age group, age groups included and sample size in yellow eel samples from commercial fyke net catches in RBD 5 (North Sea) (ICES SD 20–21) and RBD 4 (ICES SD 23, 25 and 27), collected in 2004. Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

	SD 20	SD 21	SD 23	SD 25	SD 27S	SD 27N
slope	-0,47	-0,56	-0,67	-0,71	-0,53	-0,42
min age	9	9	9	7	9	11
max age	14	14	15	10	16	15
n	98	98	198	99	192	198

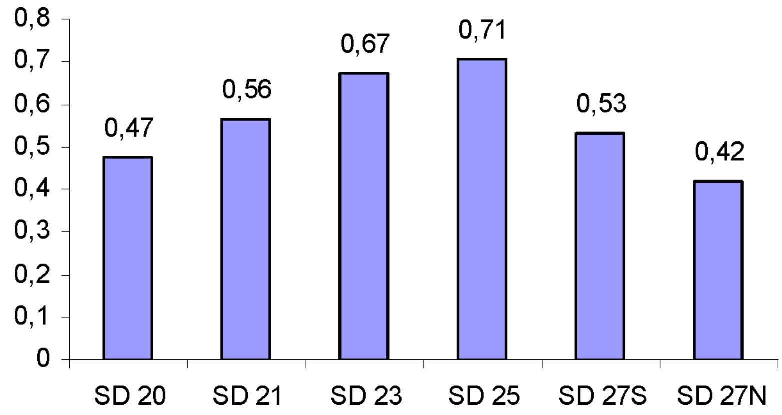


Figure SE.17. Age based instantaneous mortality rates derived from yellow eel samples from commercial fyke net catches in RBD 5 (ICES SD 20–21) and RBD 4 (ICES SD 23, 25 and 27), collected in 2004. Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

SE.H.2 Freshwater

In addition to the programme mentioned under SE G.3 no data on catch composition is collected in freshwaters.

SE.I Other biological sampling

The National Food Administration in Sweden has analysed both yellow and silver eels sampled in 2000 and 2001 from nine different sites in Sweden with respect to 17 dioxins and furans and 10 dioxin-like PCB congeners (www.slv.se). Pooled samples showed that eels had less than 1 pg TEQ/g fresh weight of sum TCDD/F in muscle (TEQ = Toxic Equivalents, TCDD = $C_{12}H_4O_2Cl_4$). To this came about 3,8 pg PCB-TEQ/g fresh weight. Silver eels had higher levels than yellow ones. Compared to the other fish species analysed, eels have a higher ratio of PCB to dioxins. Due to the high costs for this type of analyses only few eels will be sampled regularly in future. Recent analyses of mercury (Hg) in eels from Lake Mälaren did show very low levels.

The swim bladder parasite (*Anguillicola*) does occur in eels from most sites. All eels dissected at the Swedish Board of Fisheries are analysed macroscopically for the prevalence (at both Institutes involved) and intensity (at the Institute of Freshwater Research only) of *Anguillicola* in their swim bladders. The prevalence in coastal waters in 2002–2005 was close to 10% in the marine habitats of RBD 5 and about 60% in the central parts of RBD 4. The straight between Sweden and Denmark (Öresund, SD 23) took an intermediate position.

Table SE.l. Prevalence of *Anguillicola crassus* in yellow eel from Swedish coastal waters in 2002–2005. ICES subdivisions 20–21 represent RBD 5, other subdivisions represent RBD 4.

	ICES Subdivision				
	20	21	23	25	27
Not infested	723	611	442	475	493
Infested	80	93	361	753	794
Grand Total	803	704	803	1228	1287
Prevalence	**0.10**	**0.13**	**0.45**	**0.61**	**0.62**

SE.J Other sampling

SE.J.1 Cormorants

Cormorants are believed to predate substantially on eels. As about 2900 young eels stocked in Lake Ymsen 1998–2000 were equipped with PIT-tags in the spring 2004 we took the opportunity to scan the ground below the only cormorant colony in that lake for tags. In total 30 PIT-tags were found corresponding to a minimum loss by cormorant predation of 1%.

An extensive study of the stomach content of cormorants at three sites along the Kattegat-Skagerrak coast revealed that eels were taken by about 5% of the cormorants. That was equivalent to about 1% of their diet. Although the low percentage, it corresponds to a total annual predation of 310 000 yellow eels, i.e. one fourth of the commercial catch on this coast (Lunneryd and Alexandersson, 2005).

SE.J.2 Obstacles to eel migration

During 2005 and 2006 an inventory of obstacles for eels migrating both up- and downstream is performed. Not only are the obstacles as such studied but also the occurrence of fish passes, by-passes, deflecting screens, etc. and their suitability for eels. The purpose is to achieve a database to be used as background when installing new or improving existing eel passes and deflecting devices. Water Courts decisions might be reconsidered with this database as argument.

SE.K Stock assessment

So far the collected data has not by routine been used for stock assessment.

However, published mortality estimates from subdivision 20 and 21 (Svedäng, 1999) (approximating RBD 5, Västerhavets vattendistrikt (“the North Sea”)) has been used in a simple length based mortality rate model to assess the effect of present yellow eel exploitation on spawner escapement in relation to present and estimated past unexploited levels of spawner escapement (Åström and Wickström, 2004). The relation between the present and past population levels has been estimated using the longer data series on ascending elvers and young eels, indicating that the present population probably is less than 10% of the one in the mid-1900s.

An attempt has also been made to use the length sampling from the yellow eel fishery in fives areas in ICES subdivision 25 and 27 (part of RBD 4, Södra Östersjöns vattendistrikt (“the Southern Baltic Sea”)) in a catch-at-length analysis to estimate natural and yellow eel fishery induced instantaneous mortality rates, in terms of mortality rate per unit length increment. The result from analyses of a large number of mark recapture studies on silver eels has been used as a rough estimate of the silver eel fishery mortality rate. Data on average length of female silver eels in the subdivisions were also needed for the analyses. Males have been disregarded because of their very low prevalence in Swedish waters. The simple length based mortality rate model has then been used to assess the effect of present yellow and silver eel exploitation on spawner escapement in subdivision 25 and 27 in relation to present and estimated past unexploited levels of spawner escapement (Åström, 2004).

The above analyses indicate that the yellow eel exploitation allows at most 15% of the present possible escapement to the silver eel stage. This applies both to subsections 20 and 21 (~ RBD 5) as well as to subsections 25 and 27 (part of RBD 4), and indicates a severe overexploitation. The silver eel fishery in the latter two subsections then further reduces the spawner escapement by about half, so that only about 7% of the present possible spawner escapement remains from these subsections. In perspective of past possible spawner escapement this would only amount to less than 0.7% of the spawner escapement possible in the mid-1900s.

Using additional data on the amounts of yellow and silver eels caught in the different subdivisions have allowed for analyses of the possible effects of fishing restrictions and re-stocking of elvers on spawner escapement using the same conceptual model (Åström, 2005).

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Annex 1

Table SE.m Commercial landings of eel in Sweden (Kattegat-Skagerrak corresponds to RBD 5 and the data come from the contract notes).

Year	South C. (Baltic Sea)	East C. (Baltic Sea)	Kattegat-Skagerrak	Freshwater	Total Sweden
1925	624	936	155		1715
1926	520	1011	176		1707
1927	642	1216	152		2010
1928	373	509	157		1039
1929	582	644	167		1393
1930	716	596	216		1528
1931	782	497	252		1531
1932	769	701	253		1723
1933	645	704	196		1545
1934	798	830	215		1843
1935	829	880	240		1949
1936	608	818	226		1652
1937	548	931	244		1723
1938	666	969	235		1870
1939	535	988	248		1771
1940	553	974	98		1625
1941	633	926	69		1628
1942	426	592	110		1128
1943	820	648	77		1545
1944	879	1042	79		2000
1945	778	790	96		1664
1946	658	738	116		1512
1947	980	761	169		1910
1948	979	689	194		1862
1949	999	671	229		1899
1950	1109	911	168		2188
1951	962	755	212		1929
1952	791	627	180		1598
1953	1146	879	353		2378
1954	1186	780	140		2106
1955	1599	780	272		2651
1956	714	707	112		1533
1957	1158	856	211		2225
1958	938	642	171		1751
1959	1658	977	154		2789
1960	778	703	165		1646
1961	896	870	300		2066
1962	980	713	215		1908
1963	997	802	272		2071
1964	1303	749	236		2288
1965	749	768	285		1802
1966	748	893	328		1969
1967	646	703	268		1617
1968	713	794	301		1808
1969	622	733	320		1675

1970	476	515	318		1309
1971	545	587	259		1391
1972	425	582	197		1204
1973	419	553	240		1212
1974	322	470	242		1034
1975	494	629	276		1399
1976	283	363	289		935
1977	346	340	303		989
1978	376	385	315		1076
1979	267	404	285		956
1980	371	438	303		1112
1981	243	153	491		887
1982	342	250	569		1161
1983	267	171	735		1173
1984	559	136	378		1073
1985	647	213	280		1140
1986	479	138	234	92	943
1987	439	119	250	89	897
1988	532	190	304	136	1162
1989	447	132	264	109	952
1990	452	119	242	129	942
1991	486	181	285	132	1084
1992	534	162	352	132	1180
1993	550	93	438	129	1210
1994	654	98	630	171	1553
1995	444	79	555	127	1205
1996	564	67	406	97	1134
1997	546	181	513	142	1382
1998	318	50	165	112	645
1999	339	69	186	140	734
2000	286	39	123	113	561
2001	107	123	195	118	543
2002	126	183	222	102	633
2003	115	145	209	96	565
2004	84	134	227	106	551
2005	*114*	*168*	*210*		492

Data from 2005 are not yet complete

Table SE.n. Mean length at age with standard deviation in Swedish samples of yellow eel fromcommercial fyke net catches in 2002–2005.

Mean length in mm

	SD 20				SD 21				SD 23			SD 25		SD 27	
	Stenungsund				Kullen				Öresund			Valjeviken		Simpevarp	Kvädöfjärden
	2002	2003	2004	2005	2002	2003	2004	2005	2003	2004	2005	2003	2004	2004	2004
3												336	341		
4		403		407								357	385		
5	396	342		376	403	374	423	428		399	409	369	381	499	
6	378	375	375	396	429	427	449	447	464	444	412	413	435	526	413
7	419	396	441	436	446	447	463	465	432	418	471	414	466	535	485
8	416	418	471	466	451	462	484	499	460	448	491	444	461	549	525
9	459	428	478	513	454	500	501	508	485	457	504	496	484	564	545
10	436	496	484	572	492	525	511	576	508	497	524	477	492	591	553
11	493	502	497	565	541	549	546	590	534	512	527	529		654	559
12	484		543	668	523	524	655	654	521	566	524	628		639	599
13	523	561	573	711		576	561	635	579	562	614			675	609
14	475		547		496	604	565	614	582	568	589			682	645
15					726	512			585	606	568			693	624
16				617										678	
17															
18						778									
20															778

Standard Devation

	SD 20				SD 21				SD 23			SD 25		SD 27	
	Stenungsund				Kullen				Öresund			Valjeviken		Simpevarp	Kvädöfjärden
Age	2002	2003	2004	2005	2002	2003	2004	2005	2003	2004	2005	2003	2004	2004	2004
3												72	37		
4		-		19								37	42		
5	-	20		30	91	18	14	17		61	80	28	33	62	
6	45	45	49	30	61	64	18	35	49	68	22	55	37	45	41
7	38	53	44	53	65	51	51	34	44	40	61	34	55	64	56
8	49	66	44	60	59	56	44	60	33	50	41	33	54	72	50
9	70	54	46	56	39	78	43	69	48	50	53	48	37	62	59
10	56	67	49	51	74	70	71	68	64	56	50	49	43	62	67
11	62	48	32	55	59	70	49	57	41	63	64	111		87	61
12	26		34	67	72	63	102	49	38	77	92	-		100	60
13	95	80	41	-		70	-	-	15	98	64			58	58
14	-		2		56	-	101	-	15	6	16			68	82
15					-	-			-	-	-			112	38
16				-										-	
17															
18						-									
20															-

Report on the eel stock and fishery in Estonia 2005

EE. A. Author

Ain Järvalt

Centre for Limnology, Institute of Agricultural and Environmental Sciences, Estonian University of Life sciences, 61101 Rannu, Tartumaa, Estonia.

Tel. +372 454 544, fax +372 454 546

ain.jarvalt@emu.ee

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EE. B. Introduction

Eel fisheries in Estonia occur in Lake Võrtsjärv (20–100 t) and in costal waters (10–30 t). Annual catch from small lakes and rivers mostly in L. Peipsi basin and L. Peipsi itself is 2–4 t. Eel catches by amateur fishermen constitute about 1 t from brackish water and about 2 t from inland water bodies. According to the fishery statistics during the last decade the total annual catch of eel from Estonian waters was nearly 50 tons. During the first half of previous century eel was very abundant and one of the most important commercial fish in western costal waters of Estonia. At that time annual catch of eel exceeded hundreds of tons.

Natural eel stocks have never been very dense in Estonian large lakes. The annual catch of eel in 1939 was only 3.8 tons from L. Võrtsjärv and 9.2 tons from L. Peipsi. The construction of the Narva hydropower station in the early 1950s blocked almost totally the natural upstream migration of young eel from the Baltic Sea to the basins of lakes Peipsi and Võrtsjärv. As a result, eel almost disappeared from the fish fauna of Estonian large lakes. Today, thanks to the introduction of glass eels or farmed eels into L. Võrtsjärv, it has become one of the most important commercial fish in this lake. Probably the downstream migration of eel through the hydropower station is still possible.

Management of eel stock (re-stocking and fishery) is under the governmental control. The Fishery Department of Ministry of Environment takes care of stocking and local services of Ministry of Agriculture give out fishing licences. There are gear and size restrictions.

Estonia has the state programm of reproduction and re-stocking of fish (2002–2010) including European eel. In connection with this programme we have ongoing special investigations and monitoring projects concerning eel in Estonia financed by Ministery of Environment:

1) Re-stocking results in small lakes
2) Food resourses of eel in water bodies suitable for stocking
3) The distribution of eel and long-term re-stocking results in L. Peipsi and L. Võrtsjärv basin.

There are three main eel fishing areas in Estonia:

1) L. Võrtsjärv is a large but very shallow and turbid lake with a surface area of about 270 km^2 and mean and maximum depths of 2.8 m and 6.0 m, respectively. Its drainage basin (Figure EE 2) (3104 km^2, incl. 103 km^2 in Latvia) is situated in the Central Estonia. Eel *Anguilla anguilla* (L.), pikeperch *Sander lucioperca* (L.), northern pike *Esox lucius* L. and bream *Abramis brama* (L.) are the main commercial fishes in the lake. Professional fishing gears are fyke nets and long lines are used by recreational fishermen. Every fisherman has own individual licences.
The eel production of L. Võrtsjärv is entirely based on stocking with wild caught elvers or farmed eels (4–20 g). During the half hundred years (1956–2005) 45 million eels were stocked. According to the official statistics in 1988, the

maximum annual catch of eel exceeded 100 t. In the 1990s, the reported annual catch of eel (22–49 t) was much smaller than real catch (estimated catch was 80% higher). Nearly half of the income of fishermen comes from eel, despite their annual investments to the state Foundation of Environmental Investments (>100 000 € annually) in stocking material. Due to the changes in fishing law, the number of fishermen has increased during the last 5 years. During 1970–1998, the number of professional fishermen varied between 20–25, followed by an increase to 32 in 2003 and 41 in 2004. The total number of people involved in the fishery of L. Võrtsjärv is estimated to be two times higher.

2) In costal waters, the Gulf of Riga, the Väinameri, the Gulf of Finland, the catches of eel have increased (from 3–10 t in 1991–1995 to 20–28 t in 1999–2003), but in 2005 decreased again up to 15 t. Along the shore of the Baltics eels are caught with bottengarns (pound nets) and fyke nets; long lines are also used. As there are thousands of fishermen in that region, eel is not first-rate fishing object.

3) Small lakes in Peipsi basin, where eel has migrated from L. Võrtsjärv and was additionally stocked consistently during last 5 years: in Vooremaa district (Figure EE 1) L. Saadjärv (700 ha), L. Kuremaa (400 ha) and L. Kaiavere (250 ha) and L. Vagula (500 ha) in South Estonia. Fishing gears are dominated by fyke nets.

The WFD subdivides the Estonia into 3 districts and 8 subdistricts, what are not connected only with one river. The Narva River District is the biggest (1/3 of territory of Estonia and shared with Russia (Figure EE 2.) Other more important rivers are River Pärnu, River Kasari and River Gauja, shared with Latvia.

EE.C.D.E. Fishing capacity, effort, catches and landings

No data available of fishing capacity.

The exact number of fyke nets being used in costal waters is unknown. The number of fyke nets in L. Võrtsjärv in 1970s and 1980s was 200–250, in 1990s 300 and from 1998 up to 2004 350. This year the total number of fyke nets was reduced to 324 (1.2 fyke nets per km^{-2}). Long lines (622 fishing nights of 100 hooks, catch 990 kg in 2004) are used only for sport fishing. In Vooremaa lakes licensed fishermen have 36 fyke nets (2.6 fyke nets per square kilometre) and 3 eel boxes. 20 licensed long lines (100 hooks) are not continuously in use.

The eel catches have two peaks in inland waters: May and August–September. Eel has a legal (minimum) size: 55 cm in lakes Võrtsjärv and Peipsi, 50 cm in other Estonian inland water bodies and 45 cm min costal waters.

Figure EE.1. Location of Estonia, Lake Võrtsjärv and the Vooremaa Lake District.

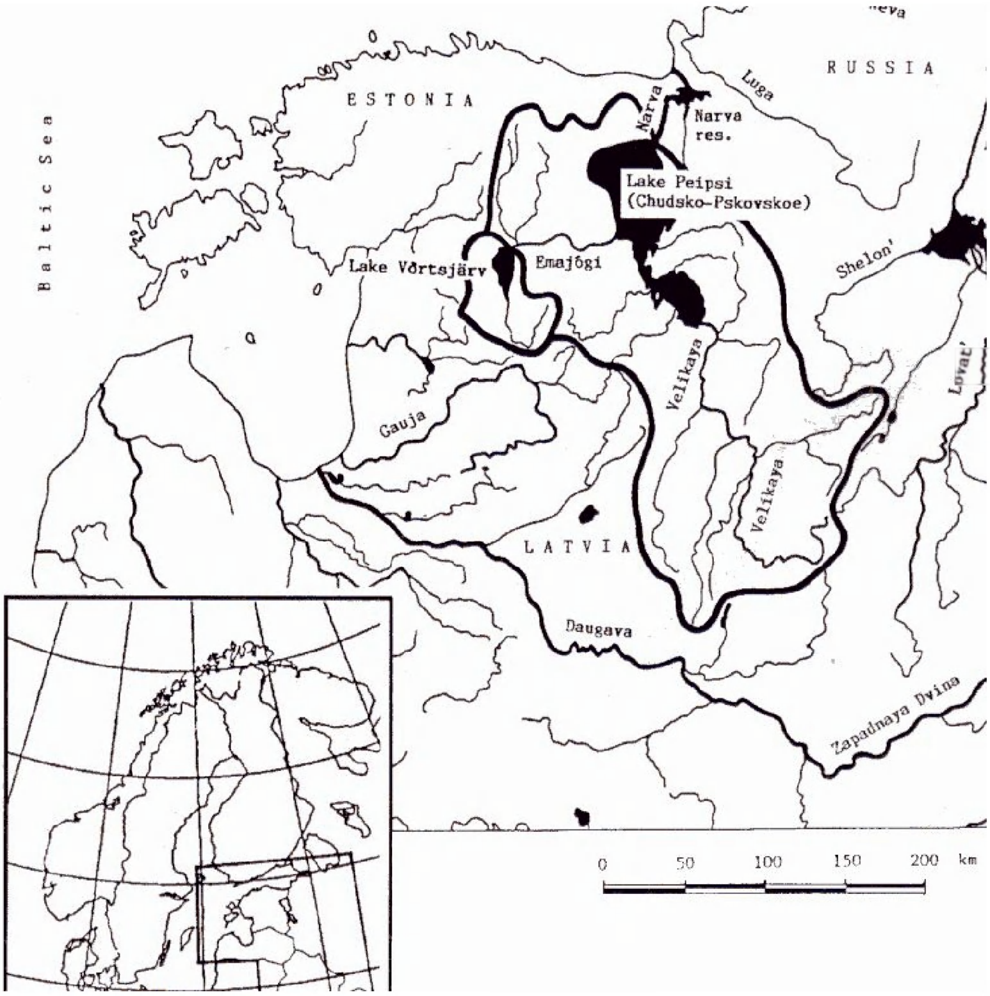

Figure EE.2. Location of watershed areas of L. Peipsi and L. Võrtsjärv

More than half of the catch of eel in Estonia comes from L. Võrtsjärv (Table EE A). According to the information provided by fishermen, the actual catches of eel in L. Peipsi are significantly higher. 80% from registered catch of eel from small lakes and rivers originated from the three lakes situated in Vooremaa district. The real total catch in Estonia should be 1.5 up to 2 times higher.

Table EE.A. Catches of eel in tons per year in different water bodies in 1993–2005.

Year	Baltic Sea	L. Võrtsjärv	L. Peipsi	Others	Total	Percentage of L.Võrtsjärv
1993	10,0	49,0	0,2	-	59,2	83
1994	10,0	36,9	-	-	46,9	79
1995	6,0	38,8	-	0,6	45,4	85
1996	20,0	34,1	0,1	1,2	55,4	62
1997	18,3	40,3	0,5	-	58,8	69
1998	22,2	21,8	0,2	-	44,2	49
1999	28,3	36,3	0,2	-	64,8	56
2000	26,7	38,9	0,2		67,0	58
2001	27,1	37,6	0.3	1,2	65,2	58
2002	27,3	20,4	0,2	2	50,3	41
2003	18,8	26,4	0,2	3,2	48,6	54
2004	15,6	20,1	0,3	3,2	38,9	52
2005	15,7	17,6	?	3		

Table EE.B. Landings per tons year from Lake Võrtsjärv.

Year	1933-39	1960	1970	1980	1990	2000
0	1,8	0	6,5	17,8	56,1	38,8
1		0	6,5	16,5	48,5	37,6
2		0	16,4	10,8	31	20,4
3		0	21,3	24,5	49	26,3
4		3	18,7	66,7	36,9	20,1
5		0,3	36,9	71,9	38,8	17,6
6		1,9	49,6	55,6	34,1	
7		2,7	50	61,2	40,3	
8		2,9	44,5	103,8	21,8	
9		5	45	47,6	35,2	

EE.E.2. Re-stocking

Estonia has re-stocking programme for years 2002–2010. 75–100% of re-stocking has been financed by local fishermen, exept Soviet time. Restocking quantities are listed in Table C. Estonia imported glass eel up to 1987 from France, afterwords from England. Young yellow eel (average weight approx. 5g) was imported from Germany in 1988 and 1995, from Netherland in 2003 and 2005, from local fishfarm in 2002 and 2004.

Table EE.C. Re-stocking of glass eel and young yellow eel in the Estonia, in millions re-stocked.

	1950		1960		1970		1980		1990		2000	
		young		young		young		young		young		young
	glass	yellow	glass	yellow	glass	yellow	glass	yellow	glass	yellow	glass	yellow
Year	eel	eel	eel	eel	eel	eel	eel	eel	eel	eel	eel	eel
0	0,0	0,0	0,6	0,0	1,0	0,0	1,3	0,0	0,0	0,0	1,1	0,0
1	0,0	0,0	0,0	0,0	0,0	0,0	2,7	0,0	2,0	0,0	0,0	0,44
2	0,0	0,0	0,9	0,0	0,1	0,0	3,0	0,0	2,5	0,0	0,0	0,36
3	0,0	0,0	0,0	0,0	0,0	0,0	2,5	0,0	0,0	0,0	0,0	0,54
4	0,0	0,0	0,2	0,0	1,8	0,0	1,8	0,0	1,9	0,0	0,0	0,44
5	0,0	0,0	0,7	0,0	0,0	0,0	2,4	0,0	0,0	0,15	0,0	0,37
6	0,2	0,0	0,0	0,0	2,6	0,0	0,0	0,0	1,4	0,0		
7	0,0	0,0	0,0	0,0	2,1	0,0	2,5	0,0	0,9	0,0		
8	0,0	0,0	1,4	0,0	2,7	0,0	0,0	0,18	0,5	0,0		
9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,3	0,0		

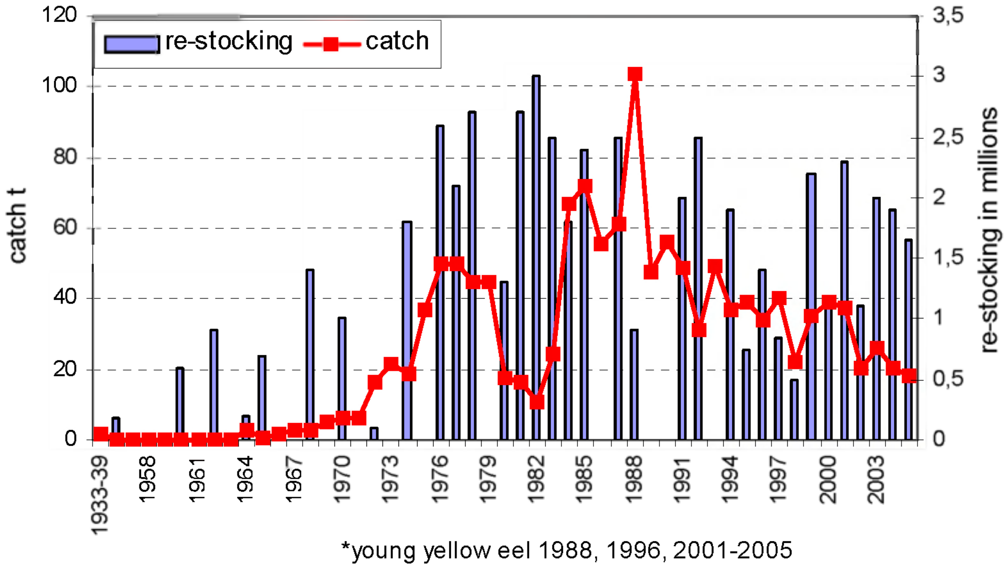

Figure EE.3. Re-stocking and catch of eel in L. Võrtsjärv. (1 young yellow eel = 5 glass eels).

In 1956 re-socking of glass eels into L. Võrtsjärv was restarted. However, re-stocking has been irregular (Figure EE.3). In the years 1988, 1995 and 2001–2005 young eels reared previously min a fish farm, were stocked. The re-stocking rate with glass eels has been relatively low: annual average in 1956–2001 was about 35 ind. ha^{-1} with a maximum of 84 ind. ha^{-1} in 1980–1984. The peak of re-stoking with glass eels occurred in the early 1980s. As a result, during the following five-eight years the catches of eel were the highest, constituting 2.5 kg ha^{-1} y^{-1}. The maximum catch of this fish was recorded in 1988 (104 t or 3.7 kg ha^{-1}). From the end of 1980s the declared annual catch was decreased.

EE.E.4. Aquaculture

There is only one eel farm in Estonia. Aquaculture production was:

YEAR	2003	2004	2005
Production (tons)	10	15	40

EE.E.5. Recreational fishery

Eel catches by amateur fishermen, using mostly long-lines, constitute about 2 t from brackish water and about 2 t from inland water bodies.

EE.F. Catch per unit effort

In logbook every professional fisherman makes records daily, according to specific fishing gear (fyke nets, long-lines). According to the long-line data the natural density of eel population in Estonian lakes outside of Peipsi watershed area was 2–3 times lower (Table EE B; Figure EE.2). In 2000–2004 the mean annual catch of eel per fyke net in L. Võrtsjärv was 80 kg.

Table EE.B. CPUE (catch in grams per 100 hooks per night) of long lines in water bodies of different river basins (Figure EE.2) and in L. Võrtsjärv in 2000–2004.

RIVER BASIN, LAKE	CPUE	
R. Emajõgi	2847	re-stocked
R. V.-Emajõgi	1393	re-stocked
L. Võrtsjärv	1316	re-stocked
R. Õhne	976	re-stocked
R. Gauja	700	natural
R. Pärnu	421	natural
R. Võhandu	397	re-stocked
R. Daugava	338	?
R. Salaca	0	natural

EE.G. Scientific surveys of the stock

EE.G.1.

No data available.

EE.G.2.

Until the end of 1990s Estonian investigations, based on commercial catches, were focused on stocking and fishing return of eel in L. Võrtsjärv. Since 2001 the cathes of yellow and silver eel were investigated in many lakes and rivers all over Estonia. Main source of the information for the eel were official catch and special long-line fyke net catches and electrofishing in rivers (multispecies survey in more than 300 stations every year, relative abundance). Special survey of eel in costal waters was not done in Estonia. During last five years investigations of eel were financed by Ministry of Environment.

EE.H. Catch composition by age and length

There is a sampling programme including measuring of length, weight and age determination of eel in L. Võrtsjärv and small lakes (Figure EE.4; Table EE C).

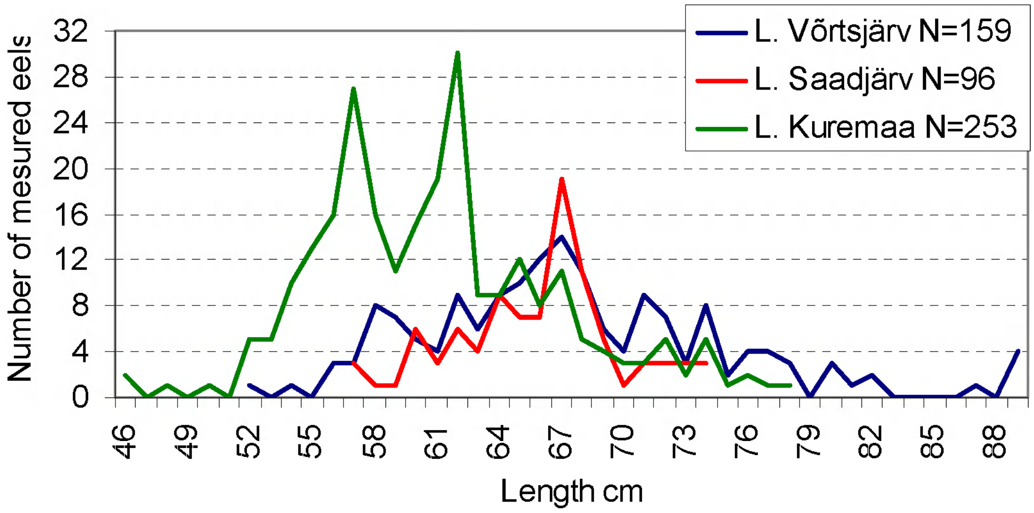

Figure EE.4. Number of measured eels and length distribution in fyke net catches in L. Võrtsjärv, L. Saadjärv and L. Kuremaa in May 2004.

Table EE.C. Number of the studied eels from Estonian lakes in 2000–2004.

LAKE	YEAR	NUMBER OF MEASURED EELS	NUMBER OF EELS AGE DETERMINED
L. Saadjärv	2000	177	14
L. Saadjärv	2003	19	19
L. Saadjärv	2004	132	16
L. Kuremaa	2002	174	31
L. Kuremaa	2003	5	5
L. Kuremaa	2004	459	16
L. Vagula	2001	8	8
L. Vagula	2004	3	1
L. Tamula	2004	1	0
L. Pulli	2003	19	15
L. Kaussjärv	2003	5	5
L. Kavadi	2002	1	1
L. Rõuge Valgjärv	2002	6	6
L. Visnapuu	2002	2	2
L. Lõõdla	2001	37	35
L. Lõõdla	2002	13	13
L. Lõõdla	2003	40	39
L. Lõõdla	2004	23	23
L. Tsolgo Mustjärv	2004	2	1
L. Võrtsjärv	2000	464	101
L. Võrtsjärv	2001	1095	109
L. Võrtsjärv	2002	573	29
L. Võrtsjärv	2003	293	67
L. Võrtsjärv	2004	311	43
L. Ülemiste	2003	40	5
L. Ülemiste	2004	158	2

EE.I. Other biological sampling

Since 1992 the intensity of *Anguillicola* infection in the eel population of L. Võrtsjärv have studied. During last 20 years the feeding and the condition factor of eel in L. Võrtsjärv have studied.

EE.J. Other sampling

During 1999–2003 there was estimated food composition of cormorants in the costal waters including the proportion of eel.

EE. K. Stock assessment

The fish stock assessment programme of Fishery Department of Ministery of Environment financed Environmental Investments Centre, includes special project of eel stock investigations (length, and age structure, recapture calculations, prognoses, limits) in L. Võrtsjärv and in other inland waters of Estonia. The results are reported to the Fishery Department.

EE. L. Sampling intensity and precision

Since 1973 measurments of eel in L. Võrtsjärv have been carried out. A total of 11000 specimens have been analysed. In 1990s and 2000s were measured 500–1000 eels annually mostli during two high seasons, in May and in August–September.

EE.M. Standardisation and harmonisation of methodology

EE. N. Overwiew, conclusions and recommendations

- registration of fishing efforts is well organised in inland waters, but not so good in costal waters
- biological sampling almost absent
- stock surveys are good in L. Võrtsjärv, in decent level in some small lakes but it is absent on costal waters

EE.O. Literature references.

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Report on the eel stock and fishery in Latvia 2005

LV.A. Author

Janis Birzaks
Latvian Fish Resources Agency
Daugavgrivas 8, Riga, LV- 1048, Latvia
Tel. +371 7612536. Fax: +371 7616946
Janis.Birzaks@latzra.lv

This report was completed in December 2005; the data for 2005 are not available.

LV.B. Introduction

The eel fishery in Latvia occurs in coastal and inland waters. Only stationary gear is used in eel fisheries by Latvian fishermen. Since 50ies anchored bottom long- lines were main gear in eel fisheries in the coastal waters, unlike fyke- nets, weirs and trapnets dominated in the inland waters fisheries. Currently different construction trapnets are more common gear in the eel fisheries.

Historically the eel fishery in Latvia is carried out in coastal waters, river estuaries and lagoon- type lakes close by the sea. After the initiation of artificial restocking of eel in 30ies, fisheries were organized in the inland lakes and lake outlets. Only in some lakes fisheries targeting especially eel still exist. In the coastal waters eel mostly is bycatch in fisheries targeting other fish species, especially herring, eelpout and perch.

From 1992 significant changes have been occurred in fisheries organization and ownership rights. From state owned and regulated sector fisheries become private. In the coastal and inland waters fisheries are organized by municipal level- the local municipality is the lessor of the fishing rights.

The fisheries in Latvia are organized by the fee. Every person (some exceptions for children and pensioner people) using commercial or recreational gear for every fishery should pay. There are no special eel fisheries licenses, fishermen pays on number of different gear used. Prices for the different fishing gear are fixed by the order of Latvian board of fisheries. Anglers should pay for seasonal or yearly “anglers card”. In some watercourses local licensing of angling still exists as extra payment for day or weekend angling rights. The part of the aid taken or fishing rights reach in the “Fish fund” and spends every year for restocking and resources management.

Control of fisheries is realized by the general rules limiting the construction, size and number of the gear for every watercourse where fisheries are allowed. In the last decade there is a clear tendency for decreasing of commercial fisheries in the inland waters due to political lobby of Anglers Association. At present eel fisheries are carried out in 16 lakes and along the coastline in ICES Subdivisions 28-1, 28-2.

LV.C. Fishing capacity

In the coastal waters of Latvia there are no fisheries companies targeting only eel. In 2004 92 fisheries rights owners reported eel catch.

In the inland waters eel catches are reported in 16 lakes belonging to 3 river basins (potential RBD’s). In 2004 43 fishermen, 8 small enterprises and one municipality owned fishery company where engaged in eel fishery in 16 lakes.

Only 2 of these lakes are accessible for diadromous fish, other watercourses are blocked by HPS dams. Eel fisheries in these lakes are based on restocked fish.

Table LV.A. Eel fisheries in the RBD's (2004), Latvia.

RBD	Number of lakes with eel fisheries	Surface of RBD (km^2)	Number of companies/individual fishermen	Catch of eels (t)	Data source
Daugava	13	27041.5	8/28	5.8	Logbooks
Venta	2	15632.7	0/15	2.4	Logbooks
Lielupe	1	8841.7	1/0	0.5	Logbooks

LV.D. Fisheries effort

The fisheries effort data for eel fisheries from 1992 seems to be stable and tended to decrease. Fisheries effort is fixed by the limited number of gear used in the both inland and coastal fisheries.

Table LV.B. Number of gear in coastal/inland waters used in fisheries targeting/bycatching eel.

Watercourse	Trap nets	Fyke nets	Long- lines (in num. of hooks)
Coastal waters	221	760	43500
Inland waters	62*	504	Not allowed

*- only these fisheries/gear targeting eel

LV.E. Catches and landings

LV.E.1. Catches of glass eel

There are no catch of glass eel in Latvia

LV.E.2. Restocking

The first official glass eel and young yellow ell stocking are carried out in 1927. Interruptedly eel re- stocking has been performed till nowadays, the maximum was fixed in 1960–70's. From the dawn of eel restocking till 1990's this measure was organized by the state (for example to increase an income and welfare of fishermen's in 1930's). In last decade eel restocking are carried out by the fishing rights/lakes leaseholders.

On the whole young eel restocking in the inland waters of Latvia was irregular, stocking material was imported from the France.

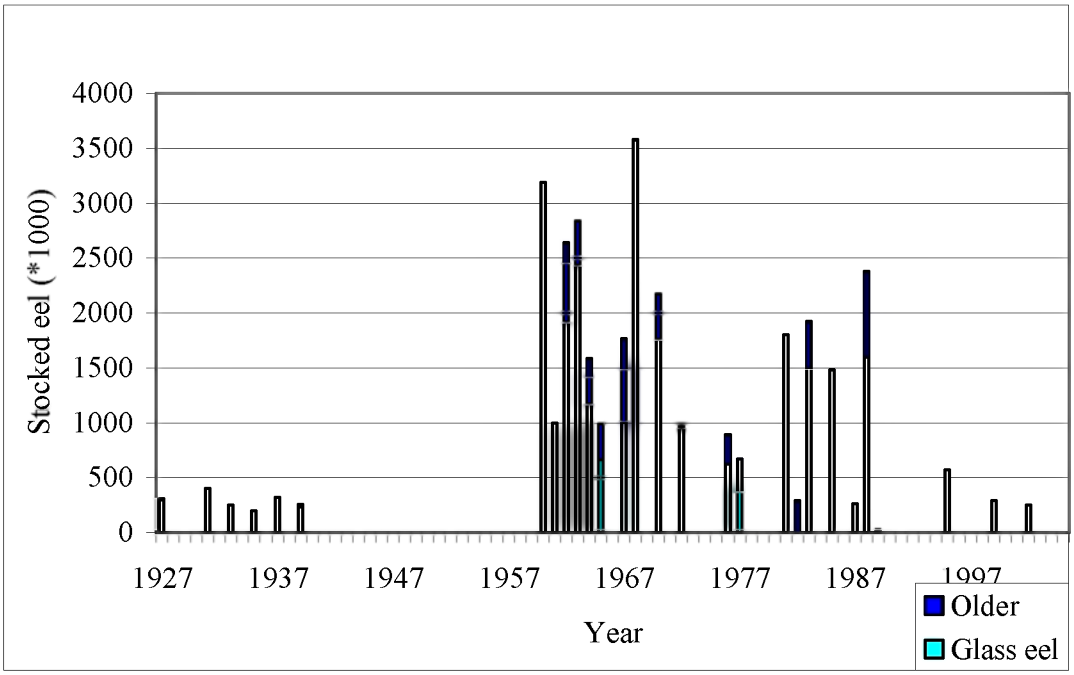


Figure LV.1. The young eel re-stocking in the Latvia inland waters.

LV.E.3. Catches of yellow and silver eel

Latvian fisheries legislation does not contribute the separation of eel catch in two different strains. One of the reasons could be the fisheries traditions. The most valuable eel for market are specimens at least 0.7–1.0 kg weight. Quality differences of (yellow- silver) eel are well known for fishermen's as yellow eels ("zaļš"- green in Latvian) are better for smoking in comparison with silver eels ("melns"- black in Latvian). So, that all smoked eel are similar.

Only small scale data regarding proportion of silver/yellow eel in the coastal catches. This data was collected in the summer of 2005 from three reference areas/fishermen who voluntarily checked the own catch and marked the yellow or silver eel presence.

The question for WG- would the eye fitted differences in coloring and other externals for 2 different strains of one species to be a basic for official fisheries statistics? From our opinion without clear looking "yellow" or "silver" ell still have transition forms.

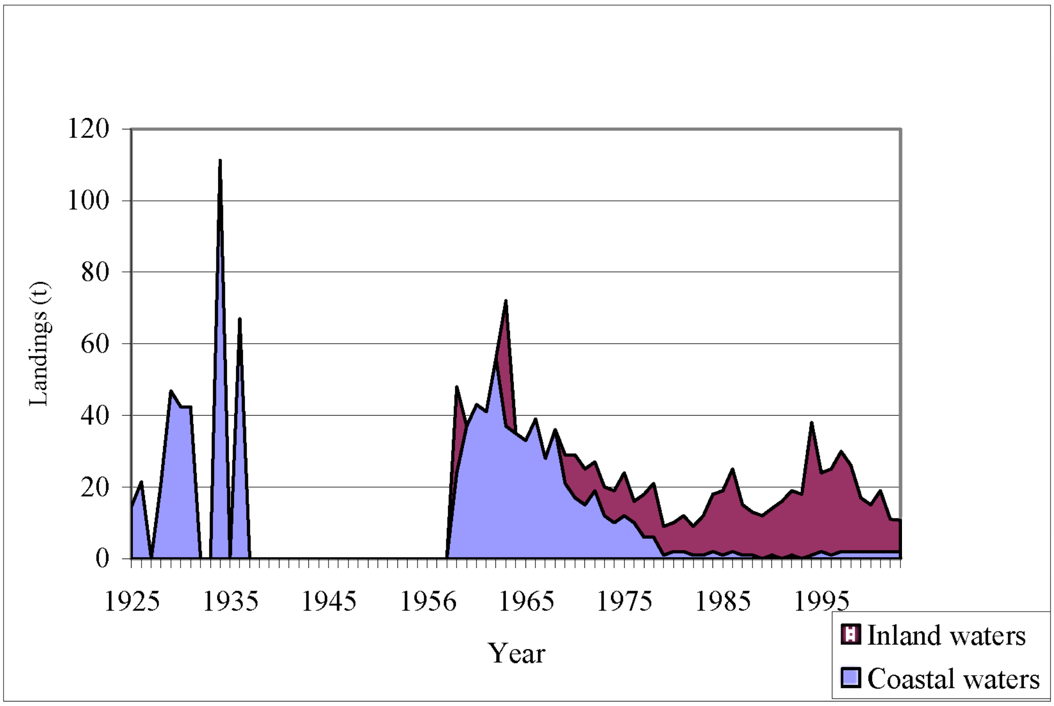


Figure LV.2. Historical eel catches in coastal and inland waters of Latvia.

Fisheries statistics in coastal and inland waters of Latvia are based on monthly logbooks. Each fishery should recorded including watercourse, catch and gear data. Monthly logbooks collected by the Marine and Inland waters Administration regional officers. The logbook data are processed and stored in LFRA.

In the course of time the fisheries statistics principles, organization and collection changed significantly. At present eel fisheries statistics in the inland waters by RBD's would be accessible from 1946, but in the coastal waters from the period of 1927–1938 and 1946 till now. At the moment all accessible data is not computed and partially still exists on paper format in the State Archive.

LV.E.4. Aquaculture

There is no eel aquaculture in Latvia.

LV.E.5. Recreational fisheries

Share of recreational fisheries in inland and coastal waters is estimated by questionnaires organized in 2000 and 2001. The number of anglers in Latvia assessed to be 80 000–120 000. The eel was not included in questionnaire as species dominating in the catch, only occasional eel catches were reported by anglers.

Nevertheless, eel was limited by bag limit and size in recreational fisheries. In the some lakes restocked by eel leaseholders restrict the angling in the night time to decrease the pressure on eel stock.

LV.F. Catch per unit effort

Catch per unit effort data seem to be achievable for the some lakes where eel fisheries are carried out in the outlet of lake by "eel weir". The eel weirs covered practically all the outlet for all escapement (sea dwelling migration) time. These data should be combined by the restocking data too. For few lakes of Latvia 30–40 years data series still exist. Nevertheless, question is disputable.

LV.G. Research

Till the 70s there are no special research programs on eel. To contribute the National Fisheries data collecting programme in 2006 LFRA planned:

1) Survey on catch composition, biological sampling in Daugava RBD;

2) Initiation of eel tagging.

LV.H. Catch composition

At present nothing is done to analyse eel catch composition. Last biological sampling and age reading of the eel in Latvia carried out in 1974–1975 in the Gulf of Riga.

LV.I. Other sampling

There are not other biological samplings of eel. For our opinion WG eel should contact with people/organisations providing FW fish monitoring (especially by electrofishing in the lakes/rivers) in the own countries to collect data on:

- distribution;
- abundance;
- length/weight/age composition.

Report on the eel stock and fishery in Poland 2005

PL.A. Authors

Wojciech Pelczarski
Sea Fisheries Institute
ul. Kollataja 1
81-332 Gdynia, Poland
Tel. +48 58 7356219
wpelczar@mir.gdynia.pl

Stanisław Robak
Inland Fisheries Institute
ul. Oczapowskiego 10
10-719 Olsztyn, Poland
tel. + 48 89 524 0171
robak@infish.com.pl

Tomasz Nermer
Sea Fisheries Institute
ul. Kollataja 1
81-332 Gdynia, Poland
Tel. +48 58 7356211
nermer@mir.gdynia.pl

This report was completed in January 2006, and contains data up to 2004.

PL.B. Introduction

Eel fisheries in Poland occur in lakes, rivers, coastal open waters and two brackish water basins namely Szczecin Lagoon and Vistula Lagoon, however, part of Szczecin Lagoon belongs to Germany and part of Vistula Lagoon belongs to Russia (Figure PL.1). Inland and coastal fisheries are targeted on silver eel and on yellow eel but no data on share of those forms in the catches are available.

The total area of inland lakes, reservoirs (over 50 ha) is 2293 km^2. In the main stream of Vistula and Odra Rivers and in supporting rivers many dams were constructed, which successfully stopped the upward migrations of eel, as well as other fish species.

Eel fisheries have a long tradition in Poland. Before WW II it was concentrated mainly in inland waters, because Poland had a very small piece of coast available for sea fishery at that time. After WW II, with gaining a broader access to the Baltic (over 500 km of coastal line), the Polish coastal eel fisheries has developed much more and achieved up to 388 tons per year while inland eel fisheries, which also increased substantially its number of lakes, reached up to 1500 tons per year. In the period of 1974–1994 inland catches constituted up to 75% of total yearly Polish catch of eel. Since then dropped very much, almost to the level of coastal catch and recently both fisheries achieve the level of 200–300 tons.

Until late 1950' Polish eel fisheries based almost exclusively on natural recruitment, later on, extensive restocking mainly with glass eel was carried out in many lakes and both lagoons. This stocking decreased almost to zero in late 1990' due to changes in the fishery management and high prices for glass eel. The lack of stockings resulted in very serious decrease of catch, mainly in inland fisheries.

The eel is a non-licensed species in Poland, both in coastal and inland fisheries. All eel fisheries is in private hands and, at the present, there are no organized fishing companies in the coastal fishing, however, in some river districts so called "cooperatives" operate and they are also fishing for eel. There are private fishery farms having also several lakes with eel but most of lakes have a separate owner. There is no solely eel stock and fisheries management in Poland, however, all eel management issues are within hands of the Ministry of Agriculture and Rural Development. Governmental control is limited only to a set of general rules: size limits, gear restrictions, closed seasons and areas. Special protection rules applies to eel fyke net fishing, in Szczecin Lagoon, Pomeranian Bay and Vistula Lagoon, where all fyke nets have to be equipped with protection metal "sieves" in the end of bag to allow release of undersized eel. The three Regional Inspectorates of Fisheries, located in Szczecin, Slupsk and Gdynia, are responsible for management, monitoring and surveillance of fisheries at territorial level. In the coastal fisheries landings and effort are registered and reported on obligatory basis as monthly reports (boats up to 8 m) and in the EU-standard logbooks (boats 8-10 meters, if they are fishing cod, otherwise only as a monthly reports) Boats over 10m all have EU-logbooks. There is no obligatory reporting from fishery in lakes and rivers. Polish Anglers Association has some data available but it comes from voluntary reporting by PAA members only. The Inland Fisheries Institute in Olsztyn collects selected inland catch data based on its own sources (mainly questionnaires distributed among lake owners).

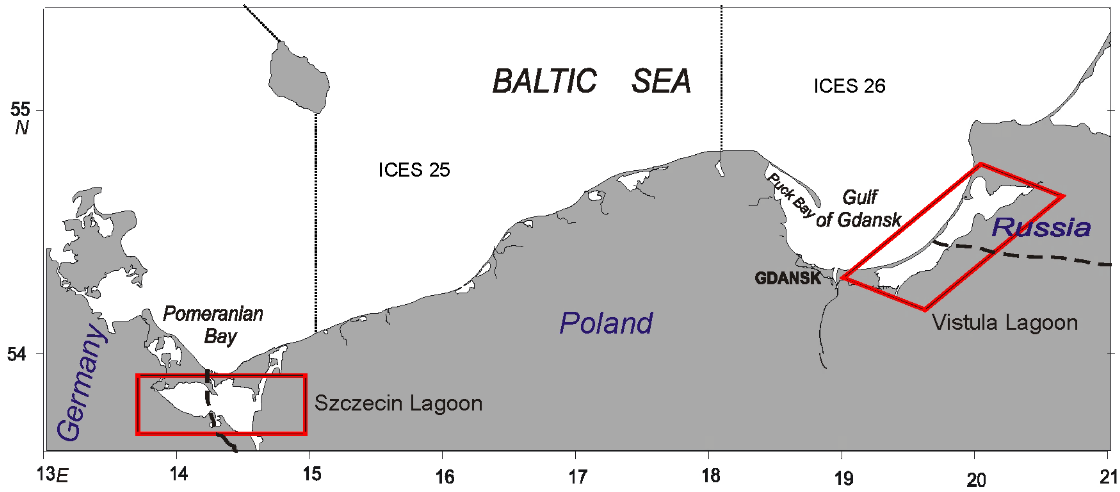


Figure PL.1. The Polish coastal area.

There are five main fishing areas along the Polish Baltic coast (also see FigurePL.1), from all of them landing statistics according to DCR are available since 1994:

1) Szczecin Lagoon; which is influenced firstly by waters of the Pomeranian Bay, where some fish migrate to feeding grounds and then return with the back flow, and secondly by the waters of Odra River and Swina, Dziwna and Piana Rivers which connect it with the bay (Figure PL.2). Total area of lagoon is 911,8 km^2, of which 457 km^2 is under control of the Polish fishing administration, the rest is under Germany control. The lagoon comprises of several bays, islands, rivers and internal channels. Total exchange of water between the lagoon and bay occurs seven times a year. The lagoon is eutrophic and relatively shallow (mean depth 3,8 m) but along shipping lanes it reaches 11–12 m. In the Polish part of the lagoon approximately 260 fishermen with 100 boats operating from 10 bases reported eel catches in 2004, however, total number of motor boats operating there is higher. The main gear used for eel are different types of fyke nets, eel baskets, seines and hooks. The Polish highest catch was 447 t in 1967. In 1975-

1990 the lagoon was restocked by Poland with an average of 2,5 tons of glass eel per year. The volume of catch is shown in Table PL.d.

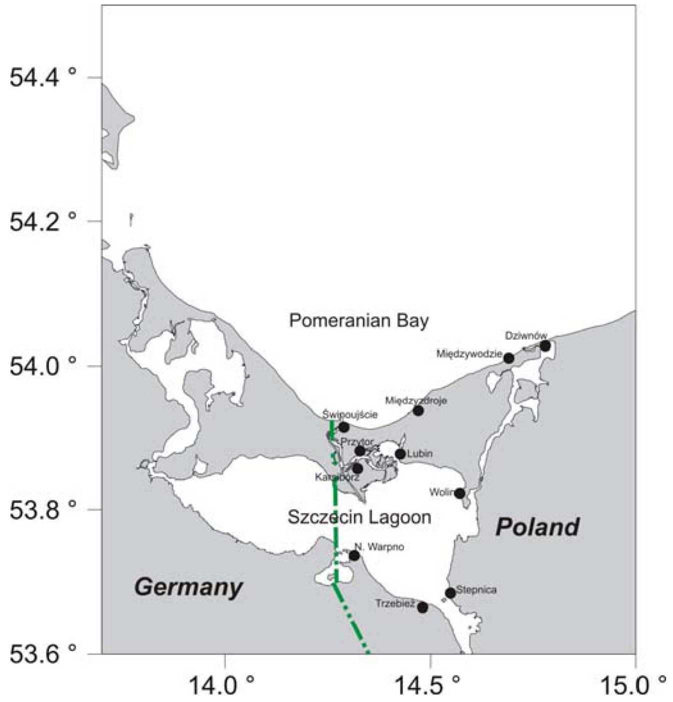


Figure PL.2. Fishing bases in the Szczecin Lagoon and Pomeranian Bay.

2) Pomeranian Bay; is a broad open area of ca. 6000 km^2, which in part is situated within Polish EEZ (Figure PL.2). Its depth is up to 20 m and mean depth is 13 m. The south-west part is under influence of fresh water of rivers: Odra, Piana and Swina. The boat fishing effort in the whole area was "frozen" to the level of 1996. Main gears for eel: hooks fyke nets. In 2004 there were 8 boats from three fishing bases reporting eel catches from the area. The volume of catch is shown in Table PL.d.

3) Open coast (ICES Subarea 25): an open broad belt of coast from 15^{0}E to 18^{0}E, with fisheries operating up to 6 mile from the shore and up to depth of 20 m. There are several rivers discharging to the sea; some of them are connected with near-coastal lakes. The eel fishing there has minor importance and its catches dropped from 5 tons in 1954 (Trella, 2000) to 2,5 tons recently (Table PL.d). There were 8 fishing bases with 33 boats reporting eel catches in 2004.

4) ICES Subarea 26: the Polish waters of Gulf of Gdansk and some part of waters north of Hel Peninsula, from 18^{0}E to the Polish-Russian border (without Vistula Lagoon). Salinity ranges from 4–7‰ in the inner part of Puck Bay to 13–14‰ in open coasts. Coastal eel fishing is carried out mainly in shallow waters of Puck Bay and also in coasts on both sides of Vistula River mouth. This area has big tradition in fisheries and has 17 fishing bases with over 100 fishermen and 76 boats reporting eel catch in 2004. Yearly eel catch was 118 tons in 1955 (Borowski, 2000) but in the last decade decreased to 9–16 tons (Table PL.d).

5) Vistula Lagoon – the largest estuarial coastal eutrophic reservoir in the southern Baltic and very important in coastal eel fishing. Total area is 915,5 km^2 out of this 328 km^2 is within Polish borders (Figure PL.3). Total length of the lagoon is 91 km, average width is 9,5 km and mean depth is 2,8 m. The salinity is 0,10‰–1,60‰ during summer and 2,90‰–4,70‰ during autumn. The water has very low transparency (30–90cm). The only one and narrow connection with Baltic Sea is in the Russian part. The highest eel catches of 350–500 tons yearly were

recorded in 1926–1940 (Borowski, 2000) but in last decade it decreased from 108 tons in 1996 to 21 tons in 2004 (Table PL.d). There are ca. 200 fishermen and 115 boats, reporting eel catches (2004), operating from 8 bases. Fishing gears: fyke nets, hooks.

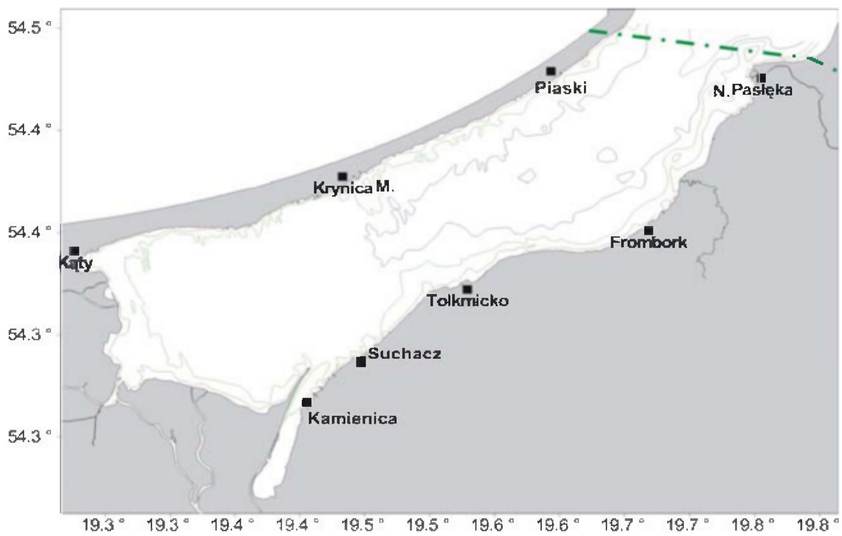


Figure PL.3. The Vistula Lagoon (Polish part) and main fishing bases.

There are three big complexes of lakes in Poland, where eel is present (see Figure PL.4):

1) Pojezierze Wielkopolskie – central-western part of Poland,

2) Pojezierze Pomorskie- northern part of Poland

3) Pojezierze Mazurskie (Masurian Lakeland) - north-eastern part of Poland,

Figure PL.4. The big lake complexes in Poland.

River Basin Districts in Poland

Water Framework Directive separates two RBD's in Poland (Figure PL. 5):

a) Odra RBD (ORBD) of total area within Polish borders 118 462 km^2, which includes:

- Odra drainage -118 861 km^2, out of this 106 057 km^2 is within Polish borders, 7217 km^2 within Czech and 5587 km^2 within Germany borders;
- Szczecin Lagoon of 12 100 km^2, out of this 2459,2 km^2 is within Polish borders and 9471,2 km^2 is within Germany borders;
- drainages of three Pomeranian rivers (Rega, Parseta,Wieprza) of total area 9029 km^2 , which are discharging to Baltic Sea;
- drainages of other international rivers, present in the Polish territory, of total area of 249,6 km^2, out of this 239,8 km^2 is Elbe drainage, 1,3 km^2 is Danube drainage and 8,5 km^2 is Ucker River drainage (flowing to Szczecin Lagoon)

b) Vistula RBD (VRBD) of total area within Polish borders 194 223 km^2, which includes:

- Vistula drainage of total area 199 813,0 km^2 , out of this 174 087,2 km^2 is within Polish borders and 25 725,8 km^2 is outside Polish borders;
- Drainages of Pomeranian rivers discharging to Baltic Sea, with total area of 5 965,8 km^2 ;
- Vistula Lagoon of 915,5 km^2 with drainage of Pasleka River – 2294 km^2;
- drainages of other international rivers present in the Polish territory of total area 11 020 km^2 , out of this drainage of Pregola – 7519,8 km^2, Niemen (Nemunas) – 2511,6 km^2, Dniestr – 233,2 km^2, Danube – 381 km^2, and Swieza River – 374,1 km^2.

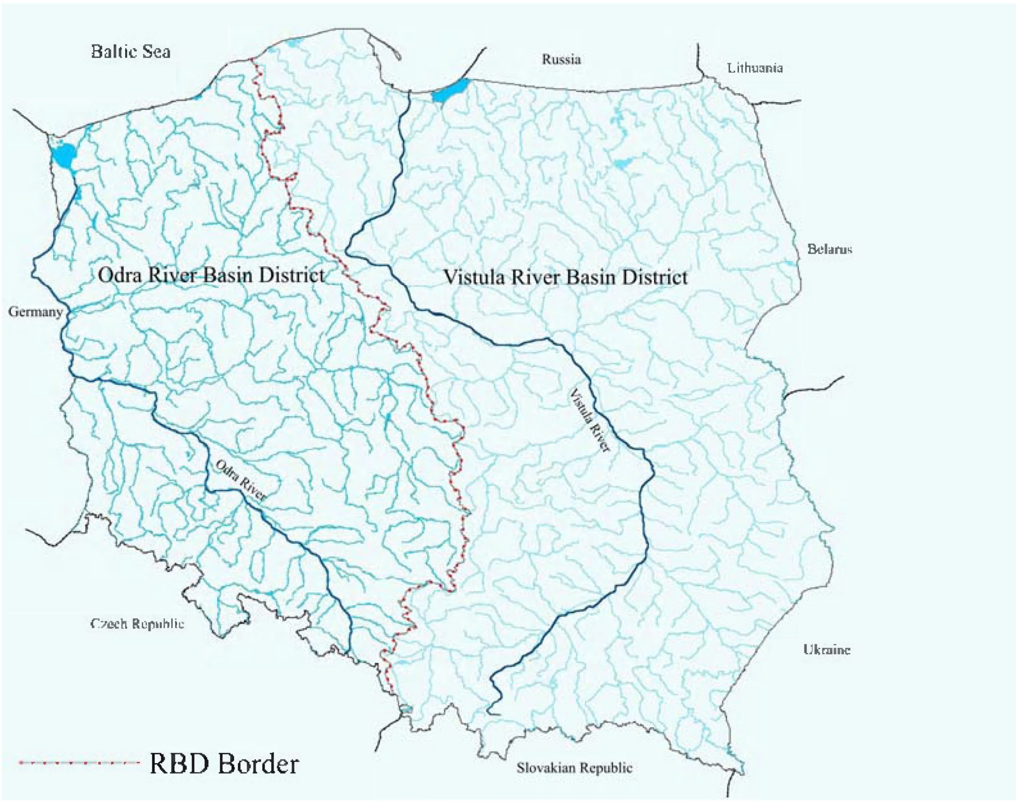


Figure PL.5. River Basin Districts in Poland.

PL.C. Fishing capacity

No data is available neither for inland fisheries nor for recreational fisheries.

There are no companies organized for coastal fishing eel and every boat owner catch fish on its own. Total number of bases and boats involved in eel fishery in 2004 in particular areas is given in Tables PL.b.1–b.3. Those figures are derived from fisheries database of the Ministry of Agriculture and Rural Development. Details on size of individual boats are readily available but there are no data on numbers of fishermen involved.

Total number of boats in register is presently changing due to implementation of EU program of reducing fishing capacity. The length of fishing boats ranges from 4 m to 11 m and their age is 6–16 years.

Mean engine power of boat differs between the areas (Polanski, 2000):

ORBD		VRBD
Szczecin Lagoon	– 37 KM,	ICES Sub-area 26- 26 KM,
Pomeranian Bay	- 63 KM,	Vistula Lagoon - 76 KM
Open coast (ICES Sub-area 25)	- 65 KM,	

Table PL.a. Fish bases and relevant number of boats involved in coastal eel fishery in 2004

ORBD		VRBD			
Szczecin Lagoon		East Coast (ICES 26)		Vistula Lagoon	
Kamień Pom.	8	Chałupy	6	Frombork	14
Karsibór	3	Hel	4	Kąty Rybackie	17
Lubin	9	Jastarnia	17	Kamienica Elbląska	4
Przytór	1	Jelitkowo	1	Krynica Morska	12
Szczecin Dąbie	11	Kuźnica	9	N. Pasłęka	20
Szczecin Stołczyn	10	Mikoszewo	2	Piaski	17
Stepnica	8	Obłuże	3	Suchacz	8
Trzebież	44	Oksywie	1	Tolkmicko	22
N.Warpno	1	Orłowo	3	TOTAL	114
Wolin	5	Puck	4		
Wapnica	1	Rewa	3		
TOTAL	101	Swarzewo	6		
		Świbno	12		
Pomeranian Bay		Sztutowo	1		
Międzyzdroje	4	Górki Wsch.	1		
Międzywodzie	1	Górki Zach.	1		
Świnoujście	3	TOTAL	77		
Dziwnów	1				
TOTAL	9				
Open coast (ICES 25)					
Chłopy	4	Mrzeżyno	1		
Darłowo	12	Unieście	2		
Dąbki	4	TOTAL	33		
Rewal	1				
Jarosławiec	2				
Kołobrzeg	7				

PL.D. Fishing effort

Before 1994 data on effort (no of gears and days) were recorded in old database (Tables PL.b1–b.3). Since 1994 the number and type of gear used are recorded obligatory in the monthly reports and in the EU-standard logbooks, from where there are retrieved into database of the Ministry. However, the number of days the gears are used, is not recorded (Table PL.c). The database is operating from 2004 and there is still lot of errors; especially data on gears are not fully reliable. Gears used are: fyke nets, eel baskets, hooks&lines, alhams and seines.

Table PL.b.1. An average number of fishing gear per boat in particular areas (all tables after Polanski, 2000).

	SZCZECIN	POMERANIAN	OPEN COAST	OPEN COAST	VISTULA
	Lagoon	Bay	ICES 25	ICES 26	Lagoon
Fyke nets	23	14	10	35	30
Eel hooks	1248	3681	1852	1665	-
Eel baskets	90	37	30	62	-
Alhams	16	-	-	-	-

Table PL.b.2. Average annual time (days) of fishing with fixed gear.

	Szczecin	Pomeranian	Open coast	Open coast	Vistula
	Lagoon	Bay	ICES 25	ICES 26	Lagoon
Fyke nets	169	210	43	58	177
Eel hooks	11	37	37	39	-
Eel baskets	27	19	200	70	-
Alhams	107	-	-	-	-

Table PL.b.3. Total fishing effort (gear/days) by coastal regions and gears.

ORBD	SZCZECIN LAGOON	POMERANIAN BAY	OPEN COAST ICES 25	TOTAL
Fyke nets	330075	2940	1280	334295
Eel hooks	689800	19866000	1225000	21780800
Eel baskets	244680	4120	-	248800
Alhams	44300			44300
VRBD	Open coast ICES 26	Vistula Lagoon	TOTAL	
Fyke nets	195180	392281	587461	
Eel hooks	8069500	-	8069500	
Eel baskets	134780	-	134780	
Alhams			0	

Table PL.c. Total effort (no. of gears set) in 2004 in Szczecin and Vistula lagoons.

Month	ORBD- Szczecin Lagoon		VRBD - Vistula Lagoon	
	Fyke nets	Hooks	Fyke nets	Hooks
I	0	0	0	0
II	0	0	0	0
III	905	0	19	0
IV	15103	0	3703	700
V	21214	47373	13037	93848
VI	18715	20900	7474	42200
VII	19499	56000	2147	27700
VIII	25019	3000	3691	58700
IX	18260	0	10947	7950
X	13007	0	7577	0
XI	1443	0	673	0
XII	0	0	0	0
Total	**133165**	**127273**	**49268**	**231098**

PL.E. Catches and Landings

Restocking

Restocking with glass eel was conducted in Vistula Lagoon (VRBD) during 1970–1988 (mean 1400 kg/year) and in 1988–1994 (mean 167 kg/year) (Borowski, 2000). Restocking in Szczecin Lagoon was conducted in 1975–1991 with mean 1240 kg/year (Borowski *et al.*, 1999)

Catches and Landings

Eel fishery in Poland applies mostly to the silver eel and occasionally to the yellow eel. Inland and Baltic coastal eel catches (tons) in 1950–2001 are presented in Figure PL.6. Time series for the coastal eel in 1995–2004 are presented in Table PL.d. In the fishery documents the volume of catch equals to volume of landing. It means that total catch is practically the total landing. The magnitude of unreported catches is probably high, but is difficult to assess. No fishing auction system, except the first one in Ustka, takes place in Poland. Monthly catches in three main coastal fishing areas are shown on Figure PL.7, Figure PL.8 and Figure PL.9.

The present database in the Ministry has still some errors, also due to misclassification of species. For inland waters, no obligatory registration of landings exists. The estimates of inland landings are based on other data sources, PAA questionnaires and lake owners' inquiries.

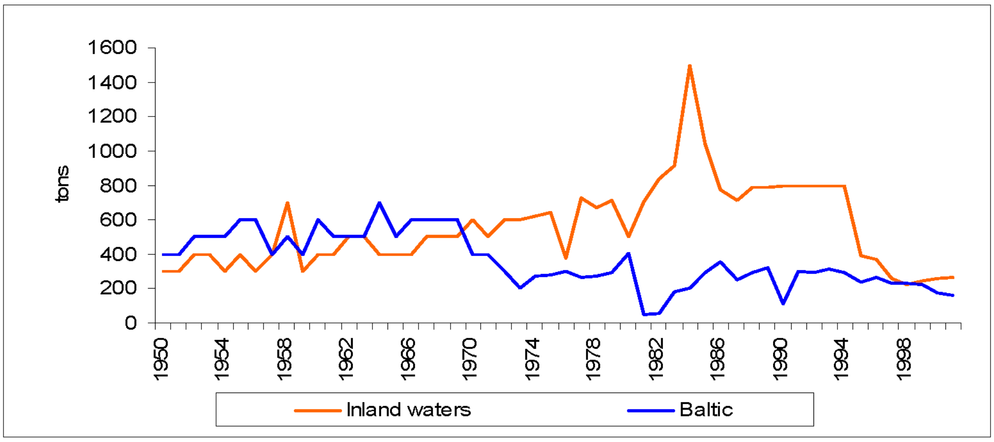


Figure PL.6. Polish inland and Baltic coastal eel catches (tons) in 1950-2001(source: FAO).

Table PL.d. Polish Baltic coastal eel catch (kg) by area in 1995–2004.

VRBD	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
East Coast (ICES 26)	18 059	14 096	8 760	7 249	16 751	16 290	12 729	14 656	15 213	14 367
Vistula Lagoon	103 847	108 034	75 513	74 373	100 300	70 155	60 585	34 182	51 472	21 233
TOTAL	121 906	122 130	84 273	81 622	117 051	86 445	73 314	48 838	66 685	35 600
ORBD										
Middle Coast (ICES 25)	3 169	1 595	2 726	2 127	2 855	1 712	787	1 916	1 550	2 562
Pomeranian Bay	13 900	17 200	15 500	14 100	9 600	10 800	12 600	12 400	8 752	2 380
Szczecin Lagoon	98 400	124 800	130 400	132 900	92 800	66 200	67 200	58 726	39 162	34 620
TOTAL	115 469	143 595	148 626	149 127	105 255	78 712	80 587	73 042	49 464	39 562
GRAND TOTAL	237 375	265 725	232 899	230 749	222 306	165 157	153 901	121 880	116 149	75 162

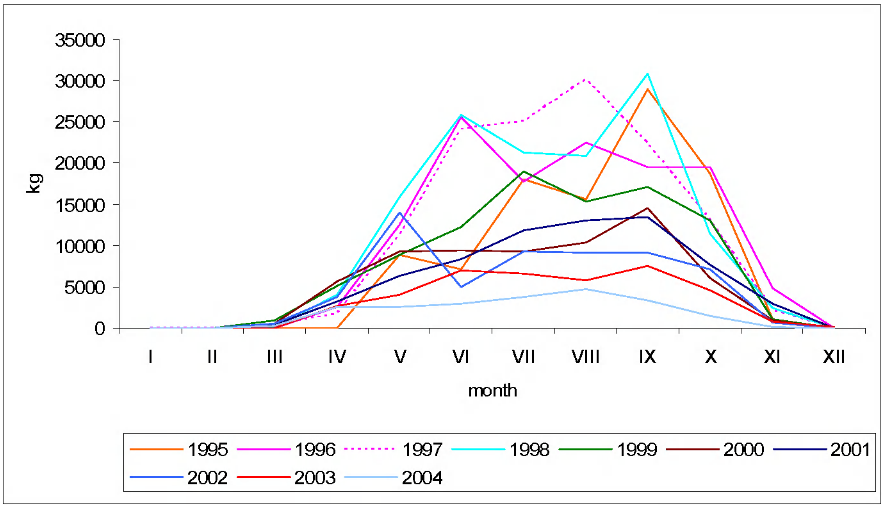


Figure PL.7. Polish monthly catches of eel in Szczecin Lagoon (ORBD) in 1995–2004.

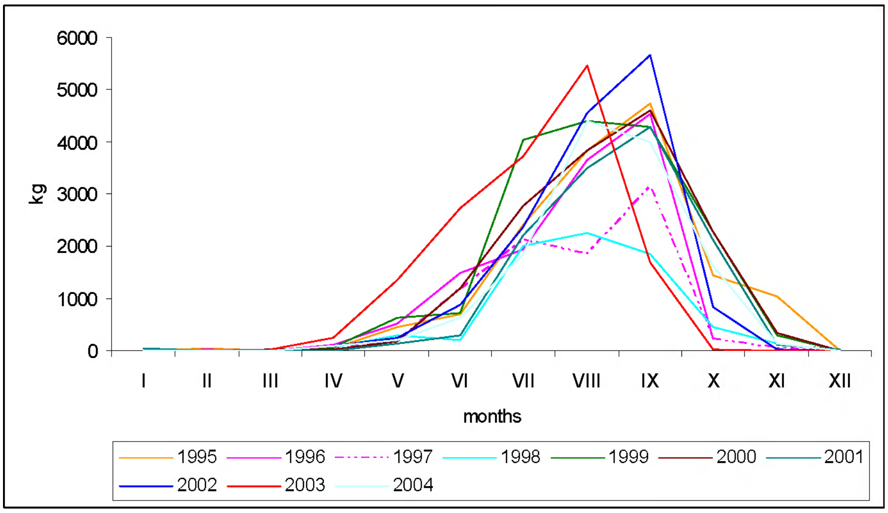


Figure PL.8. Polish monthly catches of eel in open waters of ICES Subarea 26 (VRBD) in 1995–2004.

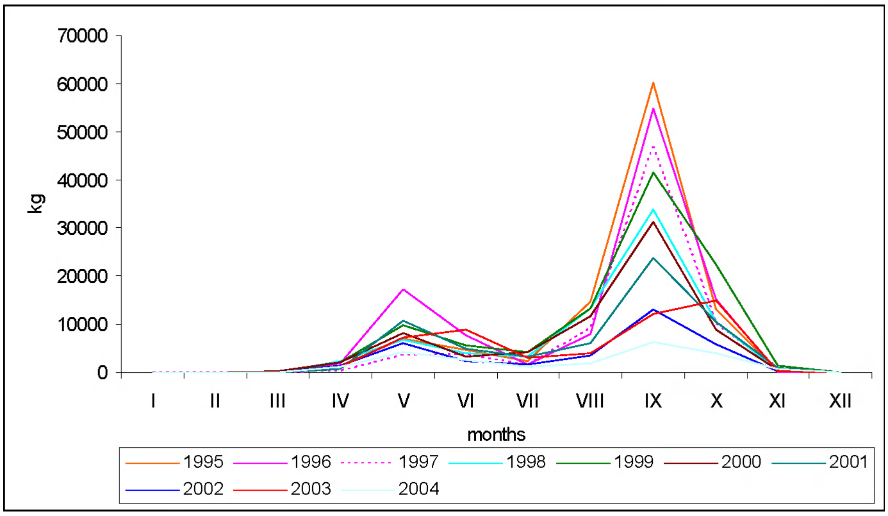


Figure PL.9. Polish monthly catches of eel in Vistula Lagoon (VRBD) in 1995–2004.

PL.F. Catch per Unit of Effort

No evaluation (by requested method) on catch per unit effort was done in coastal and inland waters.

PL.G. Scientific surveys of the stock

- PL.G.1 Recruitment surveys, glass eel -No recruitment surveys for glass eel.
- PL.G.2 Stock surveys, yellow eel -No fish stock surveys for yellow eel.
- PL.G.3 Silver eel -No fish stock surveys for silver eel.

In 1994 an experimental program for tagging eel with T-bar Anchor Floy Tags had been carried out in Pomeranian Bay, Middle Coast and Vistula Lagoon. Total of 5827 eels were tagged (Garbacik-Wesolowska and Borowski, 1995.

PL.H. Catch composition by age and length

For the Vistula Lagoon samples from commercial fyke nets landings have been collected in the years 1969–1976 (Filuk and Olsza, 1978) and 1992–2001. For the Szczecin Lagoon sampling from fyke nets was conducted in 1969–1970 and in some years during 1993–2000. After then no measurements were conducted. Samples from hook catches were collected only during 1999 in the Vistula Lagoon. During 1996–1998 also length and weight measurements from fyke nets in the Puck Bay (part of ICES Area 26) were done.

For all eels in the samples length (up to 1 cm) and weight (up to 1–2 g) were determined. In 1969–1970 otoliths from Szczecin Lagoon eels were collected and age readings were carried out in the laboratory. Fish for sampling were acquired directly from fishermen in fishing bases located in different parts of the coast.

All length-weight-age sampling was executed by the Sea Fisheries Institute in Gdynia. Having in mind that DCR specifies one sample of 100 eel per 20 tons of landings, the previous level of sampling was sufficient, even in some years much exceeding, for landings obtained. Results of catch composition findings were used in general management advice presented to the Ministry as a part of all-species sampling and fishery expertise.

There is no regular sampling for eel in inland waters; however, scientist of Inland Fishery Institute (IFI) in Olsztyn were collecting length and weight data from some lakes in the Pojezierze Mazurskie between 1986 and 1990 (Table PL.e) Data were collected from 60 lakes of overall area reaching 43 846 ha. The lakes were communicated with each other by permanent connections and varied in terms of depth, area and trophic status.

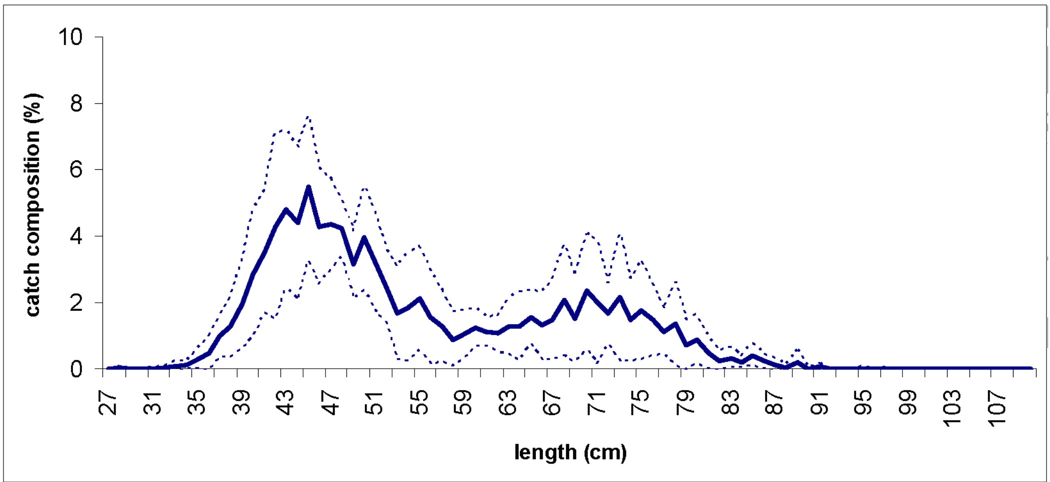


Figure PL.10. Average length composition of fyke net catches, with confidence intervals (± 4,9 std), for Vistula Lagoon, based on data sets from 1992–2001.

Average length composition of fyke nets catches for the Vistula Lagoon based on data from 1992–2001 is presented in Figure PL.10.

Table PL.e. Results of eel length and weight sampling in lakes of Pojezierze Mazurskie (VRBD) in 1986–1990.

SEX/STAGE	N	TOTAL LENGTH LT (CM)				WEIGHT (G)			
	(nos.)	Average	Range	SD	V(%)	Average	Range	SD	V(%)
Male	72	36,5	28,5-46,0	4,588	12,57	83	37-155	33,041	39,81
Female	6926	48,5	23,0-95,0	12,551	25,87	231	17-1555	187,256	81,06
Yellow	6086	46,4	23,0-90,0	11,371	24,50	198	5-1340	154,869	78,21
Silver	840	64,5	47,5-95,0	8,293	12,83	468	175-1555	223,851	47,83
Sharp-headed	5588	45,9	16,0-90,0	1,49	25,27	192	5-1450	153,921	80,16
Broad-headed	1391	58,4	29,5-95,0	11,600	19,86	376	33-1555	230,184	61,21

PL.I. Other biological sampling

A part of fish in some years in the Vistula Lagoon was analyzed by SFI for stomach fullness, presence of *Anguillicola crassus* in the swimbladder and to assess the share of "green" and "silver" eel in the autumn catch, but the number of sampled fish was rather low. No analysis for PCB or heavy metals was performed.

In 1986–1990 the IFI collected data from eel caught in Pojezierze Mazurskie (as in the Tab. PL. g) on broad-headed eel ratio, sex proportion, puberty (green and silver), age, growth rate, condition and growth potential.

PL.J. Other sampling

There are studies being carried out on the black cormorant pressure on the coastal and inland waters ichthyofauna. Eel contributed from 1,9% to 2,4% in weight of cormorants food from Gulf of Gdansk in 1998 and 1999 respectively (Bzoma, 2004). In most cases one or two eels on average weight 300g and length 56 cm were found in eel food. Total amount of eel eaten from Vistula Lagoon is estimated for 52 tons/year on average, during 1998–2000.

PL.K. Stock assessment

Landing statistics and effort data are reported to the Ministry of Agriculture through Inspectorates of Fisheries. Data on length-and-age sampling are presented every year to the Ministry and fisheries authorities in the form of research reports of the Sea Fisheries Institute.

The other data collected while doing the research is being used for cognitive aims as well as for planning and prognosis actions connected with running a rational fisheries management.

Recommendations on minimum size, effort reduction, closed periods and areas for eel in the Vistula Lagoon were presented by Borowski (2000). In the 1997 calculations of the von Bertalanffy growth equation parameters were based on a complete set of tag recoveries, as well as on recoveries from particular tagging experiments and the biomass of the eel population of the Vistula Lagoon was estimated based on the catch curve (Borowski *et al.*, 1997).

PL. L. Sampling intensity and precision

The spatial variation in mean length of fyke net catches and change in size composition of eel coastal landings was analysed by Borowski (2000), Wysokiński (1998), however the statistical properties of the sampling protocol were not given.

Number of sampled fish from Vistula Lagoon varied from 400 to 6500 per year (Tab.PL.f) and each sample included 5–>100 fish. An example of effort distribution in fishery squares and sampling distribution in 1996 is presented in the Fig.PL.11. Intensity of sampling with electrofishing and fishing gears from lakes of Pojezierze Mazurskie is shown in Table PL.g.

Table PL.f. Intensity of the eel sampling in the Vistula Lagoon (VRBD) in 1993–2000.

	Year							
Month	1993	1994	1995	1996	1997	1998	1999	2000
							Number of fish sampled	
IV			4			10	22	
V	193	648	63	397	25	53	223	33
VI	169	3503	66	180	68	103	142	46
VII	347		54	558	92	238	31	28
VIII			189	120	86	182	45	128
IX		1651	150	103	725	146	43	177
X		716	152		131	378	84	
Total	**709**	**6518**	**678**	**1358**	**1127**	**1110**	**590**	**412**

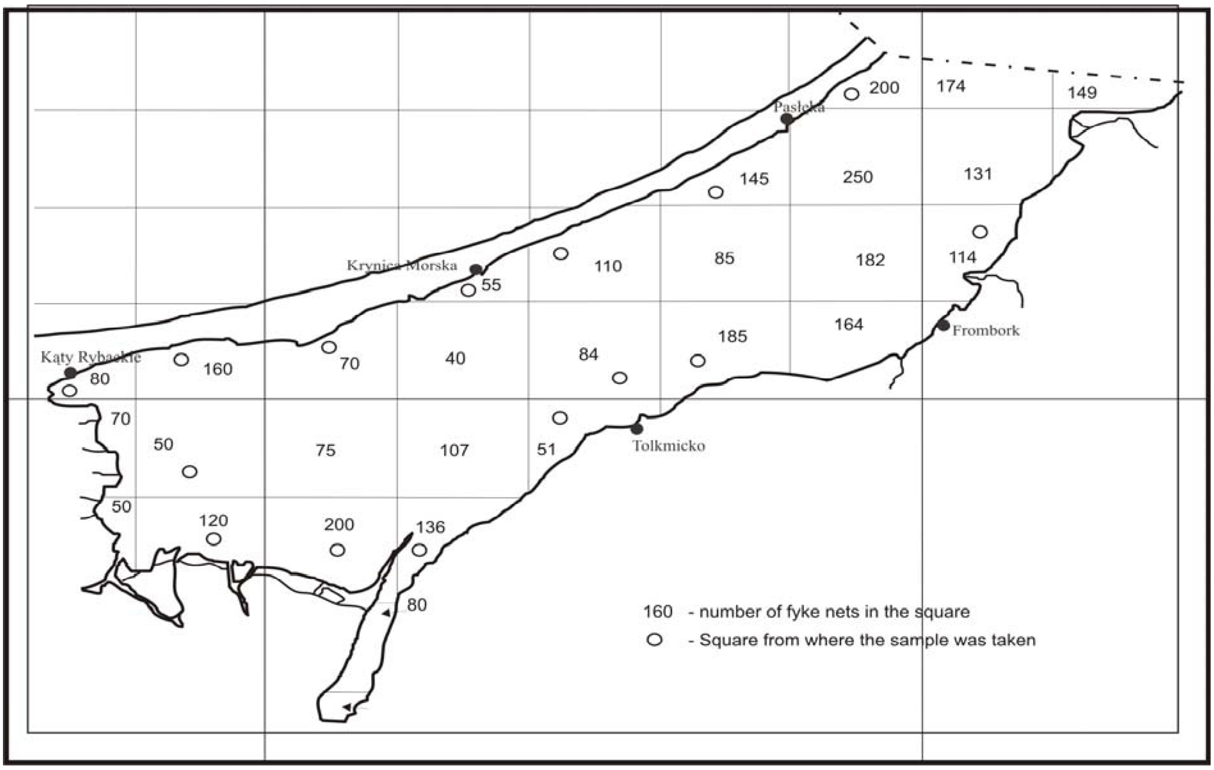


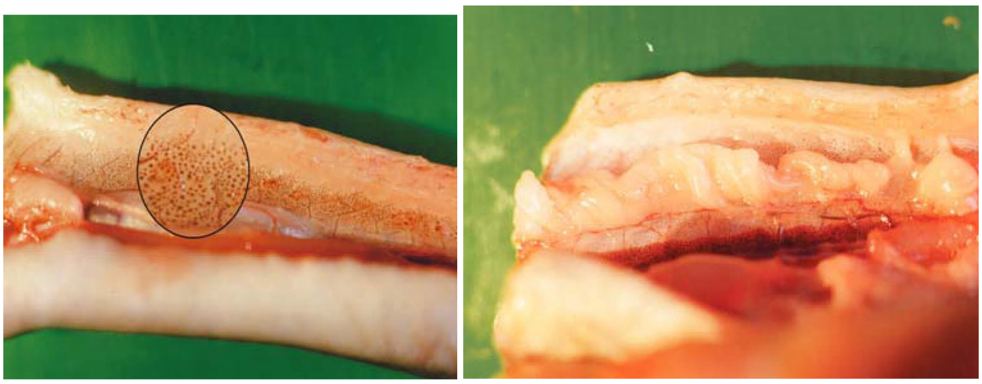
Figure PL.11. Fyke nets and sampling distribution in Vistula Lagoon in 1996.

Table PL.g. Intensity of eel sampling in the lakes of Pojezierze Mazurskie (VRBD) in 1986–1990.

Year	Period	Number of lakes	Number of fish	Participation
Electrofishing		n	n	%
1986	VI	15	880	16,3
1987	V,VI	25	3219	59,6
1988	V,VI	20	1305	24,1
Total		60	5404	100
Fishing gears- 1986 - 1990				
Węgorzewo	V,VI	6	492	24,6
Ogonki	V,VI	16	588	29,4
Giżycko	V,VI	17	445	22,2
Mikolajki	V,VI	19	327	16,3
Pisz	V,VI	3	150	7,5
Total		60	2002	100
Electrofishing 1986-1988				
Ogonki	V,VI	14	1649	30,5
Węgorzewo	V,VI	10	809	15,0
Giżycko	V,VI	16	1675	31,0
Mikołajki	V,VI	17	1077	19,9
Pisz	V,VI	3	194	3,6
Total		60	5404	100

PL.M. Standardization and harmonization of methodology

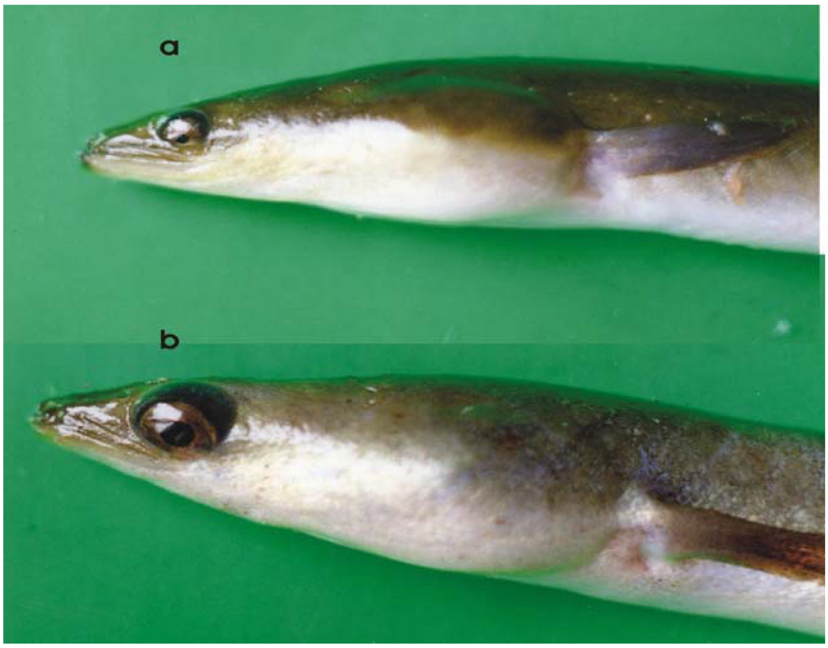
In the coastal and inland fisheries samples are collected from commercial catches. Total length is measured with accuracy of 1 cm and weight of 1–2 g. Measurements are done on anaesthetized fish. Anatomical examination are made on dead fish. The sex of eel is defined macroscopic according to established schema of ovary and core building, and microscopic (Figure PL.12) on base of histological examination (Boëtius i Boëtius, 1967).



male female

Figure PL.12. Macroscopic picture of the ovary and core.

The puberty of eel (Figure PL.13) is estimated on the bases of skin colour and size of the optic knob of eye (eye index) (Stramke, 1972; Pankhurst, 1982a, b, c, d; Pankhurst i Lythgoe, 1982).)



yellow (a) and silver (b) stage

Figure PL.13. Size of eye of yellow and silver eel.

The shape of head is described subjectively according to criterion given by Thurow (1958). Fishes are divided into two groups – broad-headed and sharp-headed (Figure PL.14).

a – sharp-headed, b – broad-headed

Figure PL.14. Broad - and sharp-headed forms of eel.

For age approximation one of the three aural statoliths (sagitta), called otolith, is used. Age is calculated based on number of growth interval rings, which are visible as dark rings, clearly differing from light protein matrix, on the surface of specially prepared otolith (Figure PL.15)

(Moriarty, 1983; Campana, 1992; Campana and Jones, 1992; Lecomte-Finiger, 1992,Tzeng *et al.*, 1994).

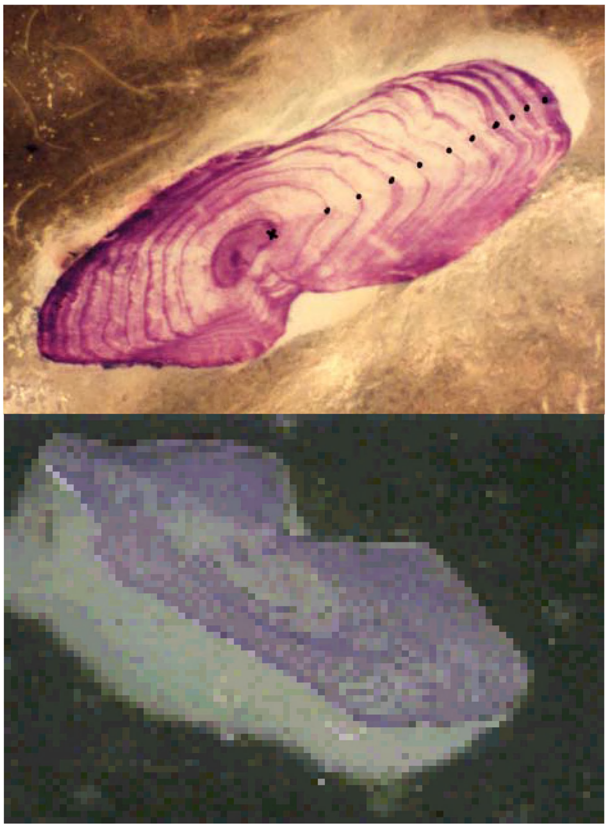


Figure PL. 15. Cross-section of the eel otolith from Great Mazurian Lakes.

PL.N. Overview, conclusions and recommendations

An overview of the information included in the report is presented in Table PL.h. and overview of the eel fisheries in Poland in 2004 is presented in Table PL.i.

Table PL.h. Overview of the data collection by area, described in this report.

+ = present, - =absent, ± = incompletely present, (+) = present, but inadequate

Area Item	Szczecin Lagoon	Pomeranian Bay	Open coast ICES 25	Open coast ICES 26	Vistula Lagoon	Rivers	Lakes
C capacity	+	+	+	+	+	-	-
D effort	+	+	+	+	+	-	-
E catch	+	+	+	+	+	-	(+)
F CPUE	-	-	-	-	-	-	-
G surveys	-	-	-	-	-	-	-
H age/length	+	+	-	+	+	-	±
I sex, growth	-	-	-	-	±	-	±
J other sampling	±	-	-	-	±	-	±
K assessment	-	-	-	-	-	-	-
L precision	-	-	-	-	±	-	±
M methodology						-	

In summary, several conclusions were drawn:

1) Registration of fishing capacity, effort and landings is well organized in coastal waters but is weak (or inadequate) in inland waters. The fishery database, which is run presently by the Ministry needs many corrections and should be improved.

2) Sampling in the coastal fisheries includes mainly length and weight measurements. Other biological sampling is very poor and in the future this part should be improved, however, other sampling in lakes had better coverage.

3) The best sampling coverage was in the Vistula Lagoon, followed by Pomeranian Bay and open coast -ICES 26, however, not all years were covered. At the present, eel sampling is postponed in the all coastal areas. Some research is carried out in the lakes.

4) The intensivity of sampling in the Vistula Lagoon fluctuates remarkable between years.

5) The volume of unreported eel catches is assumed to be rather high and it needs to be verified with quantifying methods.

Table PL.i. Overview of the eel fisheries in Poland in 2004 with break down over RBD's and main fishing regions.

		GEOGRAPHICAL AREA					C	D					E. CATCH (T)				
Country	**RBD**	water body	Latitude (° N)	Longitude (° E)	drainage area km^2	water surface km^2	Number of companies	Gears using hooks	Drift & Fixed nets	Pots & traps	Others		Glass eel	Bootlace	Yellow eel	Silver eel	Aquaculture (t)
PL	Odra	Inland			106182			++		++						+	
		Lakes over 50 ha				791,49		++		++						+	
		Pomeranian Bay						+								2380	
		Szczecin Lagoon			2001,9	457,3		127273	+	133165	+					34620	
		Open coast ICES 25			9029,1											2562	
	Vistula	Inland			183546			+		++						+	
		Lakes over 50 ha				1501,1		++		++						+	
		Vistula Lagoon			2294,5	915,5		231098	++	49268						21233	
		Open coast ICES 26 (Gulf of Gdansk)			5965,8			++	++	++	+					14367	
PL	sum				309019	3665,39											

\+ less intensive fishing

++ more intensive fishing

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Report on the eel stock and fishery in Germany 2005

DE.A. Author

Klaus Wysujack, Hans-Peter Cornus, Volker Hilge
Federal Research Centre for Fisheries
Institute for Fisheries Ecology
Wulfsdorfer Weg 204, 22926 Ahrensburg, Germany
Tel. +49-4102-51128, Fax. +49-4102-898207
klaus.wysujack@ifo.bfa-fisch.de

DE.B. Introduction

In Germany, the European eel *Anguilla anguilla* is an important species for both commercial and recreational fisheries, which occur in all types of water bodies, including coastal waters, estuaries and lakes and rivers of different size.

Germany is a federation consisting of 16 states (Figure DE.1), all of them having their own fisheries related legislation. This holds for both inland and coastal fisheries. The fisheries legislations include regulations, which are relevant for eel, such as minimum size limits or restrictions for fishing gears. In some states, the fisheries managers (fishermen or angling clubs) have to prepare a management plan, which is examined by the responsible authorities. However, there is no general obligation to provide statistics on fishing efforts or landings.

Coastal eel fisheries occur in Niedersachsen, Bremen, Hamburg, Schleswig-Holstein and Mecklenburg-Pomerania.

State borders of the 5 above-mentioned states extending 12 sm into the sea are for Niedersachsen from the Dutch border to the River Elbe, for Schleswig-Holstein from the River Elbe to the Danish border on the North Sea coast and from the Danish border near to the city of Lübeck on the Baltic Sea side, and for Mecklenburg-Pomerania from Lübeck to the Polish border. Bremen is located on the lower courses of the River Weser and Hamburg on both sides of the River Elbe some 100–140 km inland between the states of Niedersachsen on the left and Schleswig-Holstein on the right bank. Rather important water masses are drained into the Wadden Sea from the catchment areas (Figure DE.2) of the respective rivers, especially Weser and Elbe.

Coastal marine fishing areas for eel fisheries in the North Sea can be divided into the lower courses and estuaries of rivers and the Wadden Sea. In the Baltic Sea there are lower courses of rivers, the inner part of the coast especially in Mecklenburg-Pomerania, called Bodden or Haff, and the outer coast.

The North Sea coastline of Schleswig-Holstein is in total 553 km long, 256 km of which belong to the islands and 297 to the continent. The Baltic Sea coast is 637 km incl. the island of Fehrmarn. The Schleswig-Holstein Wadden Sea has a surface area of about 1700 km^2 (Ministerium für ländliche Räume, 2001).

The coastline of Mecklenburg-Pomerania is 1712 km long; 1358 km of it belong to the inner coast and 354 km to the outer coast. There are several isles of different sizes between 17 km^2 (Hiddensee) and 930 km^2 (Rügen). The total surface area of the fishing districts of the inner part is 171 400 ha and 568 000 ha of the outer part; resulting in a total area of 739 400 ha.

Generally the borderline between inland fisheries and marine fisheries is regulated in the respective state fishery legislations. It can be rather narrow to the coast as for smaller rivers like Eider and Stör or rather inland as with the River Elbe, near to the city of Hamburg, or the River Ems close to the city of Papenburg.

The European Water Framework Directive subdivides Germany into 10 separate River Basin Districts (RBD). Six of them are real international RBDs (Rhine, Danube, Elbe, Meuse, Oder, Ems). The two smaller RBDs Schlei/Trave and Eider mainly belong to Germany with only small parts of the catchment area being located in Denmark. Only two RBDs exclusively belong to Germany.

The Rhine is 1320 km long and has a drainage area of about 185 000 km^2 from which 106 000 km^2 belong to Germany. The drainage area is shared with Switzerland (28 000 km^2), France (23 300 km^2), The Netherlands (22 700 km^2), Luxemburg (2520 km^2), Austria (2400 km^2), Belgium (767 km^2), Liechstenstein (160 km^2) and Italy (70 km^2). The Rhine is draining into the North Sea.

The Elbe has a length of 1094 km and a catchment area of 148 268 km^2. The German part of the catchment area is 97 175 km^2 and 49 933 km^2 belong to the Czech Republic. Austria (921 km^2) and Poland (239 km^2) contribute less than 1% to the drainage area. Important tributaries in the German part of the catchment area are the rivers Havel, Saale, Mulde and Schwarze Elster. The Elbe is also draining into the North Sea.

The Weser is one of the two RBDs which completely belong to Germany. The total drainage area is 48 800 km^2 (including coastal waters). The Weser itself results from the confluence of the rivers Werra and Fulda. The main tributaries are Werra, Fulda, Diemel, Aller and Leine. The Weser is draining into the North Sea.

The river Ems is also draining into the North Sea. The total drainage area amounts to 18 000 km^2 which are shared with The Netherlands. About 15 000 km^2 belong to Germany and 2400 km^2 to The Netherlands. The rest results from the Ems-Dollart estuary.

The catchment area of the river Meuse (35 000 km^2) is shared with The Netherlands, Belgium, France and Luxemburg. The main tributaries in Germany are the rivers Rur (2338 km^2), Niers (1382 km^2) and Schwalm (273 km^2). The Meuse is draining into the North Sea.

With a total catchment of 4701 km^2, the Eider is a very small RBD. Only a small proportion of it belongs to Denmark. The Eider is draining into the North Sea.

With a catchment area of 122 512 km^2 (including the Szczecin Lagoon and its tributaries), which is shared by Poland, the Czech Republic and Germany, and a length of 855 km, the Oder is one of the bigger rivers draining into the Baltic Sea. The main part of the drainage area belongs to Poland (87.6 %), whereas the German part is 7987 km^2 (6.5 %).

The Warnow/Peene RBD includes a total drainage area of 13 600 km^2. The main rivers in this RBD are Warnow and Peene with catchment areas of 3300 km^2 and 5100 km^2, respectively. About 2900 km^2 coastal waters are also included. Both rivers are draining directly into the Baltic Sea. This RBD belongs exclusively to Germany.

The Schlei/Trave RBD has a drainage area of 6174 km^2. Besides Schlei and Trave, it consists of some small rivers and streams, which also drain into the Baltic Sea. The Schlei is no running water (river) but a firth of glacial origin. The RBD is also characterized by 51 lakes with areas of more than 50 hectares.

With 807 827 km^2 (including coastal waters), the drainage area of the Danube is the second largest European river catchment. The river has a length of 2870 km, and 18 countries contribute to the drainage area. The Danube is draining into the Black Sea and does not belong to the natural distribution area of the European eel.

Figure DE.1. Map of the Federal Republic of Germany and its 16 states (Länder). A coastal fishery exists in Niedersachsen (Lower Saxony), Bremen and Hamburg in the North Sea, in Schleswig-Holstein in both North Sea and Baltic Sea and in Mecklenburg-Pomerania in the Baltic Sea.

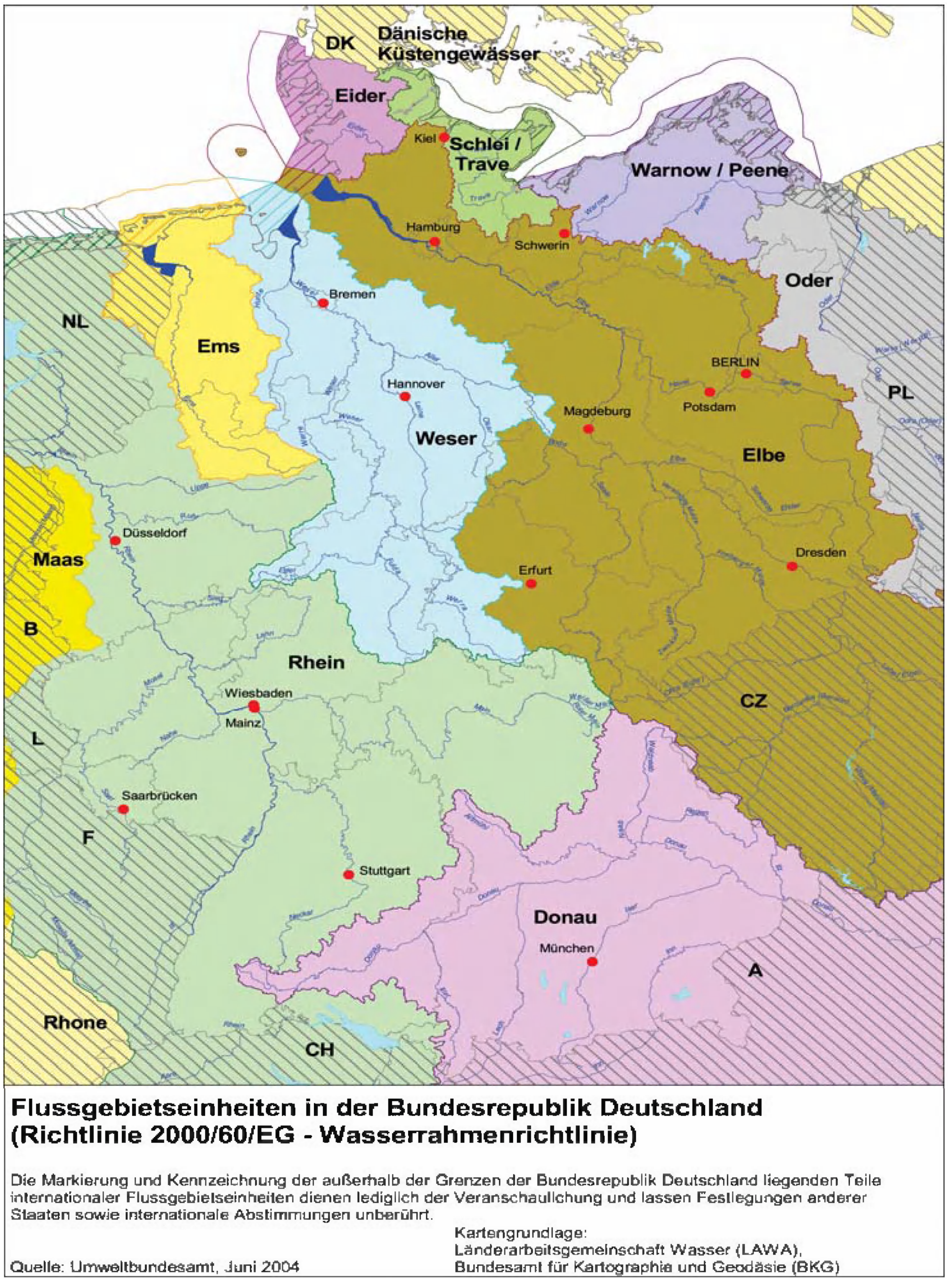

Figure DE.2. River Basin Districts (RBD) in the Federal Republic of Germany: Eider, Schlei/Trave, Elbe, Warnow/Peene, Oder, Weser, Ems, Rhine, Meuse and Danube.

DE.C. Fishing capacity

Coastal and marine fishery (if relevant for eel):

The statistics of the German fleet (2004) lists 1625 fishing vessels with lengths of less than 12 m in the North Sea and the Baltic Sea. These vessels mainly fish for ground fish and herring and are probably the most relevant part of the fishing fleet with regard to eel. Additionally, there are 108 trawlers of different size fishing in both the North Sea and the Baltic Sea. 26 vessels with lengths of more than 12 m fish with passive gears, e. g. longlines. They may be partly relevant for eel.

In 2004 about 400 vessels less than 10m landed eel, thereof about 160 from Baltic Sea Subdivision 3C22, about 220 from subdivision 3D24 and about 20 from North Sea division 4b.

The Mecklenburg-Pomerania fishermen are using hooped fyke nets, eel fyke net chains and longlines for eel in the inner coastal waters and fyke net chains, longlines for eel, pound nets and eel trawls in the outer part.

Fishery on eel in the North Sea part of Schleswig-Holstein is with fyke nets only. There is no more trawl fishery. In the lower course of the River Elbe, a stow net fishery exists. In the Baltic Sea Schleswig –Holstein fishermen are often part-time fishers. They are using fyke nets of different construction, even big sized ones fixed to piles nearly having the size of pound nets. In recent years more and more pipe eel traps are used, since they provide better catches, are cheaper and easier to protect against theft. There is also a sporadic longline fishery using sandeel and crustaceans as bait.

Lower Saxony has a small fishery on eel in the lower courses of the rivers Ems, Weser and Elbe. Trawl fishery has been finished some 10 years ago for economic reasons. On the river Ems there is a traditional fixed stow nets fishery (poles), which has been reduced for economic reasons as well. On the rivers Weser and Elbe an anchored stow net fishery exists. Fishery on yellow and silver eel starts in spring with increasing water temperatures and ends in October. Strong winds can result in good catches even till the end of the year. During summer time eel baskets are being used additionally.

Fishing capacity of inland fisheries is not reported. Data on areas, companies etc. are given in section DE.E.

DE.D. Fishing effort

Landings from vessels less than 10m which are landing eel need not to report on logbooks. Instead they are using landings declarations in which there is no record for effort or gear. Therefore, a pilot study was initiated in the frame of the Data Collection Regulation 1639/2001 to estimate effort for this part of the German fleet. Results will be available after the end of the pilot study.

DE.E. Catches and Landings

Coastal fishery

Data on landings of eel from the North Sea and the Baltic Sea have been provided by the relevant bodies of the respective states.

Schleswig-Holstein reported on trawl fishery in the North Sea around the island of Helgoland during the 60–70ies. But this fishery ceased in the meantime. Stocking size eel (in Table DE.1) were exclusively caught in lower parts of the rivers Elbe and Eider. These small sized eels are sold via the *Aalversandstelle* of the German Fisheries Association or directly to lake fishermen for restocking of inland waters of this state. For this reason the data on stocking size eels are probably more representative than data on market size eels.

In the Baltic Sea there is no trawl fishery from Schleswig-Holstein vessels since long. All landings are from small enterprises at Schlei and Trave. Around the island of Fehmarn and in the Lübeck Bight, catches decreased dramatically during recent years. According to fishermen concerned this decrease is at least partly due to cormorants often sitting on the piles of pound nets and drying their plumage after a successful visit of the catch chambers of the passive gear. During the past 5 years 2/3 of all pound nets places have been given up due to a strong decrease of catches.

Table DE.1. Eel landings from the coastal fishery in North and Baltic Sea by quantities (rounded) and value (transformed in Euro).

* Catches of stocking size eel result exclusively from the rivers Elbe and Eider (North Sea).

	North Sea						Baltic Sea		
Year	Lower Saxony (incl. stocking size eel)		Schleswig-Holstein		Schleswig-Holstein* Stocking size eel		Schleswig-Holstein		Mecklenburg-Pomerania
	t	€	t	€	t	€	t	€	t
1959	83.8	113,706							
1960	50.5	84,143							
1961	47.8	76,854							
1962	66.8	108,019							
1963	55.3	111,128							
1964	56.1	124,742							
1965	56.3	135,596							
1966	67.8	143,672							
1967	92.3	199,788							
1968	102.5	245,202							
1969	85.3	194,871	97.4	313,213			204.5	909.189	
1970	130.3	324,193	94.1	349,148			143.8	682.162	
1971	113.9	375,358	130.6	550,216			124.5	679.720	
1972	77.2	71,785	92.3	453,610			146.8	749.918	
1973	77.5	393,541	105.5	510,202			151.2	825.524	
1974	85.9	392,953	113.8	661,990			109.8	679.307	
1975	94.7	509,196	102.6	592,191			123.7	762.290	
1976	104.5	540,277	102.4	599,191			102.6	660.139	
1977	99.3	540,192	135.9	793,559			77.6	546.213	
1978	69.0	432,263	100.7	682,567			62.6	465.377	
1979	81.4	486,924	76.1	569,022			81.6	596.672	
1980	108.9	658,220	73.5	548,177			66.0	474.395	
1981	119.4	787,696	55.4	405,403			75.1	575.250	
1982	107.3	766,437	67.3	502,455			98.3	746.875	
1983	102.9	684,057	72.6	531,814			82.6	636.962	
1984	95.4	617,621	62.2	483,898			51.3	420.048	
1985	65.4	449,844	57.1	442,299			50.4	411.762	
1986	91.7	662,076	39.6	324,351			65.6	564.750	
1987	69.0	485,298	21.0	171,292			57.1	478.490	
1988	45.6	349,384	42.2	363,694			70.1	590.345	
1989	29.3	220,463	31.4	265,244			86.9	751.143	
1990	35.9	283,640	14.7	125,732			82.4	741.405	
1991	24.5	202,558	11.8	94,525			83.5	773.621	
1992	25.7	223,031	6.1	57,957			78.7	701.902	
1993	30.1	227,157	12.8	115,980	1.9	9,690	66.5	624.781	
1994	64.5	492,489	13.3	68,891	10.4	44,146	63.7	567.412	
1995	42.5	322,316	7.7	60,244	3.6	18,496	60.2	542.434	
1996	15.7	135,320	6.3	43,984	3.5	17,850	27.7	267.152	
1997	30.0	238,911	12.0	84,278	3.7	22,452	44.5	417.479	
1998	13.8	114,715	8.5	62,714	3.7	22,289	19.1	186.149	
1999	19.9	161,782	10.5	75,144	6.1	33,233	27.0	254.386	
2000	16.3	141,990	5.7	39,266	5.0	27,756	30.1	284.963	
2001	21.1	186,200	4.7	37,764	4.7	26,266	28.6	278.228	108
2002	35.3	292,198	4.4	38,850	4.0	21,547	28.0	218.217	98
2003	29.8	233,986	4.8	36,067	3.4	19,548	27.4	251.862	93
2004	31.7	246,038	5.4	39,745	4.1		17.3	136.337	94

Inland fishery

Due to the federal structure of Germany, catches are not reported separately for RBDs but for states (Bundesländer).

The data on surface areas, numbers of companies etc. differ slightly between the years. The data presented here, originate from the recent reports on the German inland fishery (Brämick, 2005) and from the General Fisheries Census 2004 (Statistisches Bundesamt, 2005).

The total surface area of German inland waters is 845 305 ha, from which at present 536 777 ha are used for fisheries purposes. In 2004, 1050 full commercial fishing companies existed in Germany. Additionally, 21 499 part-time companies (including the hobby sector – but not anglers) were registered (Brämick, 2005).

According to the recent report on inland fishery, the fishery in natural waters (lakes and rivers, also including reservoirs) occurred on a total area of approximately 245 000 ha. However, the General Fisheries Census (data from 2003) gives 357 000 ha for all companies working in this sector of the fishery (from which 228 000 ha are lakes). The difference may be explained partly by the fact that some companies fish on lakes or rivers but also manage ponds. In the 245 000 ha (219 003 ha lakes and reservoirs; 26 349 ha rivers) given first, ponds are not included, because they belong to the sector "aquaculture". By considering these slight differences, in 2004, approximately 250 000 ha of lakes, rivers and reservoirs have been managed by more than 800 companies (478 full commercial, 409 part-time and hobby fisheries). The total economic yield was about 9.1 million €.

A clear decrease in the eel catches was observed during the last 10 years (Table DE.2). The General Fisheries Census 2004 (with data from 2003) indicates reported catches of 263 t (thereof 235 t for human consumption). In these numbers, catches from all states are included.

In 2004, the most important states with regard to eel fisheries were Brandenburg (93.0 t) and Mecklenburg-Pomerania (51.0 t).

Table DE.2. Development of eel catches from the inland fishery in the last 10 years. Data represent the sum of catches from Bavaria, Berlin, Brandenburg, Mecklenburg-Pomerania and Saxony-Anhalt.

YEAR	EEL CATCHES (T)
1995	369.3
1996	300.2
1997	280.7
1998	251.9
1999	261.0
2000	276.4
2001	239.3
2002	236.9
2003	170.9
2004	168.6

Aquaculture

In Germany, the eel is the most important species for aquaculture in recirculation systems. However, with a total production of 328 t in 2004, a decrease of about 12% compared to 2003 was reported (Table DE.3). There are no other aquaculture techniques used for production of eel.

Table DE.3. Production of eel in recirculation systems.

YEAR	PRODUCTION (T)
1995	186
1996	204
1997	221
1998	appr. 260
1999	appr. 400
2000	422
2001	347
2002	381
2003	372
2004	328

Recreational Fisheries

In 2004, about 9200 angling clubs with 955 000 members existed in Germany. The total number of valid fishing licenses[1] was 1 429 763. Consequently, the number of anglers is assumed to be approximately 1.5 million. The total economic value of angling (and related branches) was estimated to about 6 billion € per year, and about 52 000 jobs were directly or indirectly related to angling.

A study revealed that 6.4 % of anglers most frequently took eel home (Arlinghaus, 2004).

Even though some associations and clubs ask their members for catch reports, there exists no general catch statistics from recreational fisheries. Consequently, the order of magnitude of angler catches is not well known. However, by considering the high number of anglers, it is likely that angler catches of eel contribute considerably to total eel mortality in the fresh waters. E. g., an estimate from Lower-Saxony suggests that angler catches (appr. 68 t/year) were nearly twice as high as the catches of the commercial fishery (appr. 36 t/year).

Restocking

Restocking of eel is very common in German waters, but as there is no central database for eel stocking, no representative data are available. Earlier data on restocking, in particular from the area of the former GDR and later from the state Brandenburg, have been presented in former reports (e.g. 2003 – R. Knösche). At present, there are no new data available.

DE.F. Catch per Unit of Effort

Data on catch per unit effort do not exist.

DE.G. Scientific surveys of the stock

DE.G.1 Recruitment

Monitoring of glass eel recruitment in Germany has been reported by Kuhlmann and Hahlbeck (2002). Glas eel fishing had been performed at the Herbrum station (53°02'N 7°20'E) and is published elsewhere (e.g. Moriarty and Dekker, 1997). Due to heavy water works on the River Ems with the consequence of strong currents which did not exist before this station is no longer in operation. In the meantime research on glass eel migration on a

1 The fishing license itself does not allow you to fish. It's possible to get the license after passing an examination (basic knowledge on fish biology, angling techniques as well as conservation or animal welfare issues). The fishing license is needed to get the fishing permit at the respective waters.

number of places like Geesthacht ((53°25'N 10°21'E) and some locations in Mecklenburg-Pomerania was initiated. Monitoring of upstream migrating eels has also been initiated at some locations in the Elbe system.

First results are available from some small rivers in Mecklenburg-Pomerania. The data indicate that the numbers of glass eels arriving are very low if compared to former data and that the numbers did not significantly differ during recent years (Lemcke, 2003; Schaarschmidt, 2005).

Table DE.4. Monitoring of upstream migrating eels (not only glass eels) in Mecklenburg-Pomerania. Data were taken from Lemcke (2003) and Schaarschmidt (2005).

		2002			2005	
	Location	Fishing gear	Number of eels	Mean size (cm)	Fishing gear	Number of eels
Müritz-Elde-Wasserstraße (and Dove Elbe) (North Sea)	Dömitz	Special eel fyke net in fish pass Eel ladder	1,043 13	18.6 17.5	Special eel fyke net in fish pass Eel ladder	1,598 701
Hellbach-System (Baltic Sea)	Neubukow	Eel ladder	25	17.6	No data	
Warnow (Baltic Sea)	Bützow	Eel ladder (right bank) Eel ladder (left bank)	179 269	12.7 12.1	2 eel ladders (pooled)	151
Uecker (Baltic Sea)	Torgelow	Eel ladder	70	19.2		No data
Wallensteingraben (Baltic Sea)	Wismar		No data		Eel ladder	152

DE.G.2. Yellow eel

There are no yellow eel surveys in German marine coastal waters.

Some data are available for the Northrine-Westfalian part of the river Rhine (see special part for the RBD Rhine).

In the course of a project at the river Elbe, data on the yellow eel stock in Elbe and some tributaries will become available in the next years.

DE.G.3. Silver eel

Generally, there are no long-term data on silver eel stocks and escapement available.

Recently, a joint study of Dutch and German scientists was started at the river Rhine. First results are given in the special part for the RBD Rhine.

Studies on silver eel escapement have also been started at the rivers Elbe (and the tributary Havel) and Warnow. Data will become available in the next years.

DE.H. Catch composition by age and length

Germany has not sampled the landings/catches of eel. Due to the Data Collection Regulation which relates only to marine landings/stocks a country need not to sample a stock when the average of landings of the last 3 years is less than 100 t for a stock not under TAC regulation as it is for eel. For each division 4b, 3c and 3d, from where landings have been recorded the averages over the last 3 years were below 100t (Table DE.5).

Table DE.5. Eel landings in ICES divisions 3 C and 3 D and 4 B.

LANDINGS OF EEL (T)	DIVISION 4B	DIVISION 3C	DIVISION 3D	TOTAL
2000	7	33	96	136
2001	0	3	19	22
2002	6	43	86	135
2003	5	38	88	131
2004	6	28	90	124

DE.I. Other biological sampling

Investigations on the health status of eels have been conducted at the river Rhine in Northrine-Westfalia (see special part RBD Rhine).

A monitoring for *Anguillicola crassus* has been established at the rivers Elbe and Weser. However, the data have not yet been analysed.

Concentrations of pollutants / contaminants in the musculature of eels from the river Elbe have been measured by the Elbe River Water Quality Board (ARGE ELBE) in 1999 and 2000 (ARGE ELBE, 2000). Along the entire German length of the Elbe, contaminant levels were measured in excess of the maximum allowable levels. This was particularly evident for HCB (hexachlorobenzene) content. Occasionally, maximum levels were also exceeded for other contaminants, e.g. DDT.

DE.J. Other sampling

Mortality of eel due to predation by cormorants was estimated by Brämick and Fladung (2006) for lakes and rivers in Brandenburg. According to the study, 109 t eel (1.4 kg/ha) were annually preyed upon by cormorants.

DE.K. Stock assessment

No regular stock assessment.

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Report on the eel stock and fishery in Germany 2005, Contribution from the River Basin District "River Rhine"

G.A. Contributing Author

Detlev Ingendahl
Northrhine-Westfalian Agency for Ecology, Land and Forestry
Heinsbergerstr. 53
57399 Kirchhundem, Germany
Tel. +49 2723 77940 Fax +49 2723 77977
Detlev.Ingendahl@loebf.nrw.de

G.B. Introduction

See Country report Germany (prepared by Bundesforschungsanstalt für Fischerei)

G.C&D&E

See Country report Germany (prepared by Bundesforschungsanstalt für Fischerei)

G.E.2. Restocking

There is a long tradition of stocking of (glass) eel in the River Rhine catchment in Germany. In Northrhine-Westfalia (federal state of Germany with borders to Belgium and the Netherlands) eel stocking is performed by local angling associations and the organisations managing the fishing rights for local water bodies. Up to date there is no central compilation available for the quantification of restocking effort and spatial distribution of restocking.

In the framework of beginning activities to prepare an eel management plan for the River Rhine catchment a database is in preparation for the management of restocking data in Northrhine-Westfalia. It is intended to introduce available data on restocking for the at least last ten years in Northrhine-Westfalia.

Since the last decade no restocking was performed in the main stem of River Rhine even if it is known to have large surfaces of eel habitat. In 2005 experimental stocking of about 30 000 tagged juvenile eel (mean 10 g) was performed in order to collect information about the impact of eel restocking on yellow eel stock in the Rhine itself.

G.E.4. Aquaculture

There is no aquacultural production of eel reported in Northrhine-Westfalia.

G.E.5. Recreational Fisheries

In Northrhine-Westfalia there are about 250 000 anglers registrated. The proportion of eel anglers and their mean annual catches of eel is not yet known. In the northrhine-westfalian part of the River Rhine there are only some semi-professional fishermen. Their annual eel catch is not yet known.

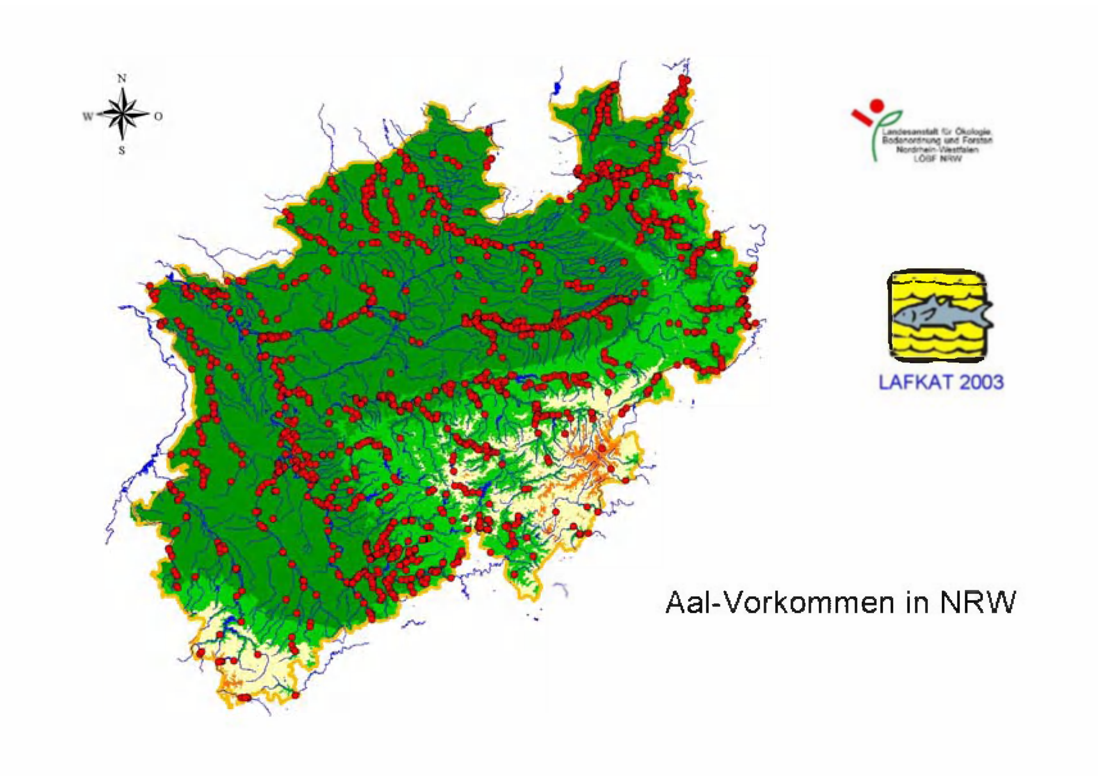
G.G. Scientific surveys of the stock

G.G.1. Recruitment surveys

There is no specific recruitment survey in Northrhine-Westfalia

G.G.2. Yellow eel surveys

There is a northrhine-westfalian database available reporting data of fish surveys mostly done by electrofishing. These surveys are not specific for eel but performed for example with regard to data collection in respect of the water framework directive. The data on eel is not yet analysed in respect to biometric information. The following figure indicates the presence of the species in northtrhine-westfalian rivers.



In 2002 and 2004 a yellow eel survey was performed in the northrhine-westfalian part of the River Rhine. In comparison to data from 1997 the density of yellow eel in the River Rhine was strongly declining and the mean length was increasing tentatively indicating a failure of recruitment of younger yellow eel from the downstream part of the River Rhine (Steinmann *et al.*, 2005).

G.G.3. Silver eel surveys

There is no longterm silver eel survey data available for Northrhine-Westfalia. Since 2003 a anchor stow net is operating close to the german-dutch boarder in order to collect data on the silver eel run of the River Rhine. The captured eel are analysed regarding to length-frequency distribution and health status (f.ex. parasitism). This investigation will be continued in 2006 but there is still concern about the representative silver eel monitoring in a large river as the River Rhine which is heavily used by commercial ship traffic.

In a german-dutch pilot study the silver eel migration in the River Rhine is studied using passive transponders (2004 and 2005, see figure).

Additionally about 3500 silver eels from the impounded Mosel tributary were batch marked and released into the free-flowing River Rhine about 150 km upstream from the german-dutch boarder. The results of both ongoing studies will be analysed regarding mortality of emigrating silver eels in the modified Rhine delta and their usefulness for an approximative estimation of total emigrating silver eel population of the River Rhine (see attached poster with a first population estimate using 2004 Klein Breteler *et al.*, 2005).

Migration routes for individual transponder tagged eel from registrations of antenna stations in the Rhine delta (courtesy of J. Klein Breteler, OVB NL).

G.H. Catch composition by age and length

See Country report Germany (prepared by Bundesforschungsanstalt für Fischerei)

G.I. Other biological sampling

Analysis of health status of yellow eel and silver eel of the River Rhine

(Contribution J. Lehmann, F. Stürenberg & D. Ingendahl, LÖBF NRW)

Samplings of yellow eels mainly from the Rhine (region NRW) and the river Mosel were done in 2002, 2003 and 2005. The first main intention was to get actualized informations about the residues of heavy metals, PCBs, HCB, total DDT and dioxins (PCDF and PCDD) in yellow eels caught in NRW. The second, further intention was to get an health status of these eels. The analysis demonstrated that especially the compounds of PCBs and dioxins are too high in the Rhine yellow eels, but in some tributary rivers of the Rhine like the river Lippe, too. (Details can be obtained by the authors).

In 2004 and 2005 we made also intensive researches of the health state of Rhine and Mosel eels, especially in referring to fish diseases: viral and bacterial diseases, mycosis, parasitisation, haematological examinations. In August/September 2004 sixteen yellow/common eels of the river Mosel had been researched with regard to bacterial and viral infections. Three eels were positive in the HVA-PCR (HVA= *Herpesvirus anguillae*).

From Mars to July 2005 fifty-seven yellow eels of the River Rhine (six sampling sites on the northrhine-westfalian stretch of the River Rhine) were caught. 16% of these eels were HVA-positive in the PCR. In addidion to these eels, eighty-six yellow and silver eels of the river Mosel, caught in August to December 2005, were examined (random samples). Nearly 20% of these eels were HVA-positive in the PCR (one eel, too, was EVE positive).

Besides these more or less latent viral infections bacteriosis especially of the skin by the *Aeromonas hydrophila/caviae*- and *A. sobria* - complex is common, mainly induced by stress. Infections by *Flavobacterium (Cytophaga) psychrophila* was observed as well.

Common parasites are: *Anguillicola crassus* (infestation rate 60% Rhine, 80% Mosel), *Trypanosoma granulosum* (infestation rate over 90% !), *Acanthocephala*, *Apicomlexa*- and *Myxozoa*-species.

An evaluation of all these data of compounds of anthropogenic pollution in eels and the pathological/parasitological results/diagnosis cannot yet be given will be later discussed especially with regard to the corresponding data published by collaborating scientists of the Netherlands.

G.J. Other sampling

See Country report Germany (prepared by Bundesforschungsanstalt für Fischerei)

G.K. Stock assessment

No stock Assessment is available for the northrhine-westfalian part of the River Rhine.

Poster presented at the Diadfish conference Bordeaux 2005.

Rhine Silver Eel

Population size of the silver eel (Anguilla anguilla) population of the whole River Rhine catchment in 2004: a pilot mark-recapture study

Jan Klein Breteler[1], Lothar Jörgensen[2], Stefan Staas[3], Jost Borcharding[4] & Detlev Ingendahl[5]

The Rhine and the Eel problem

Over the last decades, the eel (Anguilla anguilla) shows a strong decline all over Europe. In order to protect the eel, the European Commission (EC) seeks scientific advise concerning targets for escapement of silver eels from catchments. In the meantime, the EC considers the possibilities of emergency measures, such as closing the fisheries.

The Rhine is the largest river system in Western Europe and facilitates a large scale fishery on yellow eel and silver eel. But data on basic population parameters of the eel in this system are rare. In 2004 a first attempt has been made to estimate the population size of the migrating silver eels > 50 cm of the whole River Rhine system.

Mark-recapture experiment

Downstream migrating eels are caught yearly in the Moselle, a main tributary of the Rhine in Germany, and released downstream of the hydropower stations. In autumn 2004, silver eels > 50 cm were selected from this batch, marked with Heliogenblue, and released in the River Rhine near Koblenz or Cologne. A laboratory experiment revealed that no mark losses occurred and that the marks were easily recognized after 1 month (Klein Breteler et al., in prep.).

Commercial eel eel catches in the three branches of the Rhine system in The Netherlands (Waal, Nederrijn/Lek, IJssel) were sampled and checked for the presence of marks.

Downstream migration and population estimates

Marking in Germany started about 1 month earlier than checking for marks in The Netherlands. Telemetry experiments with 150 transpondered silver eels showed that it took about 25 days for an average eel released in Cologne to migrate to the downstream sections in The Netherlands, and that 47% of the silver eels did not seem to migrate at all (Klein Breteler et al. in prep.). Therefore we made separate population estimates for not synchronized mark and recapture periods (August-November and September-December respectively) and for synchronized periods (both starting in September). We also took into account the differential distribution of the silver eels over the 3 main migration routes, using the telemetry data.

Recaptures were very low (6), most of them in the Waal-system (5), none in the IJsselmeer and only 1 in the Nederrijn/Lek.

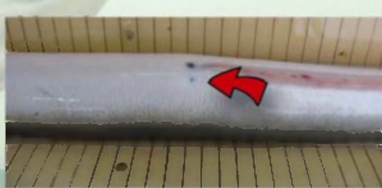
Estimates of population size of silver eels > 50 cm in the Rhine system in 2004

	M	C	R	N	B
Not corrected for downstream migration[1]					
Phase shift (1 month) between mark-recapture	2 321	4 789	6	1 852 364	971 664
Mark recapture synchronised	1 018	4 789	6	812 368	426 131
Corrected for downstream migration[1]					
Phase shift (1 month) between mark-recapture	1 222	4 293	6	874 537	459 132
Mark recapture synchronised	536	4 293	6	383 535	201 356
Rhine without IJssel(meer), corrected[2]					
Phase shift (1 month) between mark-recapture				427 743	224 565
Mark recapture synchronised				187 590	98 485

[1] correction for non-migrants as evidenced by telemetry
[2] correction for non-migrants and for diversion of migrants over migration routes

Population size and biomass

Estimates of the population size of the silver eel population > 50 cm of the whole Rhine system in 2004 range from 0.4-1.8 mln with an associated biomass of 0.2-1.0 mln kg, depending on the underlying assumptions. The silver eel population passing through both Waal and Nederrijn/Lek seems to be about 50% lower, but because of the very low recaptures in general and the absence of recaptures in the IJsselmeer, these data should be used cautiously.



1. Organisation for the Improvement of Inland Fisheries (OVB), Nieuwegein NL,
2. Struktur und Genehmigungsdirection Nord Rhineland-Palatinate, Koblenz DE,
3. Rheinfischereigenossenschaft NRW, Nörvenich DE,
4. Universität zu Köln, Cologne DE,
5. Landesanstalt für Ökologie, Bodenordnung und Forsten NRW, Kirchhundem-Albaum DE.

Report on the eel stock and fishery in Denmark 2006

DK.A. Author

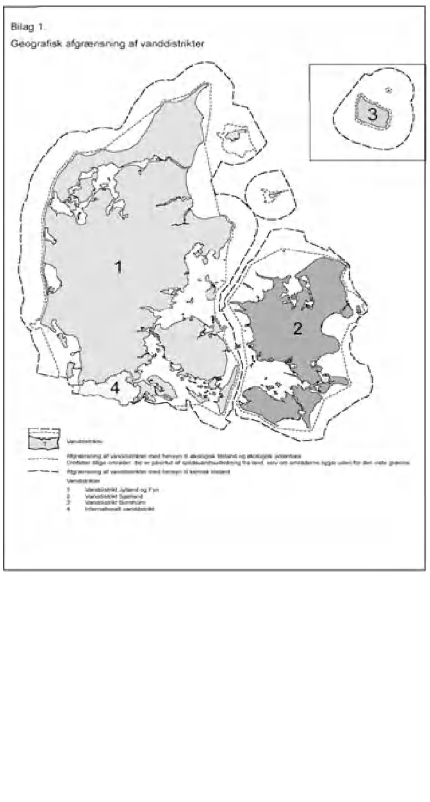
Michael Ingemann Pedersen,
Danish Institute for Fisheries Research,
Department of Inland Fisheries
Vejlsoevej 39DK-8600 Silkeborg,
Tlf. +45 89 213128; Fax. +45 89 213150
mip@difres.dk

This report was completed in January 2006, and contains data up to 2005.

DK.B. Introduction

The eel is present all along the 7500 km Danish coast line, except on the open North Sea coast in Jutland. In inland waters eels may be found naturally or stocked in ponds, lakes and streams. The fishery is concentrated in the southern and eastern parts of Denmark here the silver eel is exploited during the spawning migration from the Baltic towards the North Sea. These fisheries catch the migrating eel by pound nets out to the 10+ meter depth line. Throughout the country, in shallow Fjords, Bays, Lagoons and Inland waters, a combined yellow and silver eel fishery takes place. Most of the catch 97 % is reported from saline areas suggesting that catches in freshwater are smaller and more fragmented recreational fisheries.

Current management of the eel stock aims to secure local yield and by a set of general and local rules regarding minimum legal size, mesh size etc. The freshwater legislation ensures free movement of local stock by enforcing eel passes at migration barriers. No licences are given explicit to eel fishing but professional fisherman has a licence to fish. Catch data are reported to the directorate of fisheries by the trade and processing companies. Three different groups exploit the eel. These are: 1) Professional fisherman with a licence; either fulltime or part time fishermen. 2) Recreational fishermen with a licence and 3) land owners without a licence. Only catches from the professional fishermen are known. In this report, where possible, data are separated in River Basin Districts.



The Water Framework Directive subdivides Denmark into four separate River Basin Districts (RBD). These are:-

1) Jutland and Funen.
2) Sealand and the Isles Møn, Lolland and Falster
3) The Island Bornholm in the Baltic Sea
4) The most southern part of Jutland where the streams Vidå and Kruså share drainage basin with Germany.

Figure DK.B. River Basin Districts in Denmark.

DK.C. Fishing capacity

A total of 588 boats (Table DK. C) are registered to have landed eel in 2004 suggesting the number of companies/fishermen to be 500+ (some companies have more than one boat). These are all catching eel in marine waters. The number of professional fishermen in inland waters is very limited only 2 boats are registered. It may be assumed; some 10–20 fishermen are actively fishing in and probably mostly fishing on part time basis.

Table DK C. No of eel fishing boats, poundnets and landings of yellow and silver eel, separated by River Basin District. (Source: Directorate of fisheries).

Area		Surface area km^2	No of boats	No of poundnets	Landing, kg		
RBD	Name				Saline Yellow	Saline Silver	Freshwater 22 % silver
1	Jutland and Funen	-	269	816	18,322	51,071	1,099
1a	Ringkøb Fjord	300	15	-	565	1,656	-
1b	Limfjorden	1,500	27	-	3,088	3,390	-
2	Sealand	-	245	1,308	155,105	286,614	14,069
2a	Isefjorden	305	17	-	7,627	609	-
3	Bornholm	-	15	0	2,369	1,226	0
4	Sønderjylland	-	-	-	-	-	-
Total			588	2,124	179,449	338,911	15,168

DK.D. Fishing effort.

The Pound net fishery is concentrated in the southern and eastern parts of Denmark (BRD 2). The number and position of pound nets are in some areas known but again in others no exact figure is available. The number of pound nets registered is 2124, however this figure is probably not all active gear (Pers. Com. Lasse Aufeldt) a more realistic figure is <1000 pound net. The number of larger fyke net (Pole fyke net) used by recreational fishermen is shown in Table DK.E. Eels are also caught by long lines and bottom trawl but no record exist. Bottom trawl are most likely limited to Bornholm (BRD 3).

In freshwater landowners/stakeholders have an ancient privilege to operate eel traps fixed at the outlet of a lake or mill pond. Currently there are 103 of these eel traps.

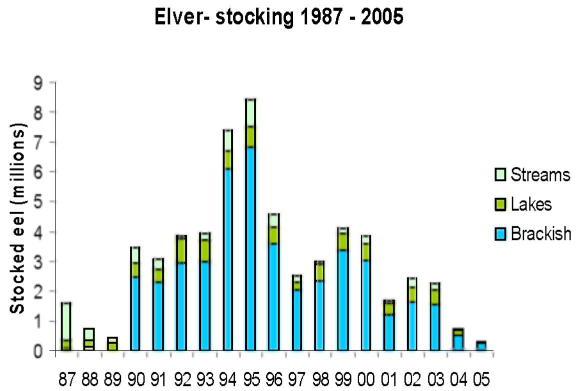
DK.E. Catches and landings

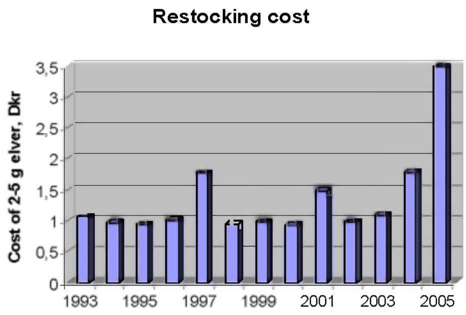
DK.E.1. Catch of glass eel

Catch of glass eel in Denmark took place between 1971 and 1990 at Vidaa and Ballum sluices in the Wadden Sea. There has been no glass eel fishery since 1990.

DK.E.2. Restocking

Restocking has taken place for many decades, by landowners in inland waters where recruitment of young eel, was limited or absent, because of distance to the ocean or migration barriers. From mid 1960's to the end of the 1980s a number of licenses were given to sell young eels for restocking. These eels were captured at pass traps and glass eels at the sluices in the Wadden Sea. This is now forbidden due to the low recruitment. Since 1988 a restocking program has been financed by the Danish government and the eel fishermen. From 1994 the restocking program has been financed solely by the recreational license fee. The eels stocked today are imported, as glass eels mostly from France. They are grown to a weight of 2-5 gram in heated culture before they are stocked. The amount stocked has been decreasing during the last years because the price for stocked eel increased 300 % in the same period. Figure DK.E.2.



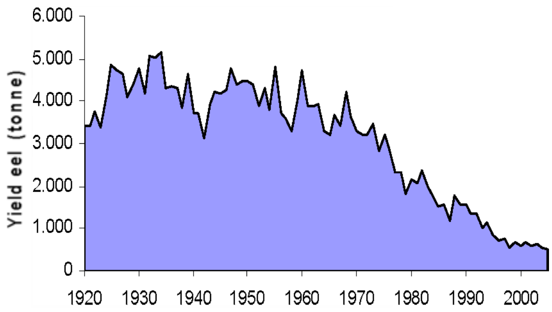


Year	Marine	Lake	River	Total	Year	Marine	Lake	River	Total
1987	0,07	0,26	1,26	1,58	1997	2,02	0,29	0,22	2,53
1988	0,11	0,24	0,40	0,75	1998	2,35	0,53	0,10	2,98
1989	0,00	0,24	0,17	0,42	1999	3,38	0,56	0,18	4,12
1990	2,46	0,49	0,51	3,47	2000	3,02	0,55	0,25	3,83
1991	2,30	0,44	0,32	3,06	2001	1,20	0,38	0,12	1,70
1992	2,94	0,81	0,11	3,86	2002	1,66	0,47	0,30	2,43
1993	2,97	0,76	0,23	3,96	2003	1,54	0,49	0,22	2,24
1994	6,12	0,61	0,67	7,40	2004	0,52	0,18	0,06	0,75
1995	6,83	0,72	0,90	8,44	2005	0,24	0,06	0,00	0,30
1996	3,58	0,58	0,44	4,60					

Figure and Table DK.E.2. Restocking of elvers (2–5g) in marine and fresh waters from 1987–2005. Numbers stocked and cost per stocked eel.

The annual catch during the last 10 years have decreased from 840 to 520- tonnes of yellow and silver eel (table DK. E). There is a trend that relatively more silver than yellow are being captured during the last 5–6 years, suggesting that yellow eels are less exploited now a days. Freshwater landings are primarily registered in RBD 2 mainly from the largest Danish lake Arresø (Table DK.C).

DK.E.3. Catch of yellow and silver eel



Year	Silver	Yellow	Total
1995	408	432	840
1996	381	337	718
1997	375	383	758
1998	306	251	557
1999	380	307	687
2000	382	218	600
2001	446	225	671
2002	365	217	582
2003	437	188	625
2004	343	187	531
2005	372	149	520

Figure and Table DK.E.3. Annual catch (Figure) and catch (ton) separated into yellow and silver eel (Table).

DK.E.4. Aquaculture

Aquaculture production in Denmark started in 1984. The production takes place at indoor, heated aquaculture systems.

Table. DK.E.4. Aquaculture production (1984–2004).

Year	Production units	Production [ton]	Year	Production units	Production [ton]
1984	??	18	1995	29	1324
1985	30	40	1996	28	1568
1986	30	200	1997	30	1913
1987	30	240	1998	28	2483
1988	32	195	1999	27	2718
1989	40	430	2000	25	2674
1990	47	586	2001	17	2000
1991	43	866	2002	16	1880
1992	41	748	2003	13	2050
1993	35	782	2004	9	1700
1994	30	1034	2005	-	-

DK.E.5. Recreational fishermen

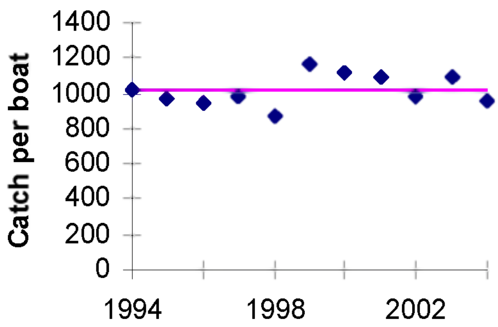
The number of licences sold to recreational fishermen was 33 516 in 2003 and has been stable for a number of years. The recreational fishermen are not allowed to sell their catch and the catch is not recorded. The number of gear allowed to fish with, is one large fyke (Pole fyke) and five small summer fykes! A questionnaire among the recreational fishermen in 1997 showed that 56% of all recreational fishermen catch eels. Based on the information given in the questionnaire it was estimated that in 1997 they caught 200 tonnes, equivalent to 26 % of the official catch. Assuming this relation to total landing hold, each licence landed 7 kg (50–70 eel) in 2004 equivalent to a recreational catch of 138 tonnes.

Table DK E. 5. Estimated no of recreational eel fishermen, estimated catch, stocking of elvers (2–5 g) and number of gear registered.

River Basin District	Recreational eel fishermen, estimated, no	Stocking elver, no	Catch, kg	Pole-fyke (Pæleruse)
1	11.181	447.000	82.249	448
2	7.260	290.000	53.406	264
3	327	13.000	2.406	0
4	-	-	-	-
Total	18.768	750.000	138.060	712

DK.F. Catch per Unit of Effort in commercial landings

The only available unit of catch per unit of effort is catch/boat. The mean catch per boat equal 1 tonnes and has been fairly stable from 1994–2004. The number of boats has decreased by about 50% percent in same period.



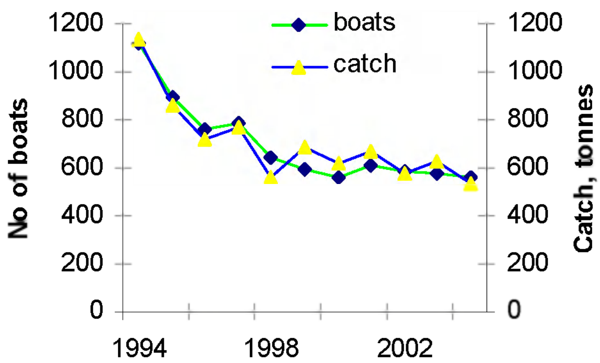


Figure DK.F. Mean catch per boat per year (dots) and average during the period 1994–2004 (line).

DK.G. Scientific surveys of the stock

DK.G.1. Recruitment surveys of glass eel and ascending yellow eel

The recruitment of young eels to Danish freshwater is currently monitored in pass traps at Harte hydropower stations in river Kolding Å and at Tange hydropower station in river Guden Å. Both rivers empty into Kattegat on the east coast of Jutland. On the west coast of Jutland no passive trapping facilities are available. Here the recruitment is monitored by annual population surveys (electro fishing four sections 2–4 times a year) in a brook by the Wadden

Sea. The method used is sampling by during the year Vester Vedsted brook). Further details in Pedersen (2002).

Table DK.G. Rercruitment monitoring of young eel at pass traps and electrofishing.

YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M²		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M²	
	Kg	Kg	Mean	Max (season)		Kg	Kg	Mean	Max (season)
1967		500			1987	145	105	-	-
1968		200			1988	252	253	-	-
1969		175			1989	354	145	-	-
1970		235			1990	367	101	-	-
1971		59			1991	434	44	-	-
1973		117			1992	53	40	-	-
1974		212			1993	93	26	-	-
1975		325			1994	312	35	-	-
1976		91			1995	83	23	2,6	2,6
1977		386			1996	56	6	4,6	6,8
1978		334			1997	390	9	0,7	1
1979		291	2,8	6,5	1998	29	18	0,3	0,4
1980	93	522	7	13	1999	346	15	0,4	0,5
1981	187	279	7,8	13	2000	88	18	0,6	0,7
1982	257	239	-	-	2001	239	11	0,6	0,8
1983	146	164	-	-	2002	278	17	0,5	0,6
1984	84	172	-	-	2003	260	9	0,6	0,7
1985	315	446	-	-	2004	246	9	0,3	0,4
1986	676	260	-	-	2005	88	7	0,5	0,5

DK.G.2. Stock surveys, yellow eel

All Danish streams are electrofished every 7th year in BRD (1,2,3,4) to determine trout stocks and the need for restocking trout. During this evaluation all fish species are recorded and the number of eels observed during the survey is included in the final report. The information on eel is semi quantitative or just qualitative.

DK.G.3. Silver eel

In the small Roskilde Fjord (BRD 2) a catch and recapture survey with tagged silver eel has taken place during autumn 1998, 2001–2004. The silver eels are tagged with Carlin tags and released in the inner parts of the fjord. On reported recapture, a fee per tag is given to the fisherman. The F-values are F-minimum values but reflecting the level of fishery mortality on silver eels in this area.

Table DK.G.3. Catch- recapture experiment with Carlin tagged silver eel during 1998, 2001–2004.

DATE OF RELEASE	STAGE	TAGGED NO	RECAPTURED NO	F %
30.09.1998	Silver	500	189	37,8
09.08.2001	Half silver	300	25	8,3
07.10.2002	Silver	400	68	17,0
19.09.2003	Silver	500	159	31,8
20.09.2004	Silver	500	135	27,0

DK.H. Catch composition by age and length

No continuous surveys are taking place. However, a survey from Roskilde Fjord, give age, length, sex of commercial silver and yellow caches from the fjord in the year 1990 (Pedersen, 1997).

DK.I & J. Other sampling

Cormorants

The number of Cormorants is estimated throughout the country every year by the ministry of environment. Cormorant's predation on flatfish, trout, salmon (smolt) and eels have been studied by DIFRES with various tagging methods e.g. floy tags, coded wire tags and radio tags near cormorant colonies in Ringkøbing Fjord (BRD 1).

Anguillicola

The swim bladder worm *Anguillicola crassus* introduced to Europe from the far east in the beginning of the 1980s was discovered in Danish wild eels in 1986. Since 1988 a monitoring program on the abundance of the *anguillicola,* in the eel population in different fresh and brackish water bodies has been continued annually.

The general finding is that:-

1) Anguillicola is present throughout the country on average in one out of three eels.

2) It is found that the rate of infection to be above 50 % in freshwater and below 50 % in saline water above 12 ppt.

3) The nutritional condition of the infected eels, do not differ significantly, from the non infected eels, suggesting that no eels were affected on their apatite by the presence of the parasites.

DK. K - N.

DK.O. Literature references.

Pedersen, M.I. 1997. Mindstemål på gule ål i Roskilde Fjord og Isefjorden. Legal size of yellow eel on Roskilde Fjord and Isefjord. Internal report, pp 10 + bilag.

Pedersen, M.I. 2002. Monitoring of glass eel recruitment in Denmark. In: Dekker W. (*ed*) Monitoring of glass eel recruitment. Netherlands Institute of Fisheries Research IJmuiden, the Netherlands, report C007/02-WD,Volume 2A, pp 97–106.

Report on the eel stock and fishery in The Netherlands 2005

NL.A. Author

Willem Dekker
Netherlands Institute for Fisheries Research RIVO
PO Box 68, 1970 AB IJmuiden, the Netherlands
Tel. +31 255 564 646. Fax: +31 255 564 644
Willem.Dekker@WUR.NL

This report was completed in December 2005; the data for 2005 are nearly complete.

NL.B. Introduction

Eel fisheries in the Netherlands occur in coastal waters, estuaries, larger and smaller lakes, rivers, polders, etc. The total fishery involves just over 200 companies, with an estimated total catch of nearly 1000 tonnes. Management of eel stock and fisheries has been an integral part of the long tradition in manipulating water courses (polder construction, river straightening, ditches and canals, etc.). Governmental control of the fishery is restricted to on the one hand a set of general rules (gear restrictions, size restrictions, for course fish: closed seasons), and on the other hand site-specific licensing. Within the licensed fishing area, and obeying the general rules, fishermen are currently free to execute the fishery in whatever way they want. There is no existing general registration of fishing efforts or landings required. In recent years, licensees in state-owned waters are obliged to participate in so-called Fish Stock Management Committees ['*Visstand Beheer Commissies*' VBC,], in which commercial fisheries, sports fisheries and water managers are represented. The VBC is responsible for the development of a regional Fish Stock Management Plans. The Management Plans are currently not subject to general objectives or quality criteria.

Recently, a committee of fishermen's organisations, sport fishermen and nature conservationists, supported by scientists, have developed a proposal for a national management plan (Aalcomité, 2005). At the heart of this management plan is the subsidiarity principle: responsibility for sustainable management can be delegated from the central government to lower levels, involving stakeholders at the regional scale. When objectives and targets are set centrally, co-operative management at the regional scale is the appropriate way to achieve this in typical small-scaled, rural eel habitats. This committee proposes to use a preliminary criterion, using the percentage of eels over 50 cm length in the catch as a proxy for the sustainability of management in a region. The Government has not participated in this committee, but has expressed a positive attitude to the resulting proposal.

The fishing areas can be categorised into 5 groups (see also Figure NL.1):

1) The Waddensea; 53°N 5°E; 2591 km^2. This is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of sea water at the western side mainly consists of the outflow of the river Rhine, which explains the estuarine character of the Waddensea. The fishery in the Waddensea is permitted to license holders and assigns specific fishing sites to individual licensees. Fishing gears include fyke nets and pound nets; the traditional use of eel pots is in rapid decline. The fishery in the Waddensea is obliged to apply standard EU fishing logbooks. Landings statistics are therefore available from 1995 onwards; 40 tons per year.

2) Lake IJsselmeer; 52°40'N 5°25'E; now 1820 km^2. Lake IJsselmeer is a shallow, eutrophic freshwater lake, which was reclaimed from the Waddensea in 1932 by a dike (Afsluitdijk), substituting the estuarine area known as the Zuiderzee. The surface of the lake was stepwise reduced by land reclamation, from an original

3470 km^2 in 1932, to just 1820 km^2 since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1200 and 620 km^2, respectively, but no further reclamation has actually taken place. In managing the fisheries, the two lake compartments have been treated as a single management unit. The discharge of the river IJssel into the larger compartment (at 52°35'N 5°50'E, average 7 km^3 per annum, coming from the River Rhine) is sluiced through the Afsluitdijk into the Waddensea at low tide, by passive fall. Fishing gears include standard and summer fyke nets, eel boxes and long lines; trawling was banned in 1970. Licensed fishermen are not spatially restricted within the lake, but the number of gears is controlled by a gear-tagging system. The registered landings at the auctions are assumed to cover some 80% of the actual total.

3) Main rivers; 180 km^2 of water surface. The Rivers Rhine and Meuse flow from Germany and Belgium respectively, and constitute a network of dividing and joining river branches in the Netherlands. Traditional eel fisheries in the rivers have declined tremendously during the 20th century, but following water rehabilitation measures in the last decades, is now slowly increasing. The traditional fishery used stow nets for silver eel, but fyke net fisheries for yellow and silver eel now dominates. Individual fishermen are licensed for specific river stretches, where they execute the sole fishing right. No registration of efforts or landings is required.

4) Zeeland; 965 km^2. In the Southwest, the Rivers Rhine, Meuse and Scheldt (Belgium) discharge into the North Sea in a complicated network of river branches, lagoon-like waters and estuaries. Following a major storm catastrophe in 1953, most of these waters have been (partially) closed off from the North Sea, sometimes turning them into fresh water. Fishing is licensed to individual fishermen, mostly spatially restricted. Fishing gears are dominated by fyke nets. Management is partially based on marine, partly on fresh water legislation.

5) Remaining waters; inland 1340 km^2. This comprises 636 km^2 of lakes (average surface: 12.5 km^2); 386 km^2 of canals (> 6 m wide, 27 590 km total length); 289 km^2 of ditches (< 6 m wide, 144 605 km total length); and 28 km^2 of smaller rivers (all estimates based on areas less than 1 m above sea level, 55% of the total surface; see Tien and Dekker, 2004 for details). Traditional fisheries are based on fyke netting and hook and line. Individual licenses permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered. 8 small companies operating scattered along the North Sea coast have been added to this category.

The Water Framework Directive subdivides the Netherlands into 4 separate River Basin District, all of which extend beyond our borders. These are:

a) the River Ems (Eems), 53°20'N 7°10'E (=river mouth), shared with Germany. This RBD includes the north-eastern Province Groningen, and the eastern part of Province Drente. Drainage area: 18 000 km^2, of which 2400 km^2 in the Netherlands.

b) the River Rhine (Rijn), 52°00'N 4°10'E,shared with Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 185 000 km^2, of which 25 000 km^2 in the Netherlands, which is the major part of the country.

c) the River Meuse (Maas), 51°55'N 4°00'E,shared with Belgium, Luxemburg, France and Germany. Drainage area: 35 000 km^2 , of which 8000 km^2 in the Netherlands.

d) the River Scheldt (Schelde), 51°30'N 3°25'E,shared with Belgium and France. Most of the south-western Province Zeeland use to belong to this RBD, but water reclamation has changed the situation dramatically. Drainage area: 22 000 km^2, of which 1860 km^2 in the Netherlands.

Within the Netherlands, all rivers tend to intertwine and confluent. Rivers Rhine and Meuse have a complete anastomosis at several places, while a large part of the outflow of the River Meuse is now redirected through former outlets of the River Scheldt. Additionally, the coastal areas in front of the different RBDs constitute a confluent zone. Consequently, sharp boundaries between the RBDs cannot be made - neither on a practical nor on a juridical basis. In the following, we will subdivide the national data on eel stock and fisheries by drainage area on a preliminary basis.

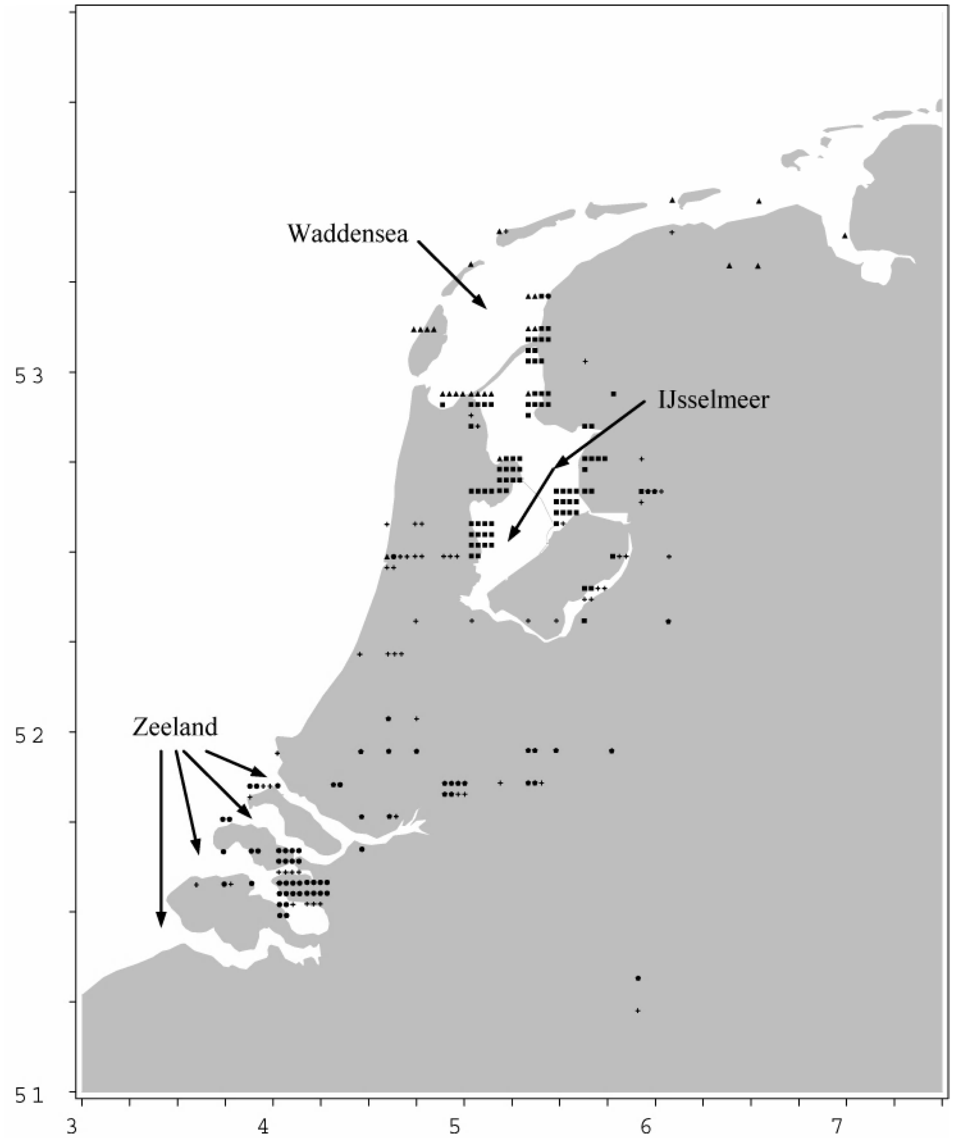


Figure NL.1. Distribution of eel fishery companies in the Netherlands (2005). Home addresses of companies have been grouped in a 10*10 km grid. Within each grid cell, individuals are listed in artificially created rows. Symbols indicate the fishing areas: ▲ Waddensea; ■ IJsselmeer; ⬟ Rivers; ● Zeeland; + Others.

NL.C&D&E Fishing capacity and Effort, Catches and Landings

Table NL.a lists the number of fishing companies having a specific eel fishing license, by fishing area. Registration of fishing effort is absent. Catches and landings in marine waters are registered in EU logbooks, but these do not allow for a break down by RBD. The estimates listed in Table NL.a are calculated on the assumption that landings must be approximately proportional to the number of companies per RBD. Other fishing companies, fishing for shrimps or flatfish, will have a by-catch of eel. Their landings will have been included in the marine total.

For Lake IJsselmeer, statistics from the auctions around Lake IJsselmeer are kept by the Fish Board (Table NL.b). These statistics are broken down by species, month, harbour and main fishing gear; the quality of this information has deteriorated considerably over the past decade, due to misclassification of catches, and the trading of eel from other areas at the IJsselmeer auctions.

Table NL.a. Overview of water surface, number of commercial companies and their annual landings (2004), by fishing area. Estimates in *Italics* have been broken down by RBD, assuming that catches are proportional to the number of fishing companies.

		SURFACE	NUMBER OF	ESTIMATED LANDINGS (T)		DATA SOURCE
Area	RBD	(km^2)	companies	yellow eel	silver eel	
Waddensea	Rhine	2591	25	*37*	-	EU logbooks
	Ems	38	2	*3*	-	EU logbooks
IJsselmeer	Rhine	1820	85†	240	40	Auction statistics
Rivers	Rhine	*120*	21	*46*	*91*	Informed guess
	Meuse	*60*	2	*4*	*9*	Informed guess
Zeeland	Meuse	535	43	75	?	(EU logbooks)
	Scheldt	428	0	0		
Others	Rhine	900	56	*222*	*133*	Informed guess
	Ems	86	2?	*9*	*5*	Informed guess
	Meuse	288	1?	*4*	*2*	Informed guess
	Scheldt	67	0			
Sum		6528	237	640	280	

† 85 licenses, owned by 68 companies.

Table NL.b. Landings in tons per year, from the auctions around Lake IJsselmeer, Rhine RBD. Only landings recorded at the auctions are included; other landings are assumed to represent a minor and constant fraction.

YEAR	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
0	324	620	1157	838	3205	4152	2999	1112	641	472	*368*
1	387	988	989	941	4563	3661	2460	853	701	573	*381*
2	514	720	900	1048	3464	3979	1443	857	820	548	*353*
3	564	679	742	2125	1021	3107	1618	823	914	293	*279*
4	586	921	846	2688	1845	2085	2068	841	681	330	*245*
5	415	1285	965	1907	2668	1651	2309	1000	666	*354*	234
6	406	973	879	2405	3492	1817	2339	1172	729	*301*	
7	526	1280	763	3595	4502	2510	2484	783	512	*285*	
8	453	1111	877	2588	4750	2677	2222	719	437	*323*	
9	516	1026	1033	2108	3873	3412	2241	510	525	*332*	

NL.E.2 Restocking

Glass eel and young yellow eel are used for re-stocking inland waters since time immemorial, mostly by local action of stakeholders. Although a minimum legal size for capture, holding and transport of eels is set in a byelaw, the existing practice of short-range transports has never been prosecuted. Since World War II, the Organisation for the Improvement of Inland Fisheries has organized a re-stocking programme, importing glass eels from France and England, and buying yellow eel from commercial fishermen fishing in the Waddensea. Data on re-stocking quantities are listed in table NL.c. Average weight of the young yellow eel amounts to approx. 33 gr.

Table NL.c. Re-stocking of glass eel and young yellow eel in the Netherlands, in millions re-stocked.

	1940		1950		1960		1970		1980		1990		2000	
	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel
0			5.1	1.6	21.1	0.4	19.0	0.2	24.8	1.0	6.1	0.0	2.8	1.0
1			10.2	1.3	21.0	0.6	17.0	0.3	22.3	0.7	1.9	0.0	0.9	0.1
2			16.9	1.2	19.8	0.4	16.1	0.4	17.2	0.7	3.5	0.0	1.6	0.1
3			21.9	0.8	23.2	0.1	13.6	0.5	14.1	0.7	3.8	0.2	1.6	0.1
4			10.5	0.7	20.0	0.3	24.4	0.5	16.6	0.7	6.2	0.0	0.3	0.1
5			16.5	0.9	22.5	0.5	14.4	0.5	11.8	0.8	4.8	0.0	xxx	xxx
6	7.3		23.1	0.7	8.9	1.1	18.0	0.5	10.5	0.7	1.8	0.2		
7	7.6	1.6	19.0	0.8	6.9	1.2	25.8	0.6	7.9	0.4	2.3	0.4		
8	1.9	2.0	16.9	0.8	17.0	1.0	27.7	0.8	8.4	0.3	2.5	0.6		
9	10.5	1.4	20.1	0.7	2.7	0.0	30.6	0.8	6.8	0.1	2.9	1.2		

NL.E.4 Aquaculture

Different sources reported slightly diverging results for the Dutch aquaculture industry (Table NL.d)

Table NL.d Aquaculture production in the Netherlands, as reported by different sources.

AQUACULTURE PRODUCTION (TONS/YEAR)	DATA SOURCE			
	FEAP	wgeel2003	FAO Fishstat	Nevevi
1985		20	20	
1986		100	100	
1987		200	200	100
1988		200	200	300
1989		350	350	200
1990		550	500	600
1991		520	550	900
1992		1250	520	1100
1993		1487	1250	1300
1994		1535	1487	1450
1995		2800	1535	1540
1996	1800	2443	2800	2800
1997	1800	3250	2443	2450
1998	3250	3800	2634	3250
1999	3800	4000	3228	3500
2000	4000	3800	3700	3800
2001	4000	3228	4000	4000
2002	4000		3868	4000
2003				4200
2004				4500
2005				4500

Nevevi is the national organisation of fish farmers; one would expect their own estimates to be the best.

NL.E.5 Recreational Fisheries

Recreational catches of eel are not recorded, and the order of magnitude is not well known. Inquiries related to angler licensing (NIPO 2004) indicate that 350 000 out of 913 000 male anglers fish for eels (in 2003); 57 500 of them take eels back home, in an average annual quantity of 18 specimens, approx. 1 kg per capita per annum. The number of female anglers is much lower, but not exactly reported. The total quantity taken home by anglers thus equals 57 tons at minimum. The impact of other anglers is unknown, but it seems rather likely that catch-and-return might damage or kill the eel. The 1 kg per capita per annum applied to the catch-and-return anglers results in an estimate of 350 tons, while the same quantity applied to all male anglers yields 913 tons. No information is currently available on the location of angling, that is: on the break down by RBD. However, it seems reasonable to assume that angling activity is more or less proportional to the drainage area of the RBD; RBD Ems has the lowest human population density, and is therefore probably overestimated. Table NL.e provides this rough estimate of the recreational catches per RBD, for the three assumptions on their overall impact.

Table NL.e. Rough estimate of the catch of recreational fisheries per RBD, based on three distinct assumptions on the overall impact of recreational fisheries.

Country	RBD	drainage area km2	Estimate based on 913,000 male anglers each taking 1 kg per annum	Estimate based on 350,000 men fishing for eel each taking 1 kg per annum	Estimate based on 57,500 men taking eel home each taking 1 kg per annum
NL	Ems	2,400	59	23	4
	Rhine	25,000	613	235	39
	Meuse	8,000	196	75	12
	Scheldt	1,860	46	17	3
NL	sum	37,260	913	350	57.5

NL.F. Catch per Unit of Effort

Starting in 1993, the fish assemblage in the main rivers and linked waters (see Figure NL.2) has been monitored, by means of logbook registration of commercial catch and by-catch, in a restricted number of fyke nets (4 large fyke nets or 2 pairs of summer fyke nets per location), mostly on a weekly basis. For eel, the number of yellow eels and silver eels caught is recorded. The annual report on the status of fish stocks in the rivers (Tien *et al.*, 2004) contains a section on eel, reporting the trend in these data. Results show no particular trend over the years, but the year-to-year variation is considerable. There is no formal application of these data in eel fisheries management, but the results have frequently been quoted in the debate on the status of the eel stock.

This monitoring programme is operated under the governmental responsibility for monitoring state-managed waters, and is executed by the Netherlands Institute for Fisheries Research RIVO.

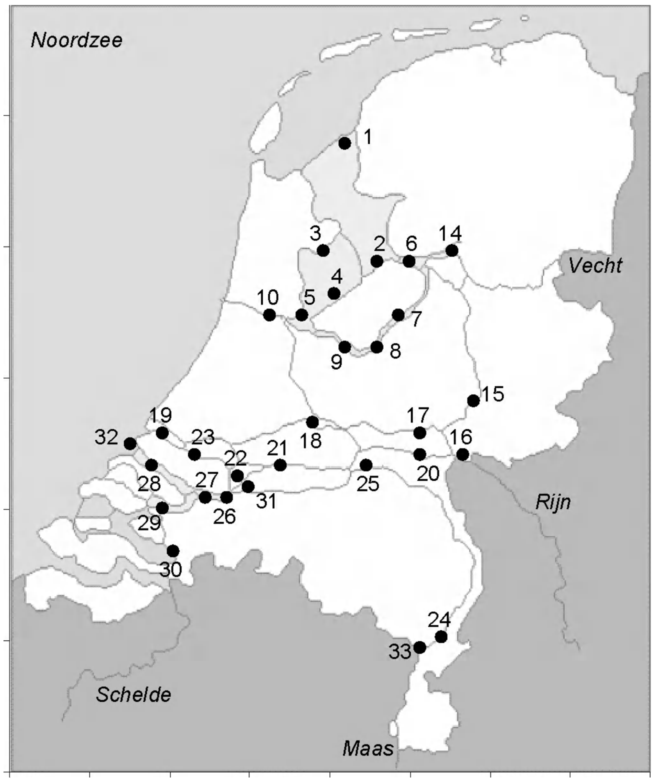


Figure NL.2. Sampling sites for the 4-fyke monitoring of commercial catches and bycatch

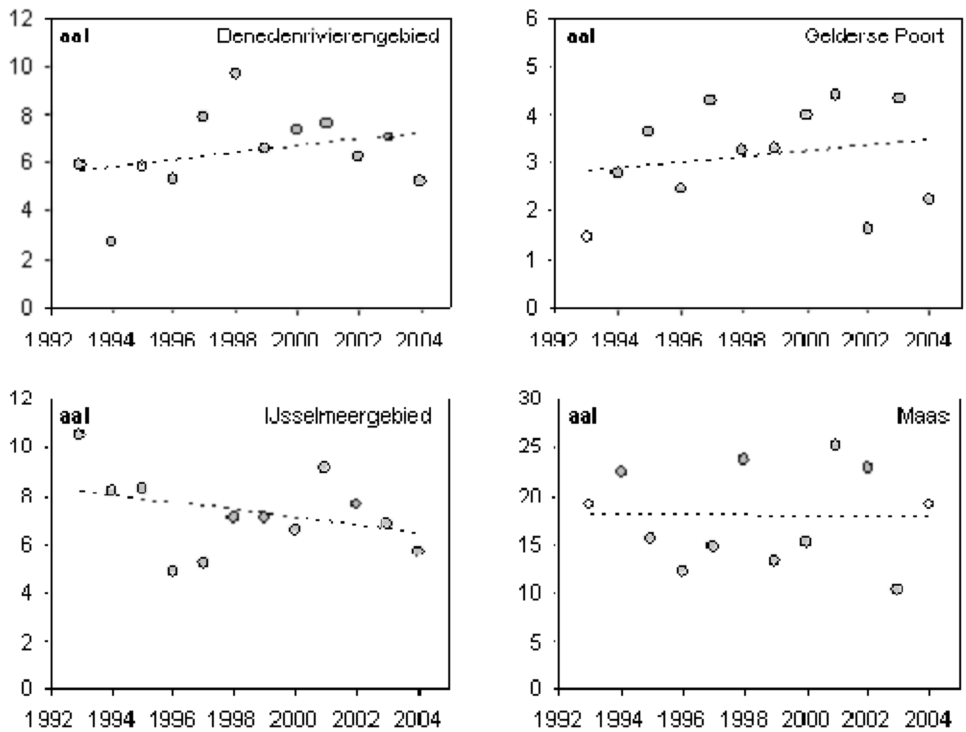


Figure NL.3. Time trends in the 4-fyke monitoring of commercial eel catches, for respectively Benedenrivierengebied (lower stretches of rivers, mostly Rhine), Gelderse Poort (Rhine near German border), IJsselmeergebied (Lake IJsselmeer and linked waters, RBD=Rhine) and Maas (Meuse). Note the influence of the first data points (1993 and 1994) on the overall trends.

NL.G. Scientific surveys of the stock

NL.G.1 Recruitment surveys.

Recruitment of glass eel in Dutch waters is monitored at Den Oever and 11 other sites along the coast (see Dekker, 2002 for a full description).

Table NL.f. Number of glass eel caught per lift net haul. All observations in a year have been corrected for time of day and month of sampling, and averaged.

DECADE YEAR	1930	1940	1950	1960	1970	1980	1990	2000
0		14.16	7.15	24.23	43.76	30.54	3.90	1.76
1		12.47	14.07	42.05	19.53	26.04	1.18	0.58
2		19.62	90.95	97.01	34.99	16.42	3.12	1.17
3		13.52	14.78	138.42	26.00	10.99	3.14	1.56
4		38.89	22.06	43.17	29.62	14.76	5.01	1.57
5			30.35	90.39	38.05	15.30	7.12	0.85
6		6.35	7.96	21.71	30.96	16.05	7.97	
7		6.17	18.20	33.31	67.32	6.25	12.97	
8	17.35	5.51	58.11	22.94	43.97	4.67	2.31	
9	38.36	5.43	31.98	19.35	60.91	3.20	3.60	

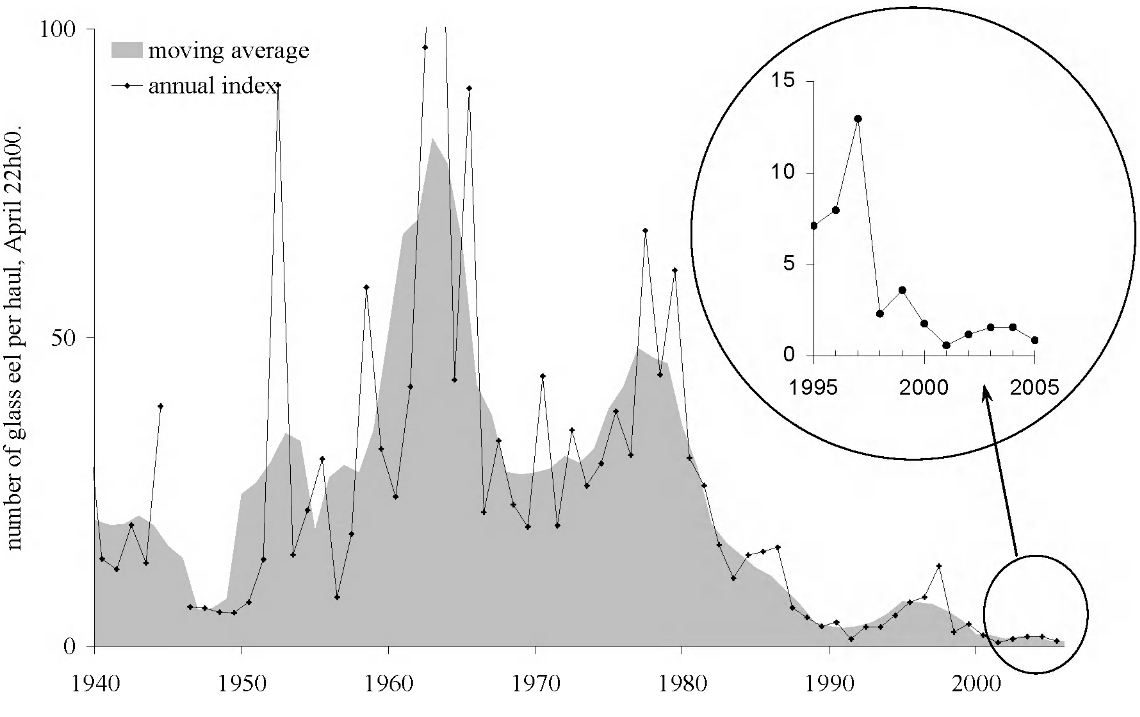


Figure NL.4. Time trend in the glass eel survey at Den Oever.

Table NL.g. Annual indices of glass eel recruitment at places in the Netherlands, other than Den Oever. Annual indices are expressed as the mean catch per lift net haul, at whatever time in the night. Most hauls are made in the evening, just in the dark.

YEAR	Otheense Kreek	Bath	Krammer	Stellendam	Katwijk	IJmuiden	Den Oever, ship lock	Harlingen	Lauwersoog	Nieuwstatenzijl	Termunten-zijl
RBD	Scheldt	Scheldt	Meuse	Mesue	Rhine	Rhine	Rhine	Rhine	Rhine	Ems	Ems
1969						47.3					
1970						31.5					
1971				15.4							
1972				4.1							
1973				13.1		32.8					
1974				22.8		119.3					
1975				13.9		66.8					
1976				11.3		73.1			14.4		
1977				42.1		159.2			28.4		
1978				42.1		131.7			83.9		
1979				27.3		176			66.2		
1980				45.1		101.5			80.3		
1981				47.3		113.9			55.1		
1982				11.3		20.8			17.4		
1983				14.3		15.6			15.1		
1984				3.8		11.4			7.1		
1985				8.7		1			25.2		
1986				6.4		4.7			1.3		
1987				9.8		7.7			52.0		
1988				7.6		3.5			0.5		
1989				4.4		1.6			12.1		
1990			0.3	11.3		4.7			5		
1991		5.9	0.1	1.7	5.1	2			6.3		0.3
1992		12.3	0.3	9.9	8.2	2.5		14.8	7.3		0.4
1993		17.5	0.3	5.2	13.5	1.6			20.8		1.4
1994		14.6	0.5	2.7	15.1	3.6		16	22.5		2.2
1995	0.5	15.7	0.3	3.2	27.1	13.1	27.8	6.8	11.6		3
1996	1	26.8	0.7	0.4	25.4	4	10.2	29.7	34.4	24	6
1997	0	40.4	0.4	2.5	10.9	1.3	10.2	12.4	20.9	21	10.6
1998	0.7	18.3	0.6	0.9	38.8	1.2	6.5	15.4	9.9	19.9	1.1
1999	1.2	23.1	0.6	1	101.3	1.6	5.6	12.7	15.1	11.8	7.5
2000	0.7	20.1	0.8	5.6	8.8	1.5	4	2.8	6.6	23.3	5.7
2001	0.5	1.2	0.1	0.9	8.1	0.4	1.5	1.8	1.7	16.1	0.8
2002	0	13.6	0.4	3.7	9.8	0.05	1	2.2	3.4	35.3	0.9
2003	0	7.0	0.1	0.4	11.8	0	4.7	3.8	1.2	25.5	0.4
2004	0	(24.9†)	0.03	0.3	4.5	0.105	4.1	(4.9†)	1.7	21.7	1.2
2005	0	13.4	0.5	0.2	4.4	0	4.6	3.3	0.9	18.2	1.3

†Sampling only took place in part of the season.

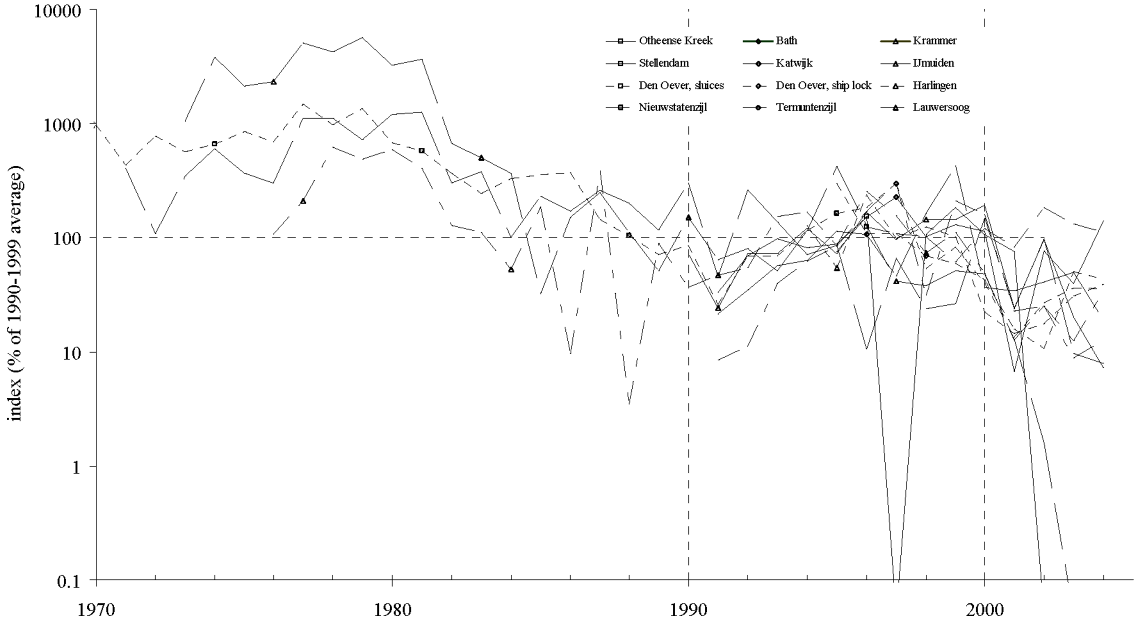


Figure NL.5 Long-term trends in the glass eel catches in the experimental fisheries at various places along the Dutch coast.

NL.G.2 Yellow eel surveys

IJsselmeer surveys: Table NL.h presents the trends in CPUE for the yellow eel surveys in Lake IJsselmeer, using the electrified trawl.

Table NL.h. CPUE trends in Lake IJsselmeer stock surveys, in number per hour trawling, using the electrified trawl. Note: The northern and southern compartments are separated by a dyke.

year	Northern	Southern
1989	220	93
1990	406	117
1991	192	36
1992	168	28
1993	386	14
1994	195	32
1995	201	39
1996	136	24
1997	191	21
1998	309	18
1999	176	43
2000	571	27
2001	168	26
2002	144	11
2003	61	2.9
2004	90	7.6
2005	xxx	xxx

Main Rivers survey: Figure NL.6 presents the trends in biomass (left) and numbers (right), per hour fishing.

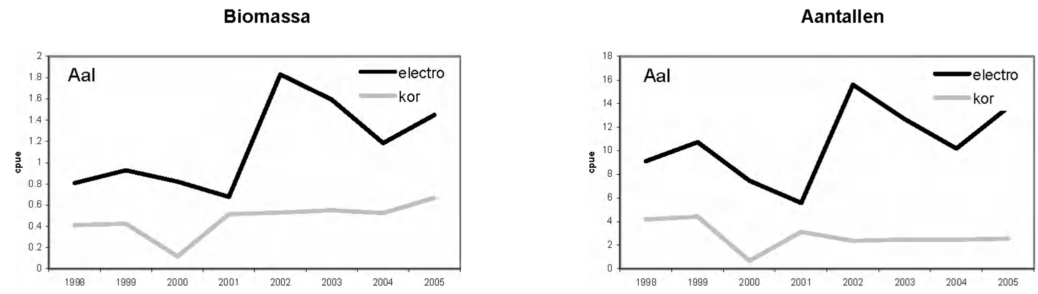


Figure NL.6. Trends in biomass (left) and numbers (right), for electro dipnet and trawl (kor), in the Main River surveys.

Coastal Surveys: the number of eels caught in coastal surveys (Dutch Young Fish Survey) is presented in Figure NL.7.

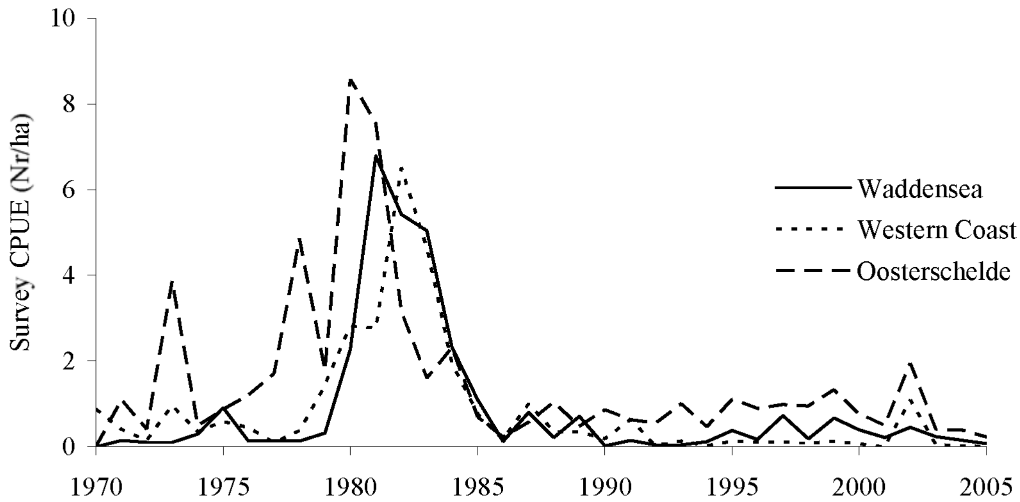


Figure NL.7. Trends in coastal survey CPUE. Most of the Waddensea belongs to RBD Rhine; Oosterschelde is mixed Scheldt and Meuse; Western Coast belongs to RBD Rhine.

Overall, these surveys are not representative for the whole River Basin Districts. Lake IJsselmeer is extremely overexploited, while fisheries in the remainder of the country is less severe. The Main Rivers Surveys are probably reasonably representative for the rivers. However, Lake IJsselmeer and the Main Rivers differ substantially, and it is not quite clear how the two should be weighted.

NL.G.3 Silver eel surveys

There are no surveys for silver eel in the Netherlands. In most recent years, an experimental silver eel tagging programme, using passive transponders and conventional mark-recapture, has been operated in the Rivers Meuse (2003-present) and Rhine (2004-present). The silver eel run is estimated at some 105–225 tonnes in the Meuse, and 200–1000 tonnes in the Rhine per year.

Bruijs, M.C.M., Polman, H.J.G., van Aerssen, G.H.F.M., Hadderingh, R.H., Winter, H.V., Deerenberg, C., Jansen, H.M., Schwevers, U., Adam, B., Dumont, U. & Kessels, N. 2003. Management of silver eel: Human impact on downstream migrating eel in the river Meuse. EU-Report Contract Q5RS-2000-31141.

Klein Breteler J., Jorgensen L., Staas S., Borcherding J. & Ingendahl D. 2005 Population size of the silver eel (*Anguilla anguilla*) population of the whole River Rhine catchment in 2004: a pilot mark-recapture study. Poster presented at Fish and Diadromy in Europe : Ecology, Management, Conservation, 29th March – 1st April 2005; and at Internationales Rheinsymposium, Fischwanderung Fischaufstieg u. Fischabstieg, 2. bis 4. November 2005.

NL.H. Catch composition by age and length.

For Lake IJsselmeer, the landings are regularly sampled at the auctions. Results have indicated extreme overfishing (see Figure NL.8). Since the catch composition did not change much over the years (see Figure NL.9), results have not been reported in detail for the past years.

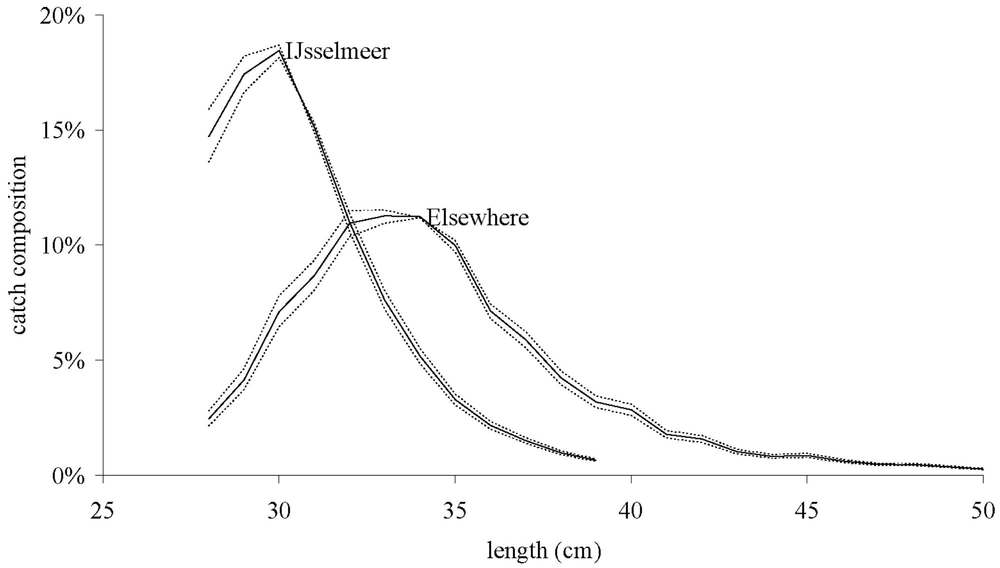


Figure NL.8. Average length composition of fyke net catches, with confidence intervals (±1 std), for Lake IJsselmeer and Elsewhere, based on the entire historical data sets. The presented length distributions conform to the situation in 1990.

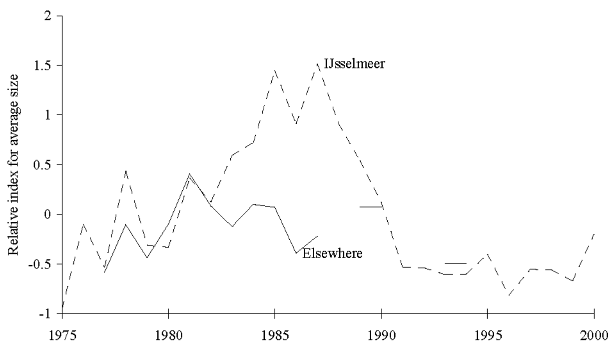


Figure NL.9. Relative change in size composition of eel landings. Positive values indicate a shift towards larger size classes. In Lake IJsselmeer, effort reductions and the recruitment failure in the 1980s initially shifted the length composition gradually to higher values. When the low recruitment had progressed into even the largest size classes, the mean size restored to normal values. Elsewhere, the data showed less variability. Presumably, sampling ceased before the 1980s recruitment failure had progressed into the exploited length classes.

NL.I. Other biological sampling

Angler catches are often consumed, without the eels becoming available on the market. Consequently, this local consumption is hidden for regular food safety monitoring. Due to the high spatial variation in PCB and mercury content, and the high site fidelity of many anglers, a small fraction of the angler population might exceed food safety limits considerably. Starting in the 1970s, a specific monitoring programme has targeted the eel (and pikeperch) in angling waters. A mixture of 25 eels (5 gr muscle tissues) for each of 23 sites (Figure NL.10) was derived from experimental fishing, and analysed for PCB and mercury content. Results are annually reported (Pieters *et al.*, 2004; Figure NL.11), focusing on areas where consumption norms are exceeded. Although the sampling scheme is not designed to be representative for the eel population, the trends observed will represent the true time trend.

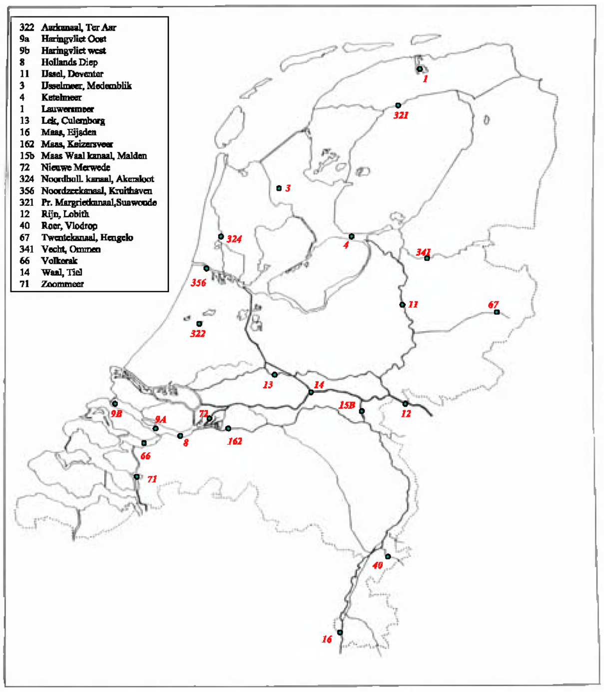


Figure NL.10. Sampling sites for the PCB and mercury monitoring programme

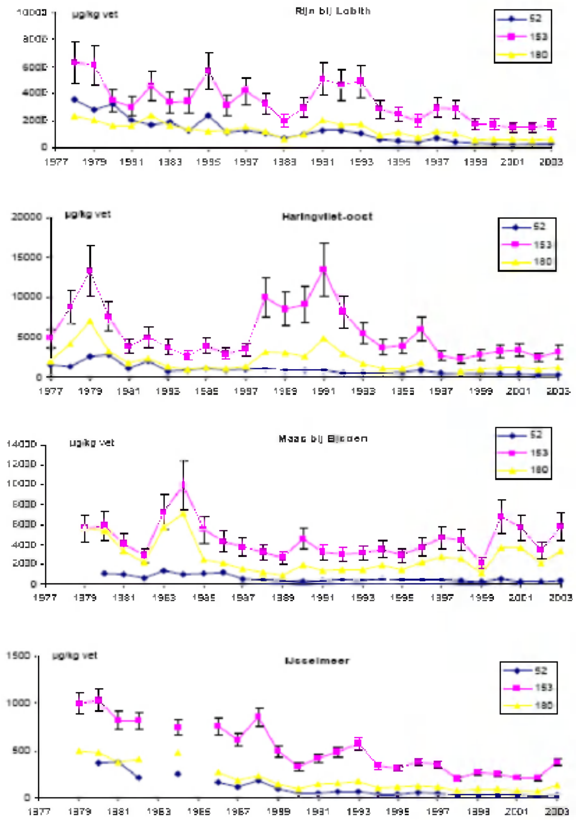


Figure NL.11. Trends in PCBs in eel, angler sampling programme.

NL.J. Other sampling

NL.K. Stock assessment

For RBD Rhine, Lake IJsselmeer, there is a good estimate of recruitment trend, fishing mortality (and trend). Silver eel escapement has been assumed to be proportional to silver eel catches.

For the remainder of RBD Rhine, there is no stock assessment.

For the other RBDs, there is no stock assessment.

NL.O. Overview.

Table NL.i. Overview of the eel fisheries in the Netherlands for 2004. For the break down over RBDs and regions, it has been assumed that catches are proportional to the number of fishing companies. Consequently, the presented information is not exact.

Geographical area							C	D								E. Catch (t)				
Country	RBD	water body	Latitude (° N)	Longitude (° E)	drainage area km2	water surface km2	Number of companies	Beam trawl	Gears using hooks	Drift & Fixed nets	Long leader, > 100 m	Short leader, < 100 m	Pots & traps	Polyvalent, combinations	Glass eel	Bootlace	Yellow eel	Silver eel	Aquaculture (t)
NL	Ems	Inland	53.20	7.00	2,400	*86*	2			+++							9	5	
		Estuarine: Dollart	53.30	7.10		38	2	+		+++							3	0	
	Rhine	Main River branches	52.00	5.50		*120*	21			+++							46	91	
		Lake Ijsselmeer	52.65	5.40		1,820	85		+		1,630	18,000	10,800				240	40	
		Inland (lakes, polders, canals)	52.00	5.50	25,000	*900*	56			+++					-0.1	-3	222	133	
		Estuarine: Waddensea	53.00	5.00		2,591	25	+		+++							37	0	
	Meuse	Main River	51.80	5.70		*60*	2			+++							4	9	
		Inland	51.70	5.70	8,000	*288*	1			+++							4	2	
		Estuarine: Haringvliet, Grevelingen, Oosterschelde	51.70	4.00		535	43			+++							75	0	
	Scheldt	Inland	51.30	3.80	1,860	*67*											0	0	
		Estuarine: Westerschelde	51.40	3.80		428		+									0	0	
NL	sum				37,260	6,933	237								-0.1	-3	640	280	4,500

Report on the eel stock and fishery in Belgium

BE.A. Author

Claude Belpaire
Research Institute for Nature and Forest (INBO)
Duboislaan 14, 1560 Groenendaal-Hoeilaart, Belgium
Tel. +32 +32 2 658 04 11. Fax : +32 2 657 96 82
Claude.Belpaire@inbo.be

This report was completed in January 2006, and contains data up to 2005.

BE.B. Introduction:

This report is written in preparation of the EIFAC/ICES Working Group on Eel (Rome, 23–27 January 2006) and presents mostly the data on eel stocks and fisheries as compiled for the Workshop on National Data Collection for the European eel (Stockholm, 2005). An attempt is made to compile the data broken down per River Basin District (RBD), in accordance with the Water Framework Directive. However it became obvious that considerable information is lacking due to the scattered fish management units (due to the specific Belgian administrative and political situation), not at all coinciding with RBD grouping and the absence of a national eel management plan.

BE.B.1. Eel fisheries, managing administrations

Eel fisheries in Belgium occur in coastal waters, estuaries, rivers, canals, polder watercourses and in small lakes. Professional eel fisheries is essentially coastal and estuarine. Fresh water eel fisheries is mostly recreational by anglers using rods, fykes or square nets. As the management of the fisheries is organised by various services quite differently, it is convenient to categorise as follows (Figure BE.1):

1) Professional coastal and sea fisheries constituted by a small fleet of beam trawlers and otter trawlers. Competence over fisheries regulation has been transferred to the Regional Governments. Regulation of marine fisheries is the responsibility of Marine Fisheries Service of the Agriculture and Fisheries Policy Division (Administration of Agriculture and Horticulture of the Ministry of Flanders). This fisheries is likely to be of minor importance with repect to eel management as eel landings are small and not reported (see below BE.E)).

2) Estuarine fisheries on the Scheldt constituted by trawlers and fyke fisheries. This fisheries is managed by the Flanders' Environment, Nature, Land and Water Management Administration, Section Forest and Green. This fisheries is specifically focused on the catch of eels.

3) Recreational fisheries in the Flemish Region. This fisheries is managed by the Flanders' Environment, Nature, Land and Water Management Administration, Section Forest and Green. This fisheries is concentrated on coarse fish, pike and pike perch, but also eels are popular.

4) Recreational fisheries in the Walloon Region. This fisheries is managed by the Ministry of the Walloon Region, General Directorate of Natural Resources and Environment. It is focused on coarse fish and salmonids.

5) Recreational fisheries in the Brussels-Capital Region. This fisheries is managed by the Brussels Institute for Management of the Environment.

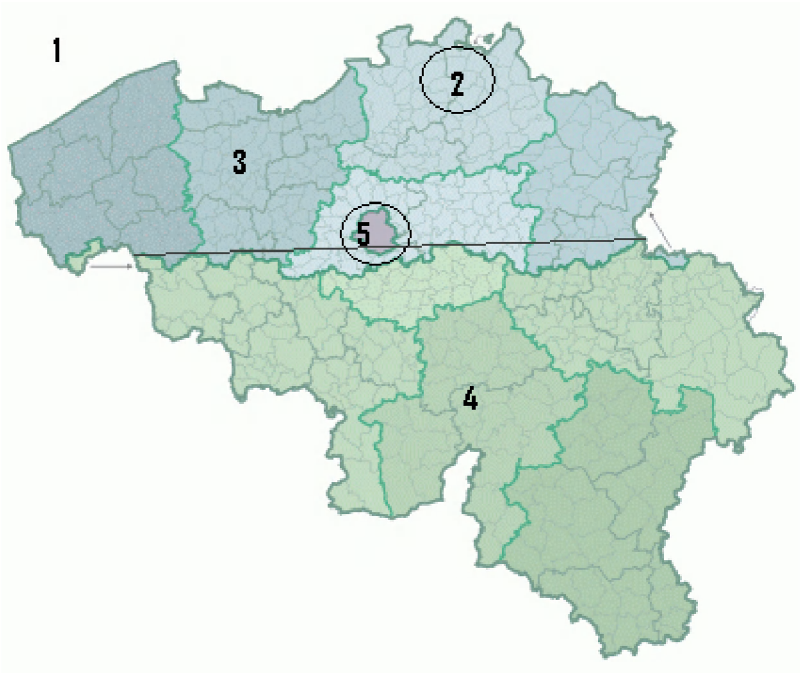


Figure BE.1. Map of the various fisheries in Belgium (for numbers : see text).

BE.B. 2. Water Framework Directive, the River Basin Districts in Belgium

The Water Framework Directive subdivides Belgium into 4 separate River Basin Districts, all of which extend beyond our borders. These are:

a) the River Basin District of the Scheldt (Schelde, Escaut), shared with The Netherlands and France. Drainage area: 37 170 km^2. The international co-ordination of the RBD of the Scheldt is assigned to the International Scheldt Commission (ISC, http://www.isc-cie.com) through the treaties of Ghent (03/12/02).

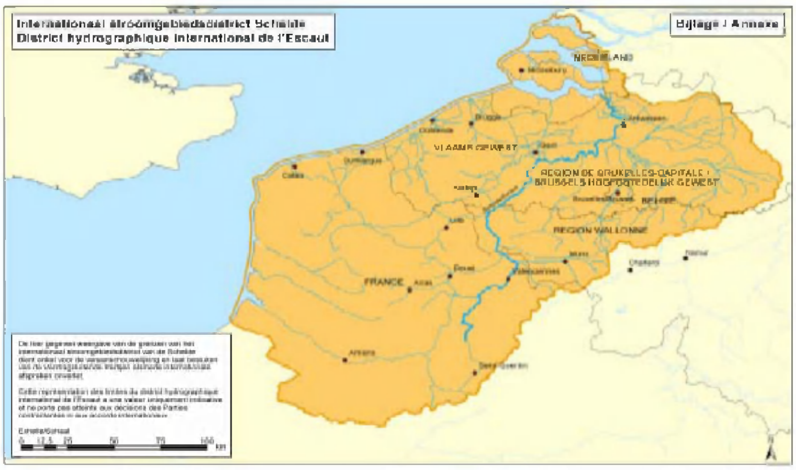


Figure BE.2. International RBD of the Scheldt.

Figure BE.3 gives a view of the RBD of the Scheldt in Flanders. It includes the River Basins of the Yser (IJzer, Isère), of the Brugse Polders and of the Scheldt.

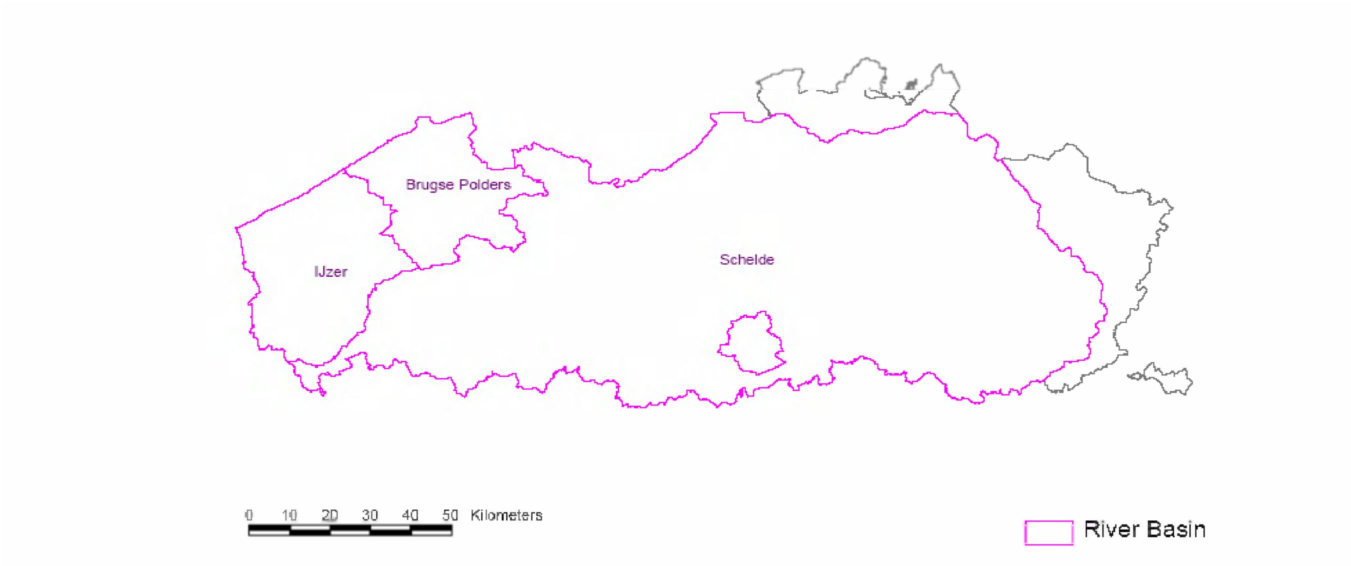


Figure BE.3. Scheldt RBD area in Flanders.

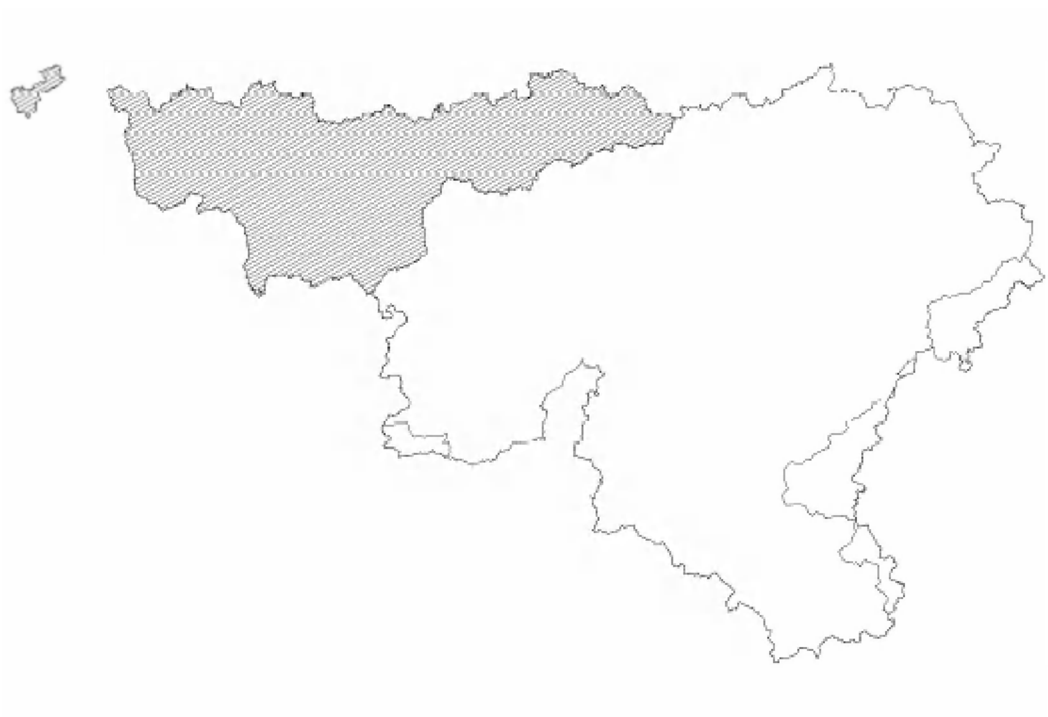


Figure BE.4. Scheldt RBD area in Wallonia.

b) the River Basin District of the Meuse (Maas), shared with The Netherlands, Luxemburg, France and Germany. Drainage area: 35,000 km^2 . 28% of the catchment area is situated in France, 41% in Belgium, 12% in Germany, 19% in The Netherlands, and a small portion in Luxembourg The international co-ordination of the RBD of the Meuse is assigned to the International Meuse Commission (IMC, http://www.cipm-icbm.be) through the treaties of Ghent (03/12/02).

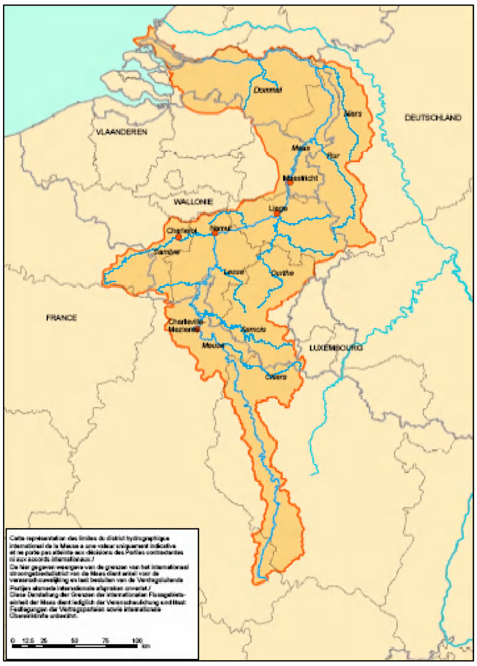


Figure BE.5. International RBD of the Meuse.

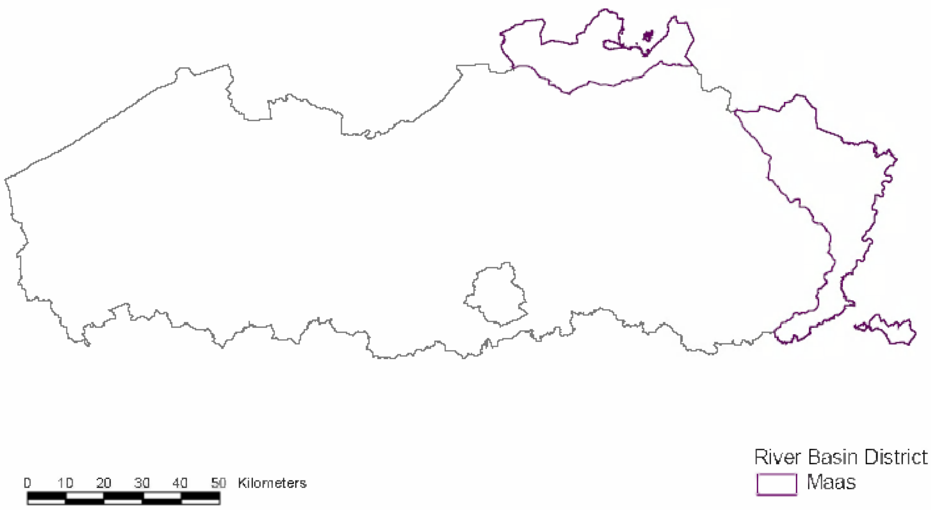


Figure BE.6. Meuse RBD area in Flanders.

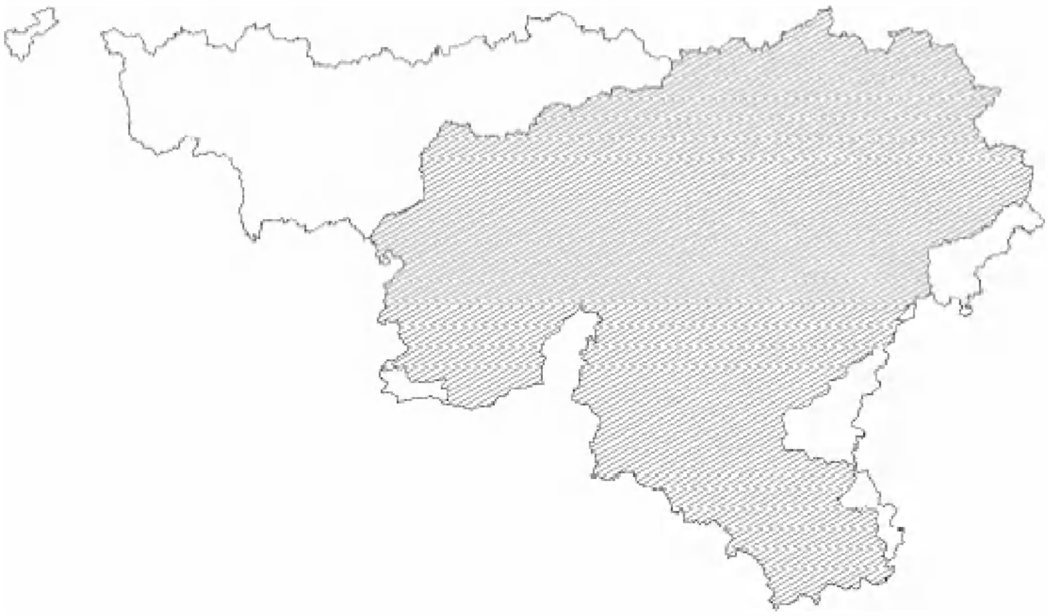


Figure BE.7. Meuse RBD area in Wallonia.

c) the River Basin District of the Rhine (Rijn), shared with The Netherlands, Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 225 000 km², of which 760 km² in Belgium. All of the Belgian Rhine RBD is situated in Wallonia. It consists of 1 single sub-basin (Moselle).

Figure BE.8. Rhine RBD area in Wallonia.

d) the River Basin District of the Seine, shared with France. Drainage area: 79 000 km², of which a very small part 92 km² in Belgium. All of the Belgian Seine RBD is situated in Wallonia. It consists of a single sub-basin of the Oise.

Figure BE.9. Seine RBD area in Wallonia.

BE.C, D & E. Fishing capacity, fishing effort and catches and landings

Professional coastal and sea fisheries.

In 2003, the Belgian fishing fleet consisted of a total of 125 motorized vessels, with a total power of 66 869 kW and a gross registered tonnage of 23 794. The fleet consists mostly (97 per cent by engine power) of beam trawlers, the remainder being otter trawlers. About half the beam trawlers are of small to medium size, up to 300 hp (<221 kW). There is a time series about the fleet capacity. There are only three fishing harbours in Belgium: Zeebrugge, Oostende and Nieuwpoort. The main fishing grounds of the Belgian fishing fleet are the southern and central North Sea, where accounting for 44% of total catches (all species) in 2003. Other important fishing grounds are the English Channel (26%), the Celtic Sea (18%) and the Irish Sea (8%).

There are data available on fishing effort. However this information is of minor relevance. By far the most important species in value is sole, representing 49 per cent of the total value of landings in 2003, although only 21 per cent of the landings. Plaice, in contrast, contributed 26 per cent by volume but was only 14 per cent of the total in value. The most valuable species in 2003 was turbot: less than 2 per cent of the landings represented 5 per cent of the value. Cod, the fourth most important species, represented 7 per cent of the landings by volume and nearly 5 per cent by value. There is a by-catch of eels, however those catches are small and unpredictable. Usually these eels are sold directly on the quay. Only exceptionally, eels are presented for selling in the fish market and reported in these statistics.

Estuarine fisheries on the Scheldt.

This fisheries is performed by 2 boat trawlers and 30 semi professional fishermen are estimated to fish with fykes. A number of those fyke fishermen are fishing illegally. The boat fisheries consisted of one beam trawler and one otter trawler operating regularly on the river. The number of fykes along the low tide waterline is estimated 150. The trawl fisheries is focused on eel. No data about catches are available.

No official landing statistics for the fyke fisheries are available. On the basis of some fishermen's logbooks and on the basis of CPUE data on scientific monitoring (see BE.F) the total landings of eels by fyke fishermen are roughly estimated at 5 tonnes per year.

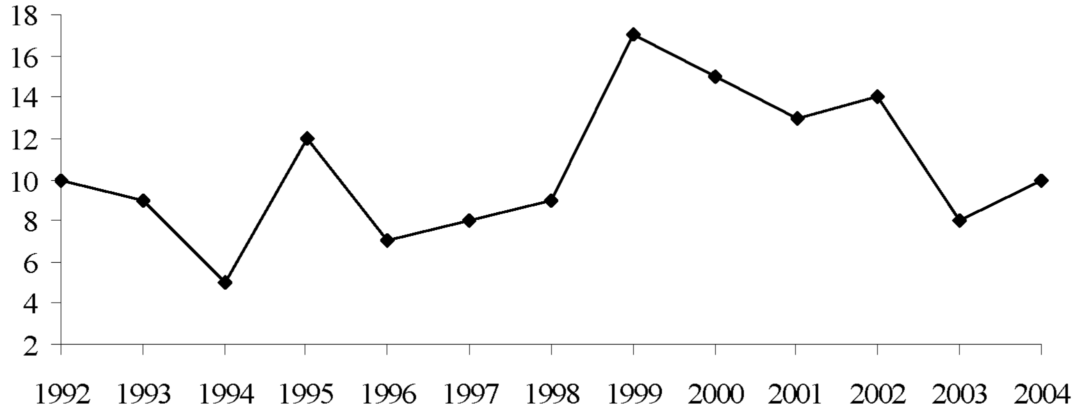


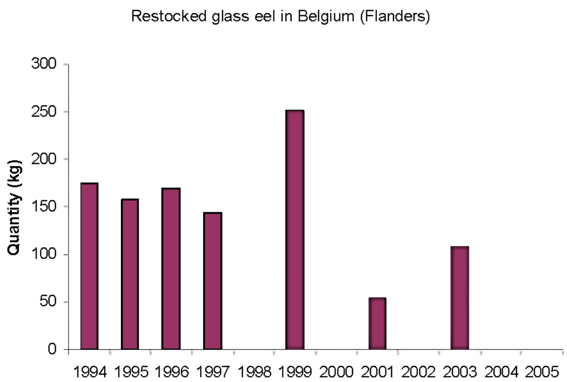
Figure BE.10. Time series of the number of licensed semi professional fishermen on the Scheldt from 1992 to 2004 (Data Section Forest and Green, AMINAL).

BE.E.2 Restocking

Glass eel and young yellow eels were used for restocking inland waters by governmental fish stock managers. The origin of the glass eel used for restocking from 1964 onwards was the glass eel catching station at Nieuwpoort on river Yser. However, due to the low catches after 1980 and the shortage of glass eel from local origin, foreign glass eel was imported mostly from UK or France.

In recent years the glass eel restocking could not be done due to the high market prices.

Also young yellow eels were restocked, the origin was mainly the Netherlands. Restocking with yellow eels was stopped after 2000 when it became evident that also yellow eels used for restocking contained high levels of contaminants (Belpaire and Coussement, 2000).



Year	Quantity (kg glass eel)
1994	175
1995	157,5
1996	169
1997	144
1998	0
1999	251,5
2000	0
2001	54
2002	0
2003	108
2004	0
2005	0

Figure BE.11 and Table BE.a. Re-stocking of glass eel in Belgium (Flanders) over the period 1994 to 2005, in kg of glasseel.

BE.E.4 Aquaculture

Allthough in recent years, two farm for intensive production of eels in recirculation systems were operating for a total production of 125 tonnes per annum (Belpaire and Gerard, 1994), nowadays eel culture has stopped completely.

BE.E.5 Recreational Fisheries

Recreational catches of eels are not recorded, data exist on number of licenses per region, and results of inquiries.

Recreational fisheries in the Flemish Region.

The number of licensed anglers was 60 520 in 2004. The time series shows a general decreasing trend from 1983.

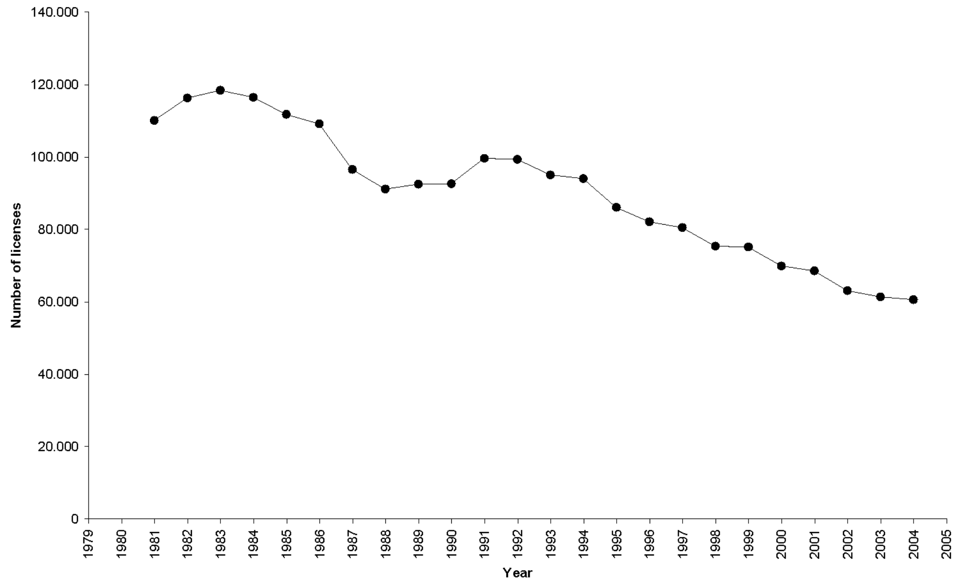


Figure BE.12. Time series of the number of licensed anglers in Flanders from 1980 to 2004 (Data Section Forest an Green, AMINAL).

Recreational fisheries in the Walloon Region.

The number of licensed anglers was 65 687 in 2004 (Data Fisheries Service, General Directorate of Natural Resources, Ministry of the Walloon Region).

Recreational fisheries in the Brussels-Capital.

The number of licensed anglers is approximately 1400 (Data Brussels Institute for Management of the Environment).

In total, there are approximately 128 000 recreational fishermen in Belgium. It was not possible to split out this information per RBD, however this is feasable as databases exist concerning the localities where licenses were emitted.

As will be clear from the information below there is a big gap in knowledge concerning the recording of eel landings from recreational fisheries in Belgium. Data available are only rough estimates.

Recreational fisheries in the Flemish Region.

There are no official data about the catches of eels. A recent estimate of the total amount of fish (all species) taken from Flemish waters by recreational anglers was 431 tonnes. 28% or 121 tonnes of the total number of extracted fish are eels (De Vocht and De Pauw, 2005). However, the catches and the number of extracted eels have been considerably influenced by a catch and release obligation for eels. This law was brought out as a result of the high PCB levels measured in most Flemish eels.

Another estimate can be deduced from data from Bilau *et al.,* (submitted). In 2003, 61 245 individuals in Flanders had a fishing license for public waters. A survey on specific aspects of recreational fisheries, including the issue of taking home a catch, was carried out (Vandecruys, 2004). The survey included questions on the fish species caught and taken home as well as the number and the weight of the fish caught and taken home. A total number of 3001 of the licensed anglers (out of 9492 contacted) completed a questionnaire about recreational fishing. Respectively 1.9% and 5.3% of these anglers indicated that they "always" (group A) or "sometimes" (on average: 1 out of 5 eels caught) (group B) take home the eel they have caught. Based on extrapolation to all licensed fishermen, the number of people taking home the eel, caught in Flemish public waters is estimated to be 4429 (7.2% of licensed anglers). Considering the catch and release obligation for eels in all public waters in Flanders, this is a high proportion, and an underestimate of the situation where all eels may legally taken home.

Based on the number of fishing occasions (average of 41.67 and 42.03 trips/y, respectively for group A and B), the number of eels caught per occasion (average of 4.14 and 3.12, respectively for group A and B) and a mean weight of edible portion per eel (150 g), it has been calculated that individuals in group A take home on average 25.9 kg of edible eel per year or a mean of 498 g/week. For group B it was calculated to be 3.9 kg per year or 76 g/week (Bilau et al, submitted). The total estimate for Flanders is thus 43 tonnes of eels per annum, which is approximately one third of the estimate by De Vocht and De Pauw (2005).

Table BE.b. Rough estimate of the catch of recreational fisheries in Belgium.

Country		drainage area km2	Estimate for the 1.9% or 1164 anglers each taking 25.9 kg eel per annum	Estimate for the 5.3 % or 3246 anglers each taking 3.9 kg per annum	Total estimate
BE	Flanders	13.521	30148	12659	42807
	Wallonia	16.845	no data	no data	no data
	Brussels	162	no data	no data	no data
BE	sum	30.528			

Recreational fisheries in the Walloon Region.

There are no official estimates about the catches of eels in the Walloon region. A 2002 survey estimated that 8% of the anglers never catch any eels and 33% sometimes catch them. More then half the anglers catch them and the others rarely. In 61% of the fishing occasions one eel is caught, in 26% of the cases two are caught, in 11% of the cases 3 eels are caught. In 1% of the fishing occasions more then 3 eels are caught. 63% of the eels are eaten. (Data from an inquiry from the Federation of Anglers in Walloonia).

Recreational fisheries in Brussels-Capital.

No information on eel catches.

BE.F. Catch per Unit of Effort

There are some data about the catch per unit of effort for the estuarine fyke fisheries on the Scheldt. These CPUE data were collected from scientific monitoring. The CPUE is strongly influenced by temporal and regional variation. Figure BE.4 gives the trend in CPUE of estuarine fyke fishing from 1995 to 2003 in the Scheldt estuary. Additional data of other sampling stations along the estuary are available.

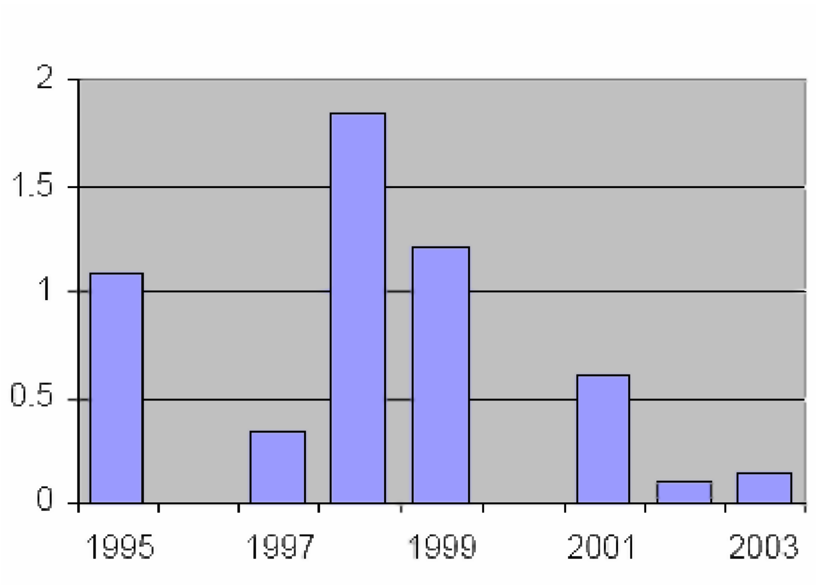


Figure BE.13. Mean number of eel per day per fyke from 1995 to 2003 in the Scheldt estuary at Zandvliet (Maes *et al.*, 2003)

BE.G. Scientific surveys of the stock

BE.G.1 Recruitment surveys, glass eel

In Belgium, commercial glass eel fisheries is forbidden by law.

Interest in glass eel recruitment has been limited to the Flemish part of Belgium. Glass eel recruitment studies in the upper part of Belgium (Walloonia) are inexistent, as this region is situated quite far from the coast. Fisheries on glass eel is carried out by the Flemish government. The glass eels are used exclusively for restocking in inland waters.

Long term time series on glass eel recruitment are available for the Nieuwpoort station at the mouth of the river IJzer. Other localities were assessed only occasionally or recently. Although the river Scheldt is the main basin in Flanders and despite the fact that many old reports mention high glass eel recruitment in the past, no quantitative series for the migration of glass eel on this estuary is available.

The IJzer is a relatively small lowland river (length 76 km) having its spring in the north of France and flowing through Flandrian polder area. The whole catchment covers 1400 km^2 and is well known for its eel population attracting many eel (sport)fishermen.

The river has a mean annual discharge of 5 to 6 m³/s, river flow is regulated by the presence of seasluices at Nieuwpoort. IJzer water flows into a basin called 'Ganzepoot'. The Nieuwpoort monitoring station is situated at the basis of a channel draining waters from several rivers and canals into the North Sea (51°08' N–2°45' E). The monitoring site is situated at 3.8 km from the sea, both in the ship lock from the IJzer mouth (Iepersluis)(dipnet fisheries), and in the basin Ganzenpoot (boat fisheries). By starting to catch the glass eel at the IJzer mouth in 1964 on an annual basis, a monitoring system for the recruitment of the European stock was unconsciously initiated. The fisheries operations have been sustained untill now.

The IJzer glass eel series is of particular interest as the series goes back to a quite early stage (1964), as the fishing technique and equipment staid identical during the whole period, and as the fisheries was not biased nor influenced by any other fisheries activity as commercial fisheries or poaching on glass eel do not exist.

At the Nieuwpoort station the glass eel fishing is starting at the end of February and continues till the beginning of May. Fishing is not carried out every day, but is mainly dependent of weather conditions and tide. Usually there are 20 to 30 fishing nights per season. Fishing is starting ca 2–3 hours before high tide and is continued untill high tide is attained.

The time series has been achieved by fishing in the ship lock of the Iepersluis at Nieuwpoort (Figure BE.20). Two to three hours before high tide the outer (sea side) doors of the ship lock are opened to allow glass eel entering the ship lock. A 5 m long steeled dipnet is held vertical from the ship lock quay and pulled forward, just under the surface, for the length of the ship lock. The dipnet has a width of 80 cm and is 60 cm heigh. This has been done in this way since 1964.

Data available are daily glass eel catches (kg), date and starting and ending hours of the fishing period. Temperature, tide data and other external factors (weather, …) are also recorded. Catches are presented as total annual yield or can be presented as maximum daily catch or mean daily catch. Catch per haul are recorded. The Institute for Forestry and Game Management is keeping up to date a database with the catches.

Additional glass eel recruitment data have been collected occcasionnally (e.g. morfometrical characteristics of the glass eel, densities of glass eel expressed as numbers per m³, mark recapture experiments, presence at other stations, capacity to pass the lock gates, influence of tide, e.g. …).

The glass eel season in Belgium is falling mainly in the months march and april.

Time series for the IJzer were presented in the past by Belpaire and Ollevier (1987), Belpaire (1987), Belpaire *et al.* (1991), Denayer en Belpaire (1992) Belpaire (2002). An updated version for the period 1964–2005 is presented in Figure BE.6.

It represents variations of the total annual catches of the dipnet fisheries in the Nieuwpoort ship lock and gives the maximum day catch per season. Overall trend of the figure confirms the general tendencies reported in the stock wide recruitment decline in most European rivers with a significant decline of annual total catches in the beginning of the eighties, and subsequent continued low catches.

Catches of the years 1964 and 1965 are low compared with later years, but have to be considered as fragmentary results of preliminary fishing experiences. Therefore, they should not be included in statistical stock wide data analysis.

In the period 1966–1979 the catches are high, mean catch is 511 kg per annum (252–946 kg). Presumably, according to verbal references, in this period the catch data are an underestimation of the recruitment as the duration of the fisheries was shortened when the local glass eel storing capacity was attained. Duration and fishing frequency at that time was influenced by the demand for restocking glass eel all over Belgium, and by the way and frequency catches were collected for transportation throughout Belgium.

As can be seen from the figure the period 1980–1982 was characterised as transitionnal years of decreasing and low recruitment, mean catch is 157 kg per annum (90–252 kg).The subsequent years (period 1983–2000) the catches are very low, mean annual catch is 28 kg per annum (1–218 kg). After 2000 catches were extremely low (2001: 0.7 kg, 2002: 1.4 kg, 2003: 0.5 kg, 2004: 0.4 kg, 2005: 0.8 kg).

Decade Year	1960	1970	1980	1990	2000
0		795	252	218,2	17,85
1		399	90	13	0,7
2		556,5	129	18,9	1,4
3		354	25	11,8	0,539
4	3,7	946	6	17,5	0,381
5	115	274	15	1,5	0,787
6	385	496	27,5	4,5	
7	575	472	36,5	9,8	
8	553,5	370	48,2	2,255	
9	445	530	9,1		

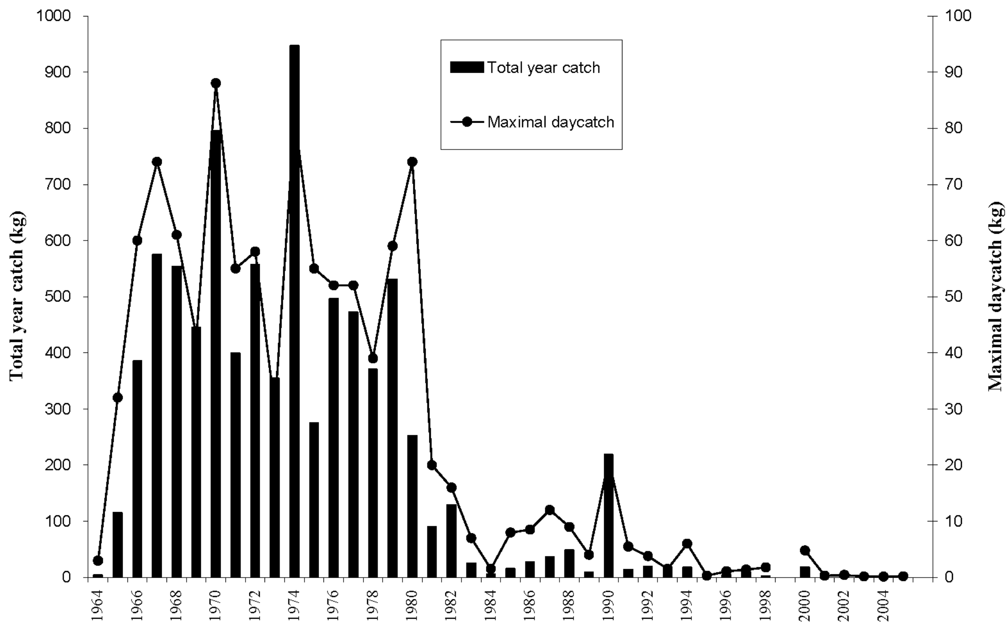


Figure BE.14 and Table BE.c. Annual variation in glass eel catches at river IJzer using the dipnetcatches in the ship lock at Nieuwpoort (dipnet catches)(Total year catches and maximum day catch per season). In Table BE.c the presented data are the total year catches.

Ascending yellow eel as recruitment indicator

Control of impinged fish at cooling water inlet and control of fish traps at fish passes are valuable techniques for monitoring recruitment by following monitoring the ascending young eels. This is particularly the case for the impingement studies at the Doel nuclear power plant on the River Scheldt and at the Liche fish trap at the fish pass on the River Meuse.

BE.G.2 Stock surveys, yellow eel

Since 1995, the Institute of Forestry and Game Management (IFGM) runs a fresh water fish monitoring network consisting of ca 1500 stations in Flanders. These stations are subject to fish assemblage surveys on regular basis (on average every 2 to 4 year depending of the typology of the station). This network includes all water types, head streams as well as tributaries (stream width ranging from 0.5 m to 40 m), canals, disconnected river meanders, water retaining basins, ponds and lakes, in all of the 3 major basins in Flanders (IJzer, Scheldt and Meuse). Techniques used for analysing fish stocks are standardized as much as possible, but can vary with water types. In general electrofishing was used, sometimes completed with additional techniques, mostly fyke fishing. A detailed description of the sampling methodology is given in Table BE.d. All fish are identified, counted and at each station 200 specimens of each species were individually weighed and total length was measured. As much as possible biomass (kg/ha) and density (individuals/ha) is calculated. Other data available are number (and weight) of eels per 100 m electrofished river bank length or number (and weight) of eels per fyke per day.

Table BE.d. Description of the techniques used for fish stock analysis in Flandrian waterbodies by IFGM.

WATERTYPE	TECHNIQUES USED
Running waters < 1.5 m	100 m electrofishing with 1 anode
Running waters 1.5-4 m	100 m electrofishing with 2 anodes
Running waters 4-6 m	100 m electrofishing with 3 anodes
Running waters 6-8 m	100 m electrofishing with 4 anodes
Running waters > 8 m	Combination of: 500 m boat electrofishing (2 x 250 mon both river banks) fykes and/or gill nets
Closed river arms and ponds Polder drainage systems	Combination of : seine netting boat electrofishing (both river banks) fykes and/or gill nets

These data allow quantification of the abundance of eels in Flandrian waterbodies, over space and time. Figures BE.7–9 give the distribution and abundance of eels in Flanders (electrofishing data), respectively is running waters, canals and polder waters and ponds and lakes. Figures BE.10 and 11 give a summary on presence and abundance of eels in Flanders for 1332 stations (Belpaire *et al.*, 2003).

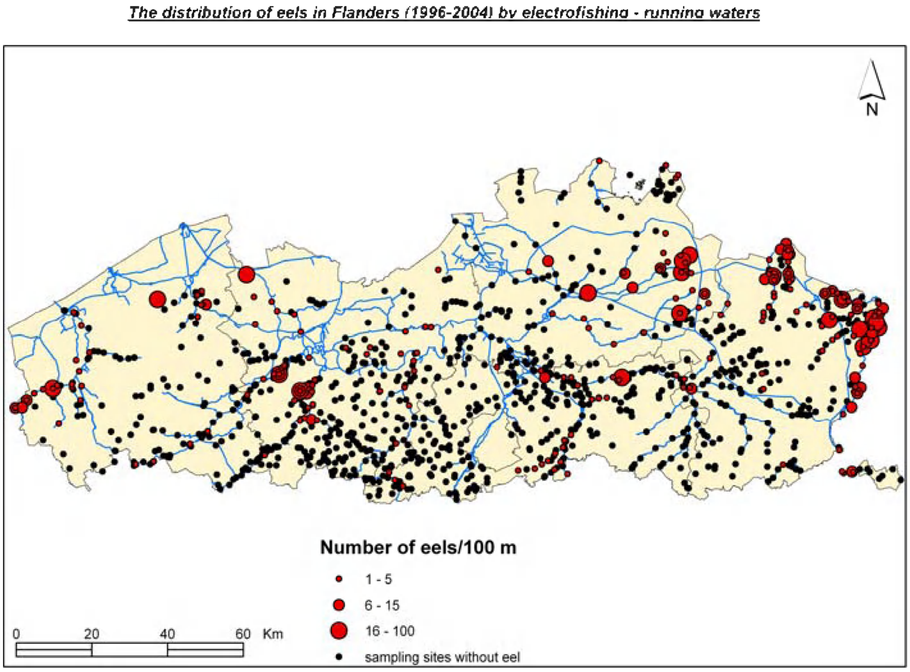


Figure BE.15. Distribution and abundance of eels in Flanders (electrofishing data) in running waters.

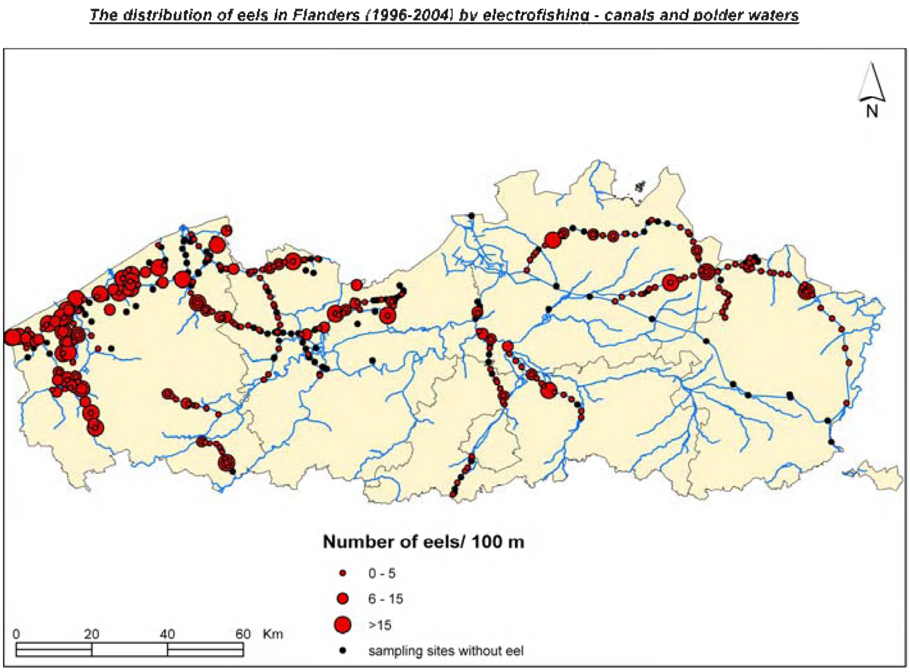


Figure BE.16. Distribution and abundance of eels in Flanders (electrofishing data) in canals and polder waters.

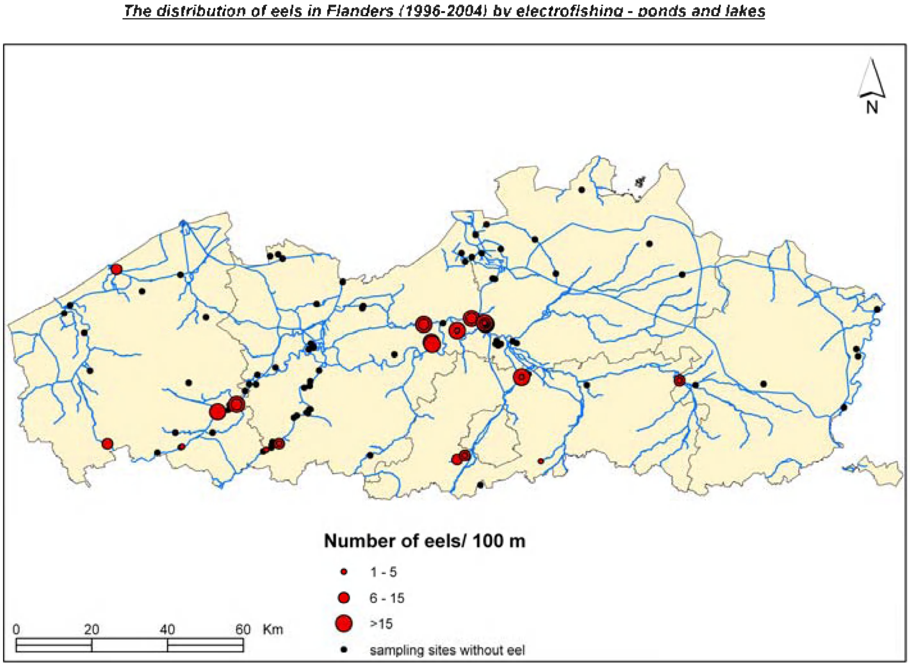


Figure BE.17. Distribution and abundance of eels in Flanders (electrofishing data) in ponds and lakes.

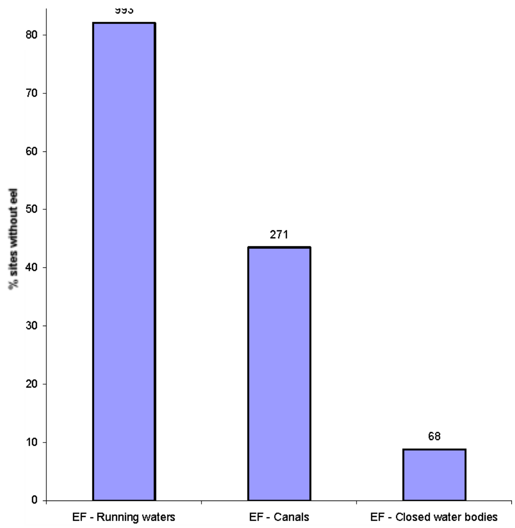


Figure BE.18. Presence of eels from electrofishing surveys on 1332 locations (Flanders) from different typology, expressed as % sites without eel (Rivers and brooks: minority with eels 18%, Canals: ca 50%, Closed water bodies: 91%)(Belpaire *et al.*, 2003).

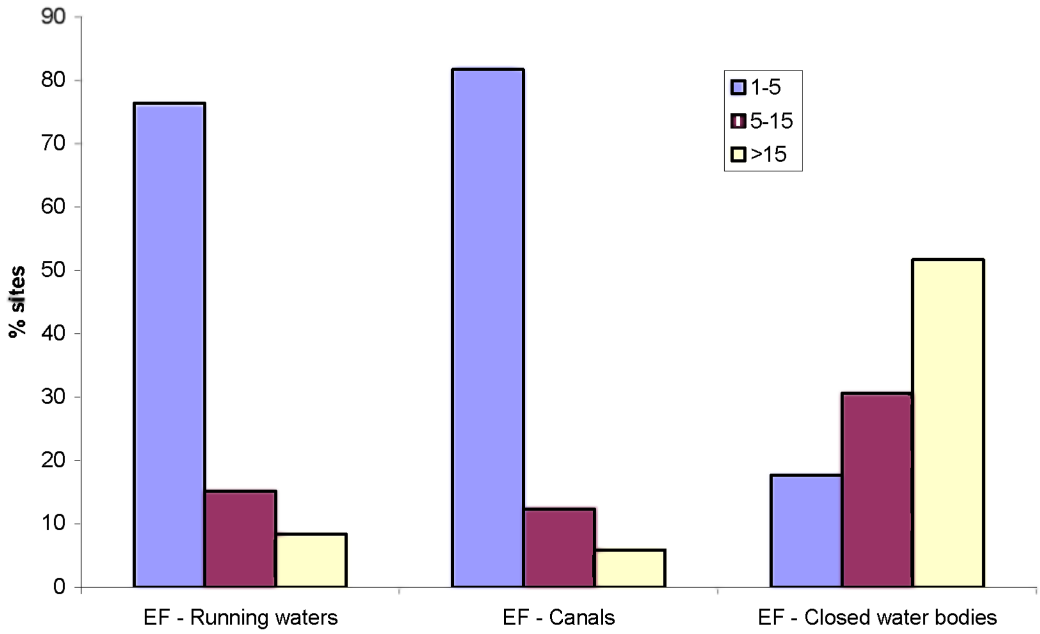


Figure BE.19. Abundance of eels (number of eels/100m EF) on sites where eels are present. Abundance in running waters and canals is usually low (1–5 ind/100m), but higher in closed water bodies (> 15 ind/100m) (Belpaire *et al.*, 2003).

A trend is also available from studies by the University of Louvain on the River Scheldt. Eel densities in the Scheldt estuary were recorded during the period 1991–2002 by analysing eels in the cooling water intake of the Doel power station and by a follow up of the fyke net fisheries. The numbers of adult eel (50–70 cm) per fyke net per day decrease from 1998 to 2002 and the numbers of pre adult eel (20 cm) per 10^3 m^3 cooling water showed a declining trend.

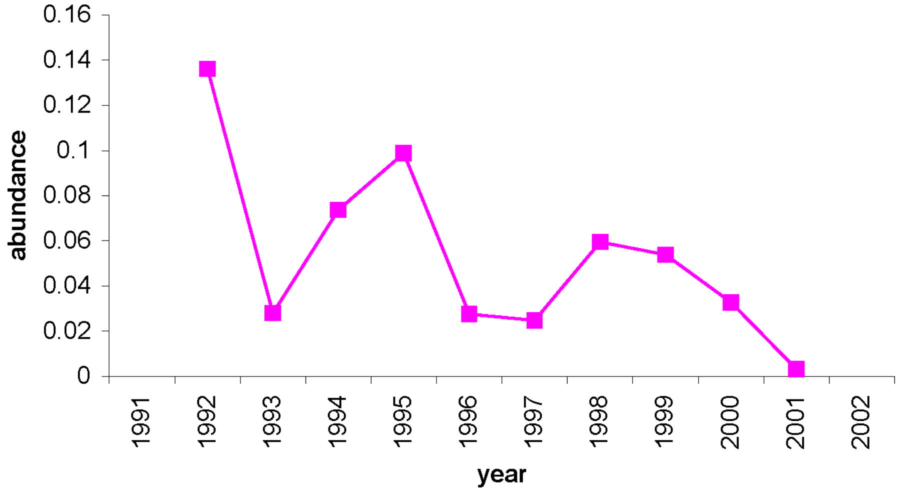


Figure BE.20. Trends in abundance of estuarine eels in River Scheldt (1991-2002) from impingement studies at the cooling water intake of the Doel nuclear power plant. Data from University Louvain (J. Maes), Belpaire *et al.* (2003).

In the Walloon Region similar fish stock assessment surveys are carried out by the Institut de Recherches Forestières et de Gestion de la Faune, and by universities. Currently, as far as our knowledge, these surveys are not performed on regular basis.

On the Meuse, the University of Liège is monitoring the amount of ascending young eels in a fish-pass. From 1992 to 2004 upstream migrating eels were collected in a trap (0,5 cm mesh size) installed at the top of a small pool-type fish-pass at the Visé-Lixhe dam (built in 1980 for navigation purposes and hydropower generation; height : 8,2 m; not equipped with a ship-lock) on the international River Meuse near the Dutch -Belgium border (290 km from the North Sea; width: 200 m; mean annual discharge: 238 m3/s; summer water temperature 21-26˚rC).The trap in the fish-pass is checked continuously (three times a week) over the migration period from March to September each year, except in 1994. A total number of 32157 eels was caught (biomass 1955 kg) with a size from 14 cm to 85 cm and a mean value of 31,6 cm corresponding to yellow eels. The study based on a constant year-to-year sampling effort revealed a regular decrease of the annual catch from a maximum of 5613 fish in 1992 to a minimum of 423 in 2004 (Baras *et al.*, 1994, Philippart *et al.*, 2004, Philippart and Rimbaud, 2005).

Figure BE.21. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam Data from University of Liège (J.C. Philippart) in Philippart and Rimbaud, 2005

BE.G.3 Silver eel

In Flanders, studies on silver eel populations are quite scarce. A 1994 study on the seaward migration of migrating silver eel from a small shallow lake in the West of Flanders (Blankaart Natural Reserve) estimated a silver eel production of at least 2.5 kg/ha (data from a 3-day survey) (Denayer and Belpaire, 1996). Length frequency distribution of both, male and female cohorts, are available.

There are possibilities to follow silver eel migration by monitoring impinged eels at the cooling water intake of power stations, especially at the Doel nuclear power plant on the Scheldt and at the Langerlo power plant on the Albertkanaal.

BE.H. Catch composition by age and length

Currently, there is no sampling programme for catch composition in commercial catches.

However in scientific monitoring length distribution is routinuously monitored in glass eel and yellow eel (see under BE.G.1 and 2).

BE.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

Anguillicola

Anguillicola infection rates were monitored in 1987, 1997 and 2000. The presence of *A. crassus* in Flanders was first discovered in 1985; 2 year later a survey revealed a prevalence of 34.1% and a mean infection intensity of 5.5, based on adult nematodes only, and 10 year later the parasite was present at all 11 sites sampled (Belpaire *et al.*, 1985, 1989, 1990). Prevalence had increased to 62.5% but the mean infection intensity had decreased to 3.9 adults per infected eel. In the year 2000, a third study revealed that *A. crassus* was present in 139 of 140 investigated sites; a further increase in prevalence to 68.7% and a decrease in mean infection intensity to 3.4 adults per infected eel was observed. When all larval stages were taken into account, mean prevalence amounted to 88.1% and mean intensity to 5.5 adults. The high infection level in Flanders is thought to be the result of restocking with glass eel and yellow eel, both of which are susceptible to *A. crassus*. The general infection parameters were similar in all 11 river catchments. It is possible that in Flanders both prevalence and mean infection intensity are stabilizing due to density-dependent regulation of the parasite infrapopulation. Fibrotic swimbladder walls were observed, mainly in large eels, and 20% of the total number of nematodes consisted of encapsulated larvae in the surveys of 1997 and 2000; 8 cases of swimbladder regeneration were observed (Audenaert *et al.*, 2003).

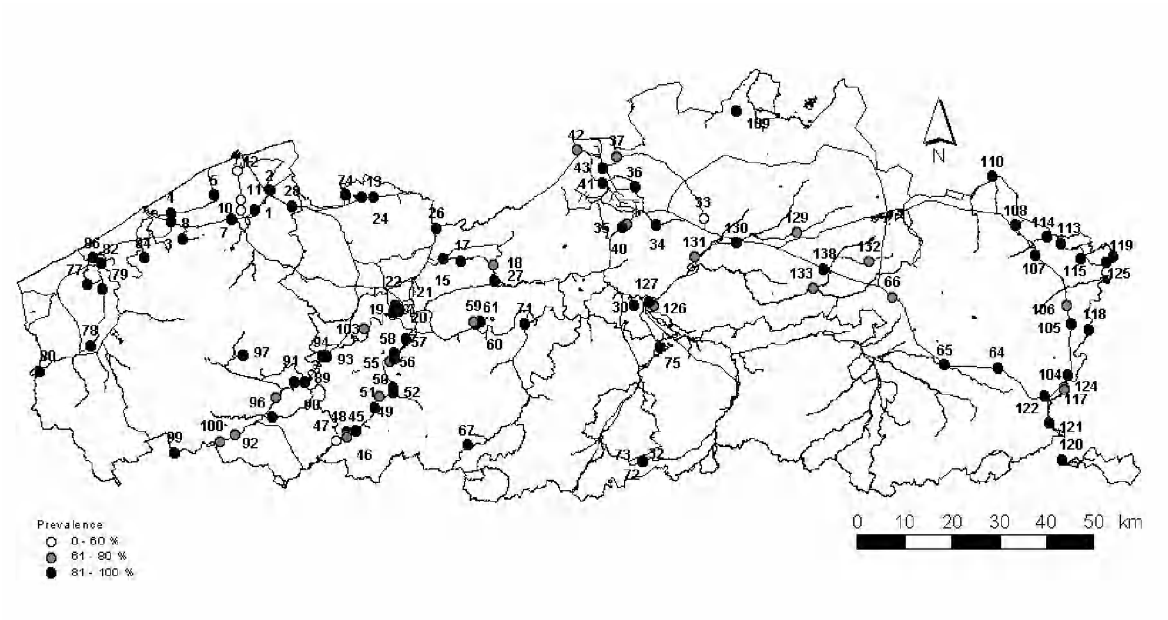


Figure BE.22. Distribution map of sampling sites of European eel across Flanders and prevalence of the parasitic nematode *A. crassus* in the year 2000 (Audenaert *et al.*, 2003)

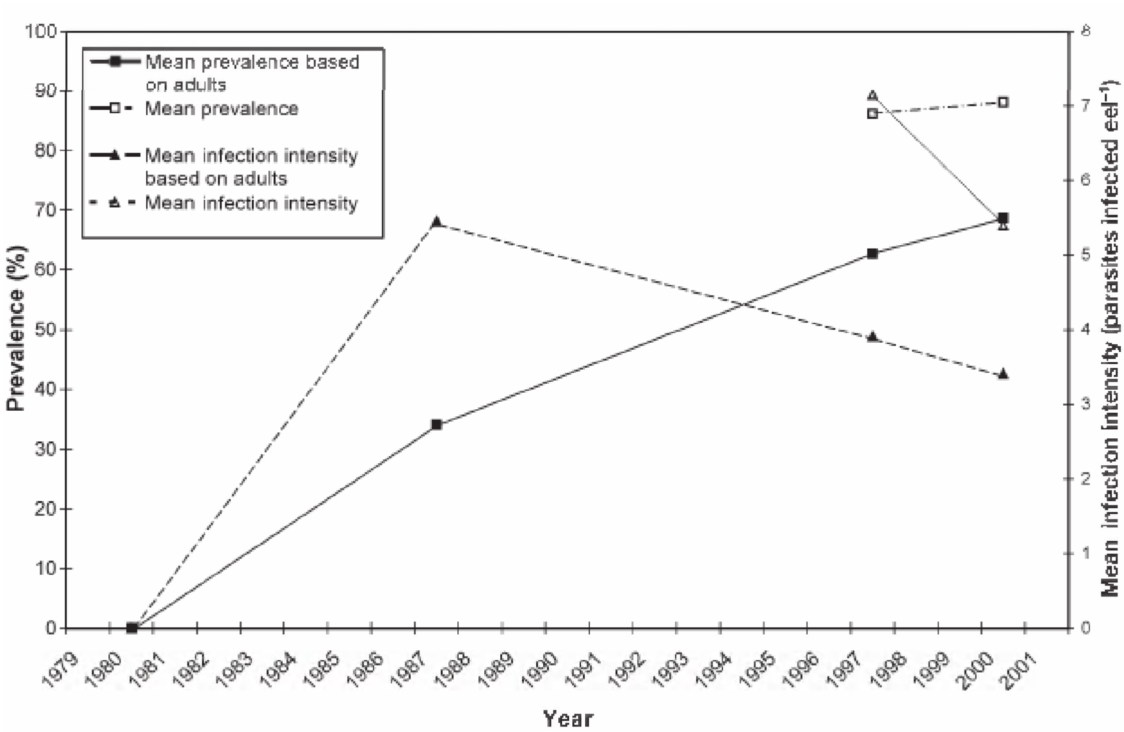


Figure BE.23. ***Anguilla anguilla*** **infected by** ***Anguillicola crassus.*** **Temporal pattern of parasite infection in Flanders between 1979 and 2001 (Audenaert** ***et al.*****, 2003)**

Growth rate

There is currently no general monitoring program for growth rates of eel. In the past studies haven been undertaken to follow growth of elvers stocked in ponds (Belpaire *et al.*, 1992). In 2001, a study has been set up to study and monitor growth of tagged eel in a Flandrian lake (Lake Weerde) over 5 years. Results are in process.

Contaminants in eel

Since 1994 the Research Institute for Nature and Forest (INBO) has built out a pollutant monitoring network for public water bodies in Flanders (Belgium) using eel (*Anguilla anguilla*) as a biomonitor. Eel is used for biomonitoring because it is a very fatty fish (strong lipophylic character of a.o. pesticides and PCBs), benthic and sedentary (during the yellow eel phase). Eels are long-living and widespread, occurring in very diverse habitats and even in polluted waters. Their position on the trophic ladder and the absence of an annual reproductive cycle, affecting lipid metabolism, are additional advantages for their use as a sentinel organism.

Contaminants analyzed were heavy metals, PCBs, organochlorine pesticides, brominated flame retardants, volatile organic compounds, and were reported at various occasions (Belpaire *et al.*, 2003, Goemans *et a*l., 2003, Goemans and Belpaire, 2004, Roose *et al.*, 2003, Morris *et al.*, 2004). At present the dataset included results from approximately 2000 individually analyzed eels originating from 325 different localities in Flanders.

The results have been communicated to national managers and especially the high PCB values measured in eels from most of the locations were very concerning. Hence, immediate action has been undertaken to protect the local fishermen's health. A catch and release obligation for every eel caught in Flanders was set by ministerial decree. In some eels PCB values as high as 7000 ng/g BW (measured as the sum of the 7 indicator PCBs) were measured, nearly exceeding the national PCB standard (75 ng/g BW) with a factor 100.

In Flanders there exists a clear spatial variation in contamination which can be linked to human interactions and/or land use. On some stations contamination levels are very high, given serious concern for eels health and reproduction success. The variation in contamination levels over the different stations are illustrated in figures BE.24–27 for respectively a heavy metal, a pesticide, PCBs and a brominated flame retardant.

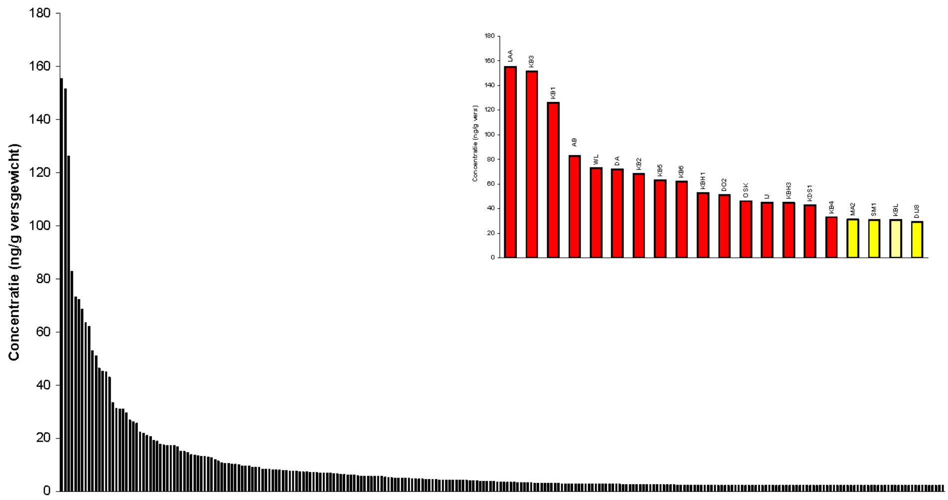


Figure BE.24. Mean cadmium concentrations in eels from Flanders (260 stations, 1994-2001) (Goemans *et al.*, 2003).

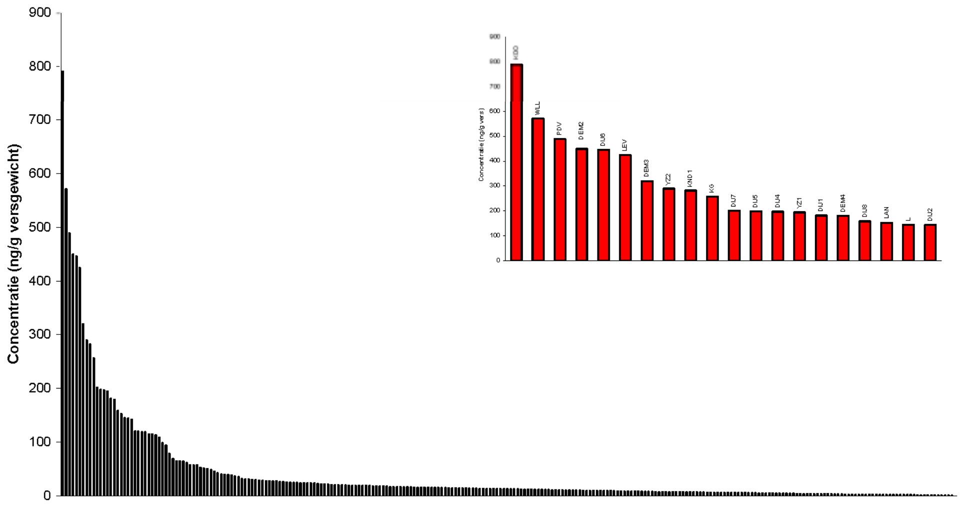


Figure BE.25. Mean lindane concentrations in eels from Flanders (260 stations, 1994-2001) (Goemans *et al.*, 2003)

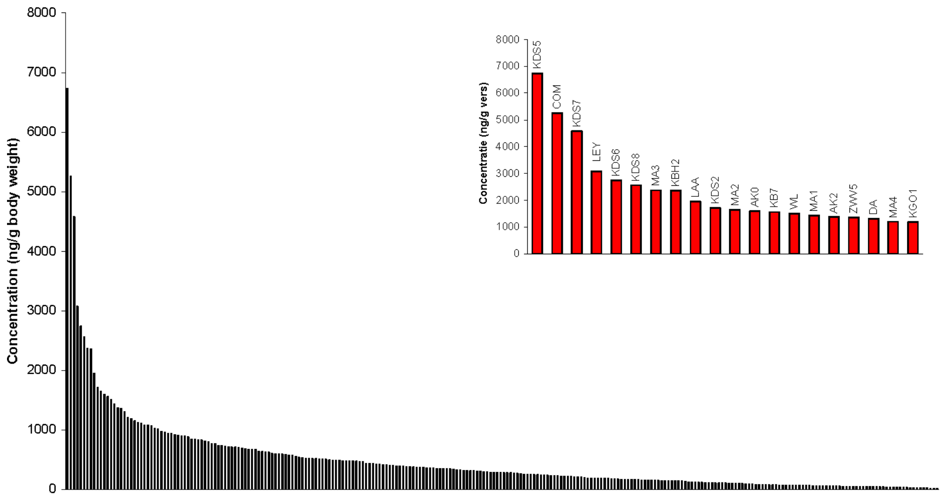


Figure BE.26. Mean PCB concentrations (ng/g body weight) in eels from Flanders (260 stations, 1994-2001). Belgian maximimu limit is 75 ng/g body weight. (Goemans *et al.*, 2003)

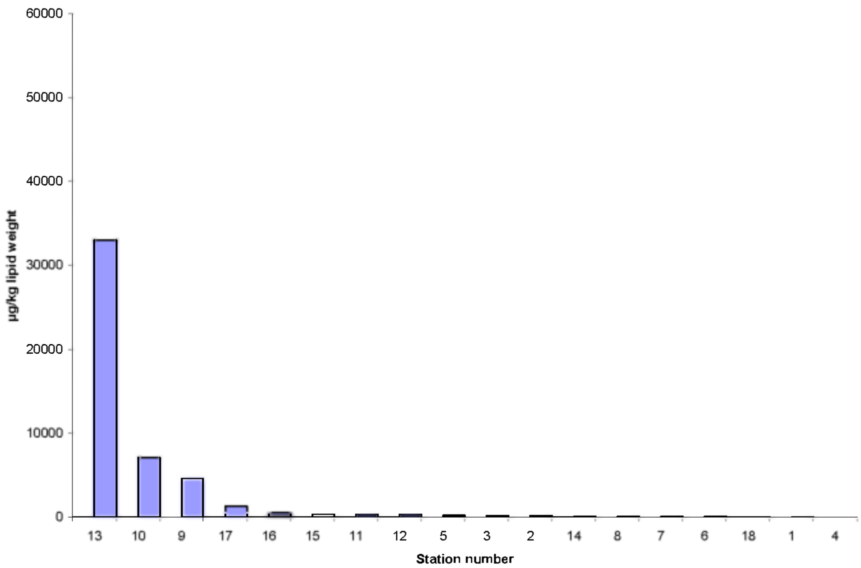


Figure BE.27. Mean HBCD (a brominated flame retardant) concentrations in eels from Flanders (18 stations, 2000) (Belpaire *et al.*, 2003).

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Report on the eel stock and fishery in the Republic of Ireland 2005

IR.A. Authors:

Dr. Russell Poole, Marine Institute, Furnace, Newport, Co. Mayo, Ireland.
Tel: 00-353-98-42300. FAX: 00-353-98-42340
russell.poole@marine.ie

Dr. T. Kieran McCarthy, Dept. of Zoology, National University of Ireland, Galway, Ireland.
Tel: 00-353-91-512008.
tk.mccarthy@nuigalway.ie

Reporting Period: This report was completed in December 2005, and contains data up to 2004 and some provisional data for 2005.

Contributors to the report:

Aidan Barry	South Western Regional Fisheries Board
John Conneely	North Western Regional Fisheries Board
Eamon Cusack	Shannon Regional Fisheries Board
Denis Doherty	Electricity Supply Board – Ballyshannon
Pat Doherty/Sean Murphy	Eastern Regional Fisheries Board
Greg Forde/Amanda Mooney	Western Regional Fisheries Board
Milton Matthews	Northern Regional Fisheries Board
Tom O'Brien	Electricity Supply Board – Parteen
Brian Sheerin	Southern Regional Fisheries Board
River Basin Districts Article 5 Characterisation Reports	

IR.B. Introduction

This report continues the sequence of reporting annual national eel data to the ICES/EIFAC Eel Working Group. In line with the requirements of the EU Eel Recovery Plan (Action Plan; COM 2003, 573: Regulation; COM (2005) 472) and the EU Data Collection Regulation for fisheries (Council Regulation 1543/2000 and Commission Regulations 1639/2001, 1581/2004) the National Eel Reports have now been restructured under the standard headings of the DCR. The EU has also recommended in the proposed regulation (COM (2005) 472) that Eel Management Plans be established and implemented on a Waterframework Directive River Basin District level and this report begins the process of reporting the data using this approach.

IR.B.1 The Irish National programme

The Irish National Programme will be conducted in close co-operation between the following organisations, although the details in relation eel and inland fisheries have yet to be established.

Department of Communications Marine and Natural Resources (DCMNR)

DCMNR is the main governmental department with responsibility for fisheries policy, management, control and enforcement.

The Marine Institute (MI)

The MI is a semi state marine research organisation charged by DCMNR with the collection of scientific data on the fisheries sector and the implementation of the module on evaluation of inputs, fishing capacities and fishing effort and the module of evaluation of catches and landings as defined in the Application regulation of EU Council Regulation 1543/2000.

An Bord Iascaigh Mhara (BIM – The Irish Sea Fisheries Board)

BIM is a semi state sea fisheries development agency charged by DCMNR with the collection of economic data on the marine fisheries sector.

The Central (CFB) and Regional Fisheries Boards (RFBs)

The CFB is a statutory body, established under the Fisheries Act 1980, operating under the aegis of the DCMNR. The principal functions of the CFB are to advise the DCMNR on policy relating to the conservation, protection, management, development and improvement of inland fisheries and sea angling, and to support, coordinate and provide specialist support services to the RFBs. The seven statutory RFBs are responsible for maintaining and improving environmental quality and developing and protecting the fisheries resource in their regions (Fig. IR.1). Eel fishing licences and authorizations are issued on a Regional basis.

Electricity Supply Board (ESB)

ESB has a statutory role in preserving and developing the Shannon fishery, since the establishment of a hydroelectric scheme on the river when the government handed over all fishing rights to the company in 1935.

IR.B.2 The Irish Eel Fishery

Glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173) and it's current government policy that fishing for juvenile eel may only be carried out under Section 18 authorisation from the Regional Fisheries Boards for the purposes of stock enhancement. Capture of juvenile eel for supply to eel farms or export requires a Section 14 Authorisation from the Dept. of Communications, Marine and Natural Resources. Capture of glass eel did not take place in Ireland until the 1990s. This is a tidal activity using a variety of techniques such as anchored nets (tela), fyke net, trawl and dip-net. Upstream migrating elver have been captured since 1959 under statute, for transfer upstream around barriers; first on the Shannon and more latterly on other rivers under the control of the Electricity Supply Board (ESB). This is usually carried out using fixed elver traps incorporating elevated ladders and collecting boxes. All juvenile eel captured are released upstream for enhancement. There is no National sampling programme for the glass eel/elver fishery.

The commercial eel fishery involves harvesting both brown and silver eel in freshwater and in estuarine or tidal waters. Brown eel are fished using a variety of techniques, the most common of which are baited long-line, fyke nets and baited pots. When silver eel are migrating downstream in the autumn they are caught in fyke nets and stocking-shaped nets called "coghill nets" which are attached to fixed structures in the river flow, often at "eel weirs".

The declared commercial eel catch in the Irish Republic, 2001–2002, was about 100t involving about 150–200 part-time fishermen (data from RFBs/MI), but inadequate reporting and illegal fishing makes this difficult to quantify accurately and maybe a substantial under estimate. The value of the reported catch in 2002 was therefore some €0.5 million. The declared commercial catch in 2004 was about 120t with a value of some €600k.

Recreational eel fishing is only carried out by a minority of anglers and there is no legal, or voluntary, declaration of catch which is probably small. Some "recreational" fishing using fyke and baited pots takes place and this is authorized under the commercial legislation.

Currently, there are no statutory instruments for the co-ordinated management of the European eel stock, it's exploitation or other impacts. Management of the Irish eel fishery is currently hampered by a number of factors, such as no national closed season, size limit, policy on estuarine and coastal fishing and a lack of sound scientific information on stock, catch returns or sales. There is no register of fishing effort, landings or sales and illegal fishing and unreported catches are believed to be considerable. The level of undeclared catch has not been recently quantified, but in some Regions this may be as much as three to four times the declared catch (McCarthy *et al.*, 1994).

IR.B.3 The Catchment Approach

In the Republic of Ireland, six main catchments, or groups of catchments, and one cross border catchment have been estimated to potentially produce at least 87% of the national eel production (Marine Institute, unpublished data). It is in these catchments, with the exception of the Laune, that the main fisheries are focussed. These catchments are:

- i) the Shannon system (Shannon RFB)
- ii) the Erne system (Cavan-Monaghan lakes -Northern RFB; Upr. & Lwr. L. Erne Dept. of Culture, Arts & Leisure, NI)
- iii) the greater Corrib system (Western RFB)
- iv) the Moy system (including L. Gill and Arrow) (North Western RFB)
- v) the Laune system, based on surface area (South Western RFB) – currently closed as a conservation area
- vi) the tidal areas of the Barrow/Nore/Suir (Southern RFB)
- vii) Wexford harbour, together with Loughs Ramor & Muckno in north of the region (Eastern RFB)

These top seven catchments fall within the relevant Regional Fisheries Board jurisdictions. This would allow for the Data Collection Regulation for Eel to be implemented at a regional and catchment level by the Fisheries Boards although, in the case of the Erne system, it will require continued close co-operation between agencies in the North and Republic of Ireland as instigated under the Erne Eel Enhancement Programme (1997–2001).

For the eel data collection programme to have any biological, or fisheries management, relevance it must be structured in order to take account of the differing characteristics of individual catchments, such as productivity, channel continuity, fishery type, and also the nuances of eel biology, such as timing of migrations, sex ratios, differences in growth rates etc.

The coast of Ireland is covered by ICES Areas VI & VII (Figure IR.2) which is in the single NE Atlantic category.

As mentioned previously, the EU has proposed (COM (2005) 472) that Eel Management Plans be established and implemented on a Waterframework Directive River Basin District level. The WFD subdivides the Republic of Ireland into four River Basin Districts and three International River Basin Districts (Data reported here is taken from the RBD Article 5 Characterisation Reports).

These are:

- a) the Neagh Bann IRBD. The Republic of Ireland (RoI) portion of the NBIRBD drains significant portions of Counties Louth and County Monaghan whilst counties Cavan and Meath have smaller drainage areas. The river basins located within the NBIRBD include the Lough Neagh/River Bann System with smaller river basins draining into Carlingford Lough and Dundalk Bay. There are 71 river water bodies in the RoI portion of the NBIRBD with a channel length of 414km. Approximately half of these are calcareous (or hard water) types covering a range of channel slope conditions. In addition, 74 cross-border river water bodies exist within the NBIRBD but these have not been characterized yet. There are 16 lake water bodies in the Republic of Ireland portion of the NBIRBD.

b) the Eastern RBD. The Eastern RBD drains to the Irish Sea and adjacent transitional and coastal waters. The surface area of the ERBD is approximately 6643 km^2, of which 94% comprises land surface water and 6% tidal waters. There are 16 distinct river catchments (with over 5600 km of river of which some 51% is first order stream), seven coastal and twelve transitional, of which three are typed as "lagoons". There are also seven reservoirs of area greater than 10 ha and two man-made canals with restricted access to the sea in the east and the R. Shannon in the west. The proportion of land area covered by lakes in the ERBD is 0.34%. There are only 20 natural lakes with an area greater than 10 ha and only six of these are greater than 50 ha.

c) the South Eastern RBD. The South Eastern River Basin District has a land area of over 12 700 km^2. The principal rivers are the Slaney River and three sister rivers which drain to Waterford Harbour i.e. the Barrow, Nore and the Suir Rivers. The Suir, Barrow, Nore river system is the second largest in the country (after the Shannon) with a combined catchment area of over 9000 km^2. There are relatively few lakes in the RBD with none over 50 ha. The South Eastern River Basin District also includes over 1200 km^2 of transitional and coastal waters.

d) the South Western RBD. The South Western RBD covers a total area of approximately 15 000 km^2 and with a coastline of over 1,800 km along the Atlantic Ocean and Celtic Sea. All river catchments have been subdivided into river water bodies based primarily on the geology and slope of the land over which they flow. The total length of river water channels within the SWRBD is approximately 3428 km. There are 20 lakes over 50 hectares, the largest of which are Lough Leane (1952 hectares) in County Kerry and Carrigadrohid (586 hectares) in County Cork. Estuaries (or transitional waters) are waters near river mouths which are saline, but which are influenced by fresh water flows. Coastal waters are surface in the area between the coast and one nautical mile (1852 metres) from the coast. 43 estuarine bodies and 27 coastal water bodies were identified in the SWRBD.

e) the Shannon IRBD. The ShIRBD is the largest river basin district in Ireland, comprising a land area of approximately 18 000 km^2 and includes an extensive area of central Ireland, from its source in County Cavan to the mouth of the Shannon Estuary. The Shannon River extends 250 km and discharges through an 83 km estuary. It drains an area of 11 700km^2 and includes some 41 000 ha of surface waters. Lakes greater than 100 ha in size make up some 90% of the total water surface area of the catchment and Loughs Derg, Ree and Allen are the principle lakes along the Shannon River. The Rivers Suck, Inny and Brosna are among the principle tributaries of the upper Shannon and the Rivers Fergus, Maigue, Deel and Mulkear are among the principle tributaries of the lower Shannon region.

f) the Western RBD. The Western RBD drains to the Atlantic Ocean, and adjacent transitional and coastal waters. It stretches from Co Clare in the south to Co Leitrim to the north, and extends out beyond the territorial limit into the Western Atlantic. The area extends over some 12 193 km^2. The coastline extends for some 2700 km. It comprises 89 river catchments with over 14 200 km of river. Of the 14 200 km of river some 52% are first order streams, the small streams draining land areas which feed into the larger river system. The major catchments include the Corrib, Moy, Ballysadare, Dunkellin and Bonet rivers. Smaller catchments drain directly in the coastal areas to the sea. The basin area is rich in lakes, the highest number of lakes in the country, with a total of 5638 lakes of which sixty nine are greater than 50 hectares. Only one percent of lakes are greater than 50 hectares in size, these include the Great Western lakes the Corrib, Mask, Conn and Cullen. Four percent are between 50 and 10 hectares, a further four percent between 10 and 5 hectares, fifteen percent between 5 and 1 hectare and seventy six percent are less than 1 hectare in size.

g) the <u>North Western</u> IRBD. The RoI portion of the NWIRBD drains all of County Donegal, significant portions of counties Cavan, Monaghan, and Leitrim, and smaller portions of Longford and Sligo. The main catchments within the NWIRBD include the cross-border Foyle and the Erne systems and the main lakes include Upper and Lower Lough Erne, Lough MacNean and Lough Melvin. There are 665 river water bodies in the RoI portion of the NWIRBD with an approximate channel length of 2350km. Approximately half of these are siliceous (or soft water) types covering a range of channel slope conditions. In addition, approximately 150 cross-border river water bodies exist within the NWIRBD. There are 227 lake water bodies greater than 50 ha in the RoI portion of the NWIRBD. There is one cross-border lake in the NWIRBD, which spans the Northern Ireland/Republic of Ireland border; Lough Melvin in County Leitrim (RoI) and County Fermanagh (NI). Typology information is available for 49 large lakes which places them into eight different types (mainly low and moderate alkalinity groups).

<u>NOTE</u>: Up to this, the collection of inland fisheries data has not be organised or presented under the WFD structure. In the following report, the national data will be sub-divided by RBD on a preliminary basis, but the catch will also be reported by Fisheries Region to allow comparisons. IRBD reports only include Rep. of Ireland data.

Figure IR.1. Map of Ireland showing the seven Regional Fisheries Boards and the 17 Fishery Districts (Source: CFB).

Figure IR.2. Map indicating ICES areas around Irish shorelines (Source: ICES).

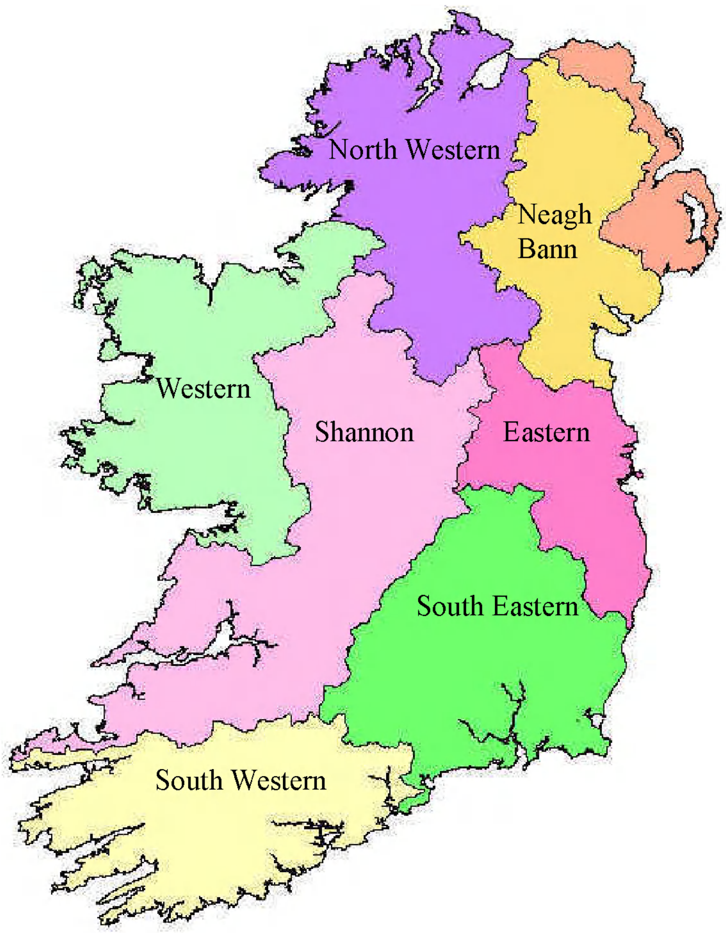

Figure IR. 3. Map showing the Waterframework River Basin Districts.

IR.C. Fishing capacity

IR.C.1 National Synopsis

There is no register of vessels, or even the number of individuals actively fishing. Table IR.1 gives the number of eel licences issued per Fishery Region in 2002 and Table IR.2 for 2004. Not all licences are actively fished and it is also not clear whether these licences target brown or silver eel. It is also difficult to ascertain the number of fishermen, or vessels, from the number of licences.

It was not possible to report the 2004 data by RBD.

IR.C.2 Neagh Bann IRBD

Data not accurate as it overlaps with Eastern and South Eastern RBD.

IR.C.3 Eastern RBD

Data not accurate as it overlaps with Neagh Bann IRBD and South Eastern RBD.

IR.C.4 South Eastern RBD

Data not accurate as it overlaps with Eastern and South Western RBD

IR.C.5 South Western RBD

Data not accurate as it overlaps with South Eastern RBD.

IR.C.6 Shannon IRBD

The ESB are issued a single licence for the R. Shannon for brown and silver eel and they have authorised crews who partake in the survey/fishery using long-line, fyke nets and coghill type nets (Tables IR.1 and 2).

The collection of glass eel, elver and other juvenile eels for lake-stocking is supervised by staff from the Shannon Regional Fishery Board and researchers from the National University of Ireland, Galway, and daily records are available.

Brown eel fishing involves authorized fishing crews, 2 persons per boat, entitled to use one or other of two methods (decided by fishery management, on biological advice); i.e. up to 50 fyke-nets or earthworm baited longlines, not exceeding 1000 hooks. Authorizations are issued by the ESB subject to weekly provision by crews of data on: Fishing locations, fishing effort, eel catch, by-catch and some environmental data (daily log-book records, analysed at end of season, and checked by fishery independent monitoring). At present no records of fuel consumption, other than by research crews, are maintained.

Silver eel fishing, at ESB eel weirs (coghill nets) and sites fished by authorized crews (cog-hill and fyke-nets) is also monitored by means of daily log-book records and fishery independent surveys. An annual, end of season report is compiled.

IR.C.7 Western RBD

Licences issued include those from the Western and North Western Regional Fisheries Boards in Tables IR. 1 and 2). Seventy two licences were issued in 2004.

IR.C.8 North Western IRBD

Thirty seven licences were issued by the NRFB in the North Western IRBD.

Table IR.1. Number of licences/authorisations issued in each Fishery Region in 2002.

Fishery Region	Type	Number	Comment
Eastern	Longline	7	
	Fyke	18	
	Coghill	9	
Southern	Fyke	5	140 nets
	Pots	26	442 pots
	Coghill	2	
South Western	Longline	3	not fished
	Fyke/Pot	6	
Shannon	Longline	8	capped @ 10
	Longline	12	by ESB
	Fyke	8	
	Fyke	19	by ESB
	Coghill	6	
	Coghill	20 max	by ESB @ Killaloe
	Coghill	2	by ESB @ Clonlara
	Coghill	17	by ESB, 1 net to each fisherman
Western	Longline	1	
	Fyke	20	2 are for tot 60 nets x 1m high
	Trap	1	
	Coghill	27	
North Western	Longline	26	or fyke option
	Coghill	2	on trial basis
Northern	Longline	29	Republic capped @ 32
	Longline	20	On Erne in North
	Fyke	13	20 nets/licence
	Total	307	

Table IR.2. Number of licences/authorisations issued in each Fishery Region in 2004.

Fishery Region	Type	Number	Comment
Eastern	Longline	4	
	Fyke	16	
	Coghill	7	
	Traps	3	
Southern	Fyke	4	100 nets
	Pots	21	354 pots
	Coghill	2	
South Western	Fyke/Pot	3	total of 80 nets
		6	
Shannon	Longline	8	capped @ 10
	Longline	15	by ESB
	Fyke	8*	
	Fyke	15	by ESB
	Coghill	6*	
	Coghill	20 max	by ESB @ Killaloe
	Coghill	21	by ESB, 1 net to each fisherman
Western	Longline	1	
	Fyke	20	2 are for tot 60 nets x 1m high
	Trap	1	
	Gap, Eye, Net	27	inc. 14 nets in Galway
North Western	Longline	16	or fyke option
	Fyke	5	
	Coghill	2	on trial basis
Northern	Longline	24	Republic capped @ 32
	Fyke	13	20 nets/licence
	Total	262	

* not verified for 2004

IR.D. Fishing effort

IR.D.1 National Synopsis

DCR Requirement for Eel, specific effort must reach Threshold 1 - 30% of the catch in a day

No data available.

Fishing effort is not generally monitored in the Irish eel fishery. There is no log-book or recording system for fishermen and there is no eel dealer register or regular monitoring of eel dealers. There is also no registration of fishing boats in the eel fishery.

The Management of Eel Fishing Bye-Law No.752, 1998 capped the number of long-line licenses that a Regional Fisheries Board may issue for long-line fishing for eels in any district. In addition, the Fisheries (Amendment) Act 1999 delegated authority to the Regional Fisheries Boards to issue authorisations for the use any fishing engine for the capture of eels including any long-line, as it sees fit.

IR.D.2 Neagh Bann IRBD

No data.

IR.D.3 Eastern RBD

No data.

IR.D.4 South Eastern RBD

No data.

IR.D.5 South Western RBD

No data.

IR.D.6 Shannon IRBD

Authorizations for brown eel fishing, issued by the ESB, are subject to weekly provision by crews of data on : Fishing locations, fishing effort, catch , and gear type.

Silver eel fishing at ESB eel weirs (coghill nets) and sites fished by authorized crews (coghill and fyke-nets) is also monitored by means of daily log-book records and fishery independent surveys.

IR.D.7 Western RBD

No data.

IR.D.8 North Western IRBD

No data.

IR.E. Catches and Landings:

As stated in Section IR.B, Ireland falls entirely into the NE Atlantic Area, VI and VII. Landings data are required separately for glass eel, brown eel and silver eel, by Quarter, by Gear Type for the Minimum Programme, and Monthly by ICES Statistical Rectangle (catchment for eel) by Gear Type.

One of the main components of the Eel Recovery Plan is the development of Eel Management Plans for each River Basin District. To facilitate proper implementation and monitoring of each plan, landings data will need to be reported for each River Basin District, and, if possible, at the individual catchment level.

IR.E.1 Catch of Glass Eel/Elver

There is no authorised commercial catch of juvenile eel in Ireland. Catches are made at impassable barriers and this is reported in Section IR.G.2.

IR.E.2 Restocking

All of the catches reported in Section IR.G.2 are used for restocking, primarily in the Erne and Shannon catchments.

IR.E.3 Catch of brown and silver eel – National Synopsis

There is no compulsory declaration of eel catch in Ireland and in many Regions, declarations of catches are not complete and under-reporting is probably widespread.

Currently, reported catches are only available on an annual basis at the Fisheries Regional Level, with some RFBs reporting on a District basis (Tables IR. 3 and 4). With the possible exception of the R. Shannon, and some silver eel fisheries, information on catches in individual catchments is generally inaccurate or unavailable. The estimated reported catches for 2004 are also shown for each River Basin District in Table IR.5.

Since 2001 the ESB has embarked on a programme of transporting a proportion of the silver eels captured in the Shannon silver eel fishery around the dams and releasing them for onward migration to the sea (Table IR.4). The eels released below the hydropower facilities are broadly representative of the overall catch in terms of sizes.

Catch data are not generally available on a quarterly basis, or by gear type.

On the Shannon the brown eel fishing season is restricted to mid-June to early September and the silver eel season is from September to mid-January. Good catches were made late in the season, probably due to increase in water level.

On the Galway Weir Silver Eel fishery, fishing commenced on 6th October and finished on 20th December, 2004. The fishery may have missed a proportion of catch by not fishing in September.

The Burrishoole silver eel migration extended from late June '04 to January '05 with 34% of the run in September, 38% in October and 20% in November.

Table IR.3. Declared Regional catches (t) of brown eel for 2001-2004.

Fishery Region	2001	2002	2003	2004
Eastern	14.0	16.0	10.7	9.0
Southern	8.5	4.8	4.7	3.6
South Western	0.6	1.0	0.1	0.1
Shannon	16.1	15.8	21.9	21.5
Western	8.9	3.9	12.4	9.8
North Western	13.9	11.0	12.5	12.1
Northern	4.7	8.9	-	4.5
Total	66.7	61.4	62.3	60.6

Table IR.4. Declared Regional catches (t) of silver eel for 2001–2004. * total catch including a proportion released below hydroelectric dam, ** amount released & (% of catch).

Fishery Region	2001	2002	2003	2004
Eastern	2.5	4.3	3.2	2.7
Southern	-	0.1	-	0.2
South Western	0.0	0.0	0.0	0.0
Shannon *	24.1	25.3	17.1	37.1
Shannon Released **	1.3 (5%)	3.9 (15%)	1.6 (9%)	2.9 (8%)
Western	9.4	13.0	10.6	13.9
North Western	1.4	1.2	2.0	4.0
Northern	0.1	0.1	-	-
Total	37.5	44.0	32.9	57.9

Table IR.5. Estimated catches (t) for River Basin Districts of brown and silver eel for 2004. * total catch including a proportion released below hydroelectric dam, ** amount released & (% of catch).

River Basin District	Brown	Silver
Neagh Bann	0.5	0.7
Eastern	4.9	1.0
South Eastern	7.2	1.2
South Western	0.1	0
Shannon *	21.5	37.1*
Shannon Released **		2.9 (8%)**
Western	21.9	17.9
North Western	4.5	0
Total	60.6	57.9

IR.E.4 Neagh Bann IRBD

Reported catch for Neagh Bann '04 was 0.5t of brown and 0.7t of silver.

IR.E.5 Eastern RBD

Reported catch for Eastern '04 was 4.9t of brown and 1.0t of silver.

IR.E.6 South Eastern RBD

Reported catch for South Eastern '04 was 7.2t of brown and 1.2t of silver. The brown eel catch was predominantly taken in tidal waters. This RBD represents that largest tidal eel fishery in Ireland.

IR.E.7 South Western RBD

Reported catch for South West '04 was 0.1t of brown. The catch was confined to the lower reaches of the R. Lee. No silvers were caught.

IR.E.8 Shannon IRBD

Reported catch for Shannon '04 was 21.5t of brown and 37.1t of silver of which 2.9t was released below the last barrier. The Shannon RBD reported catch came from the R. Shannon catchment and no catches were reported from other rivers in the RBD.

Shannon Catchment. The annual downriver migrations of silver eels have traditionally been exploited in the River Shannon and the three commercial eel weirs, owned by ESB since 1937, have continued this practice with varying success (Figure IR.4). In many respects the overall pattern of change, with steadily declining silver eel catches at Killaloe/Clonlara, but relatively steady catches at Athlone, mirrors the results obtained by monitoring the Lough Derg fyke net CPUE brown eel catches versus those in upper catchment lakes.

The silver eel catch in 2004/05 in Killaloe was 5.02 t and upstream of Killaloe it was 32.09 t, giving a total silver eel catch for the river of 37.12 t. This was more than double the catch recorded in 2003/04.

IR.E.9 Western RBD

Reported catch for Western '04 was 21.9 t of brown and 17. 9t of silver.

Corrib Catchment. The Galway Fishery comprises a weir with 14 coghill nets. These are fished throughout the dark moon phases and may be lifted during periods of very high water. The fishery was purchased by the state in 1978 and has been fished consistently since then. Fishing effort may have increased in later years. The downward trend in silver eel catch (Fig. IR.5) therefore probably reflects the decreasing stock in the greater Corrib catchment and falling silver eel escapement. The catch in 2004 was 5.83t.

Burrishoole Catchment. The Burrishoole System in the West of Ireland is a relatively oligotrophic river and lake system with a catchment area of 8949 ha. The eel population is unexploited and the total freshwater silver eel production is trapped in downstream Wolf type traps. The silver eel catch is not included in the National commercial catch as the entire catch is released downstream. The Burrishoole silver eel migration is equivalent to approximately 1% of the National silver catch, by weight, but is indicative of eel production from a considerable number of low productivity Irish river systems where eel densities are relatively low and growth rates are slow, often <2 cm.yr^{-1}.

Catches of silver eel between the years 1971 (when records began) and 1982 averaged 4400 individuals, fell to 2,200 between 1983 and 1989 and increased again to above 3000 in the '90s (Figure IR.6). There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The catch in 2001 of 3875 eel was the second highest recorded since 1982. The catch in 2005 was 2590 individual eels.

IR.E.10 North Western IRBD

Reported catch for North Western '04 was 4.5t of brown eel, largely from the Erne System, and no reported catch of silver eel.

IR.E.11 Recreational Fisheries

Recreational eel rod catches were not recorded in '04, but these were thought to be relatively low. Recreational net and trap eel catches were low and were included in the commercial catch returns.

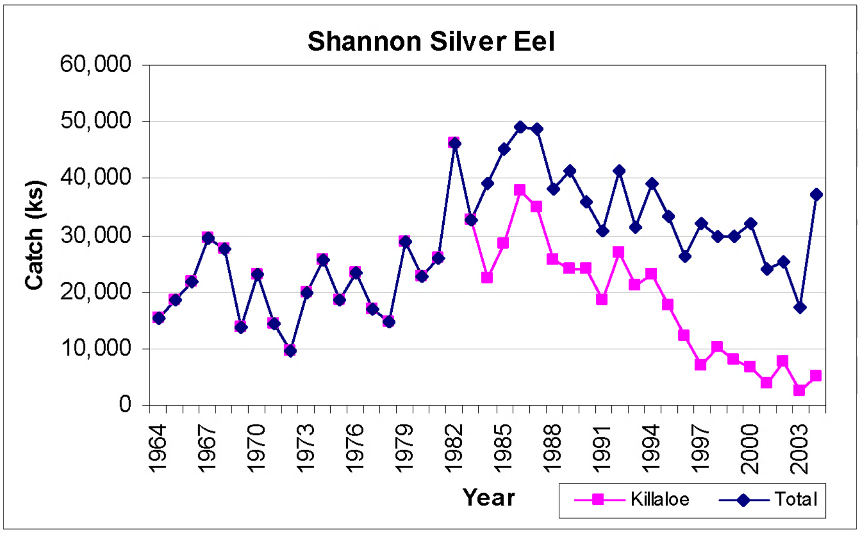

Figure IR.4. Silver eel catches from the Killaloe eel weir and the Shannon system (1964 to date).

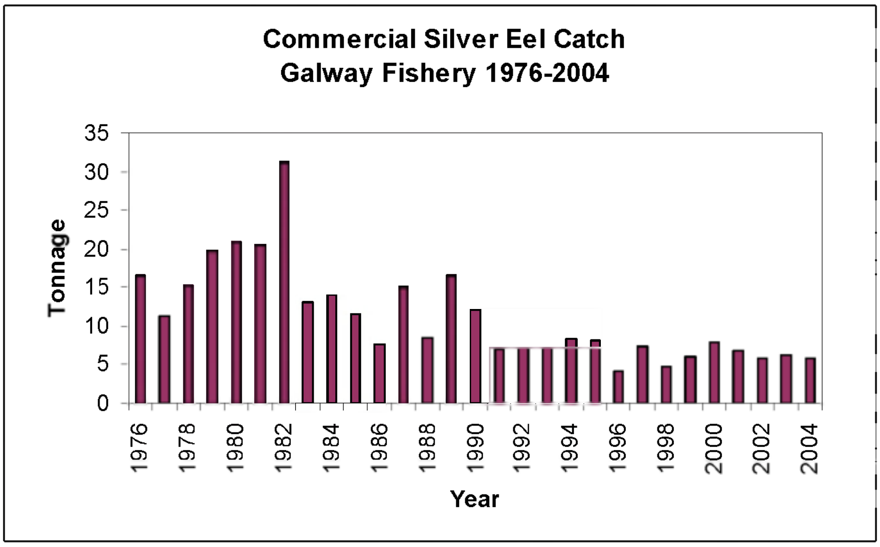

Figure IR.5. Annual silver eel catch (t) in the commercial Galway Fishery, Corrib System, for 1976 to 2004.

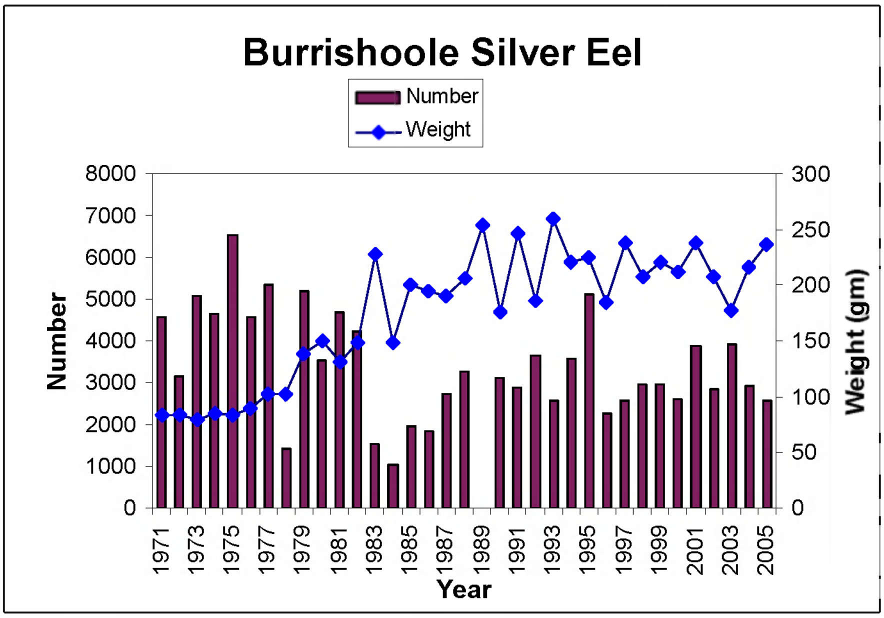

Figure IR.6. Annual silver eel catch, and mean weight (gm) in the Burrishoole System for 1971 to 2005.

IR.F. Catch per Unit of Effort:

IR.F.1 National Synopsis

Given the lack of log books or fishery register there is little CPUE information available for Irish eel fisheries. Some data is available from selected individuals, fisheries or research teams and these are summarised here.

IR.F.2 Neagh Bann IRBD

No data.

IR.F.3 Eastern RBD

No data.

IR.F.4 South Eastern RBD

No data.

IR.F.5 South Western RBD

No data.

IR.F.6 Shannon IRBD

Shannon – brown eel

Since 1992 fishery and fishery-independent records of brown eel catches are used, as total catch and CPUE, to monitor stocks at fishing zone (single crew), lake and river catchment levels. These data represent both fyke-net and long-line survey results. The overall trend, as reflected by analyses of monitored long-line surveys through out the fishery, is illustrated in Figure IR.7. Comparative studies, same night/same zone, and research crew/authorized crew, were undertaken in recent years as part of a Ph.D study and in 1992–4.

Shannon – Silver eel

As the fishing effort at Killaloe, Shannon, is similar between years, this means that the catch presented in Figure IR.4 is relatively independent of effort and reflects a CPUE time series of silver eels catches.

IR.F.7 Western RBD

Burrishoole – Brown eel

There is no commercial fishing for brown eel in Burrishoole. A series of research fishings using standard summer fyke nets has been carried out (Table IR.6). There would appear to be little overall change in the CPUE over time. The CPUE of 0.2 in L. Furnace in June 2005 should be noted. A severe toxic algal bloom, *Prorocentrum balticum/minimum* – an estuarine and coastal species, was recorded in August/September 2003 and this may have caused mortalities of eel in the lake. Dead eels were observed in fyke net catches in late 2003. However, good catches were again recorded in August 2005.

Burrishoole – Silver eel

As the trapping effort in the Burrishoole is total (+10% estimated) and continual, this means that the catch presented in Figure IR.6 is independent of effort and reflects the total migration of silver eels from the freshwater catchment. As the catchment stock is not exploited, the silver eel migration is the total spawning escapement from Burrishoole.

IR.F.8 North Western IRBD

Erne – Brown eel

CPUE data are not generally available from the Erne and there were none for 2004.

Extracted from: Matthews *et al.* (2001). An extensive fyke net survey of the brown eel stocks of the Erne lakes was carried out from May to September 1998–2000 employing up to six two-man crews stationed throughout the system. Catch data from over 56 700 net-nights was compiled.

Highest catches were obtained from Upper and Lower L. Erne in the lower reaches of the catchment where the greater part of commercial fishing takes place. Catch Per Unit Effort (CPUE) ranged from 30–45 eels weighing 4.5–8.5 kg per 10 nets per night.

In contrast, numbers from the upper reaches of the catchment were lower (4–15 eels or 1.3–4.2 kg per 10 nets per night).

Evidence for local depletion of eel stocks through commercial fishing was apparent, particularly in the Narrows, Lower L. Erne, where CPUE fell progressively from 4.9 to 2.4kg per 10 nets per night over the three years of the study.

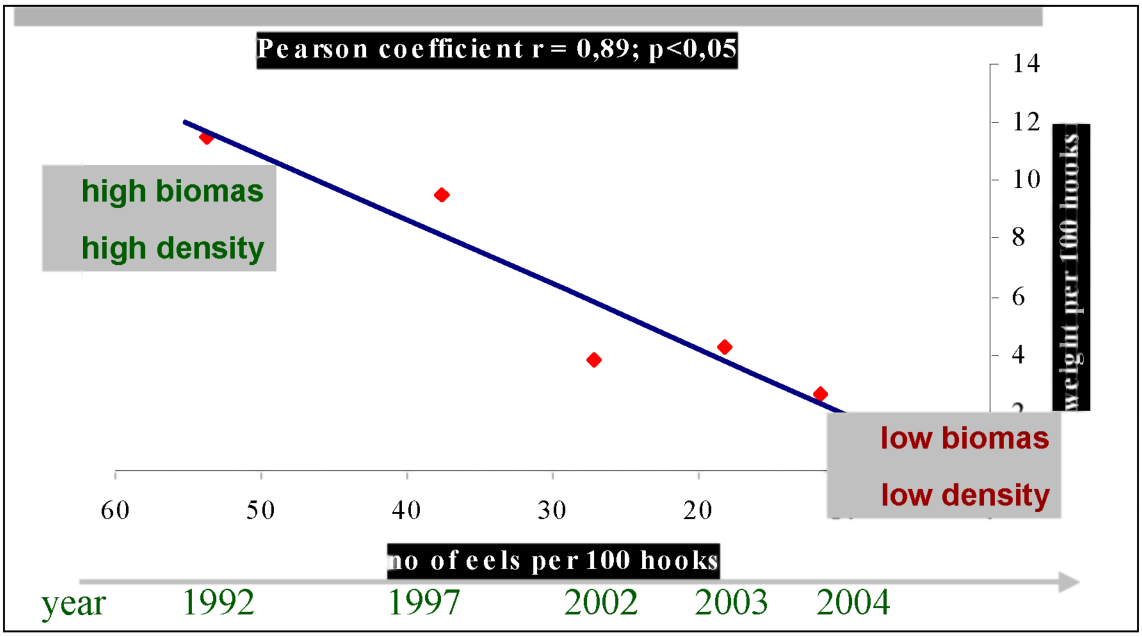

Figure IR.7. Changes in River Shannon CPUE (numbers, biomass) for eel populations, as indicated by results of monitored long-line fishing surveys (1992–2004).

Table IR. 6. Summary 'summer' fyke net catch (number of eels), effort (per net – pair of trap ends) and CPUE (number of eels per net per night) for the Burrishoole system.

LAKE	DATE	EFFORT	CATCH	CPUE
		Nets x nights		Catch/net/night
Bunaveela	April-Sept 1987	80	113	1.4
	May-Sept 1988	250	171	0.7
	May-Aug 2001	120	126	1.1
	Jun-05	30	43	1.4
Feeagh	Jun-73	100	23	0.2
	May-Sept 1987	240	399	1.7
	May-Sept 1988	380	501	1.3
	Jun-Aug 2001	120	249	2.1
	Jun-05	60	103	1.7
Furnace	May-Sept 1987	320	1558	4.9
	April-Sept 1988	330	1056	3.2
	Jun-Aug 2001	120	614	5.1
	Jul-03	40	107	2.7
	Jun-05	58	12	0.2
	Aug-05	20	90	4.5
Furnace Lwr	July-Sept 1987	60	803	13.4
	May-Sept 1988	60	532	8.9
	Jun-Aug 2001	40	329	8.2

IR.G. Scientific surveys of the stock:

IR.G.1 National Synopsis

There are no national surveys of eel currently taking place – these are not specifically required for eel by the DCR. A small number of research programmes are ongoing and data have been incorporated into the relevant sections of this report. Probably the most important datasets are the recruitment index data for the Shannon and Erne and the long-term silver eel datasets for the Shannon, Corrib and Burrishoole (presented elsewhere in this report).

Since 1992 there has been a comprehensive series of stock assessment surveys and sampling of the River Shannon eel fishery. This Shannon Eel Management Programme has included an extension of the brown and silver eel fishing, the experimental development of glass eel fishing and the improvement of the elver trapping. The focus of the River Shannon study undertaken by NUIG was changed in 2005 and much effort has been devoted to evaluation of alternative sampling protocols. This was done with a view to getting more accurate estimations of brown eel densities in lakes and to establishing the quantity, and quality, of silver eels migrating from selected lakes and through the lower section of the river system.

IR.G.2 Recruitment surveys – glass eel.

Monitoring of elver migrating at Ardnacrusha (Shannon), Cathleens Falls (Erne) and for the Feale, Inagh and Maigue Rivers and monitoring of bootlace eel migrating at Parteen Dam (Shannon). Monitoring is carried out at six fixed stations by the ESB and fishing is also undertaken by the ESB/Shannon Regional Fisheries Board in the Shannon Estuary for glass eels (Table IR.7). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded and while there is no effort data available, the total catch for all stations in 2004 was the lowest yet recorded (Table IR.7). Elver and bootlace catches in 2005 were much more unpredictable, with good catches of elvers recorded in the Erne (45% of the 1979–84 mean) and a poor catch in Ardnacrusha (1.4% of the 1979–'84 mean). The bootlace catch in Parteen was relatively good, almost equally the mean (641 kg) for the last 20 years. Figure IR.8 presents the historical elver monitoring for the Erne and the Shannon (Ardnacrusha).

All catches reported in Table IR.7 are transported upstream and used in restocking.

IR.G.3 Adult Eel surveys

There were no co-ordinated national surveys carried out in 2004 or 2005. A number of surveys were undertaken by the National University of Ireland Galway and the Electricity Supply Board, the Marine Institute and Trinity College Dublin and the Central Fisheries Board in the NSSHARE project. The majority of these are projects in progress, but will yield data compatible with Eel Management Plans and the DCR. Table IR.8 details the locations sampled.

Table IR.7. Glass eel, elver and bootlace (Parteen) catches (kg), 1985 to 2005 (nf = not fished).

		Erne	Moy	Shannon	Shannon				Sh. Estuary
Year	Erne	Estuary	Estuary	Ardnacrusha	Parteen	R Feale	R Maigue	Inagh R	Glass Eels
1985	400			1093	984	503			
1986	700			948	1555				
1987	2300			1610	984				
1988	3000			145	1265				
1989	1800			27	581				
1990	2400			467	970				
1991	500			90	372				
1992	1400			32	464				
1993	1700			24	602				
1994	4400			287	125	70	14		
1995	2100			398	799	0	194		
1996	647			332	95	0	34	140	
1997	1087			2120	906	407	467	188	616
1998	723	46		275	255	81	8	11	484
1999	1246	441		18	701	135	0	0	416
2000	1074	188		39	389	174	0	120	43
2001	699	nf	13	27	3	58	2	18	1
2002	113	nf	21	178	677	116	5	nf	37
2003	580	nf	36	378	873	36	72	111	147
2004	269	nf	0	58	256	0	0	24	1
2005	836	nf	13.5	41	612	0	1	0	41

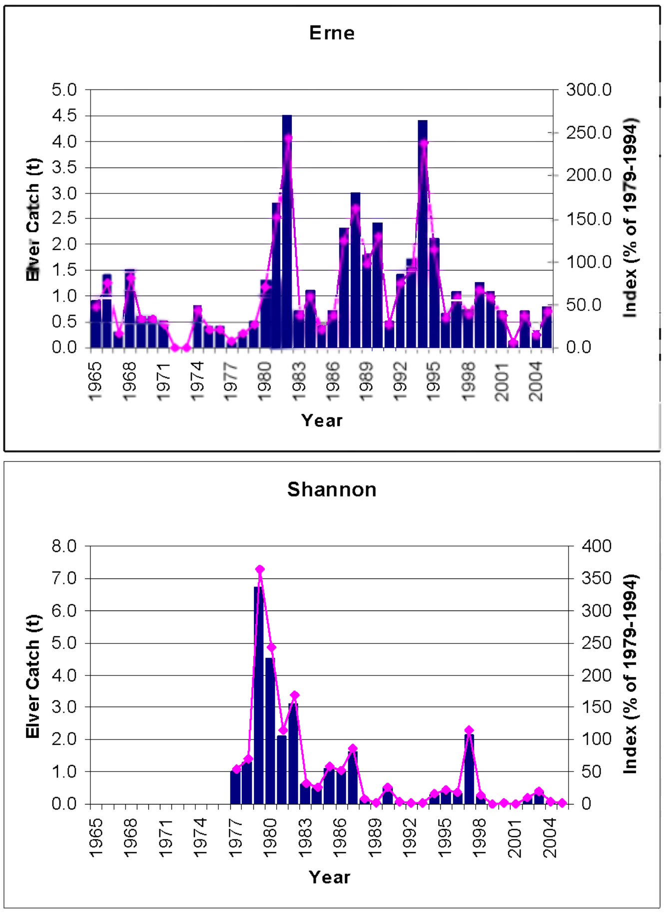

Figure IR.8. Historical data for catches of elvers at Cathleen's Falls on the Erne and Ardnacrusha on the Shannon.

Table IR.8. Summary details of the numbers of locations sampled in 2004 and 2005, and the numbers of eels sampled for length, weight, age and other elements, such as contamination and parasites.

CATCHMENT	NO. OF	RBD	LIFE STAGE	CAPTURE	NO. OF	NO. OF	LENGTH	WEIGHT	AGE	OTHER	SOURCE
	Sites			**Method**	**Samples**	**Fish**	**(n)**	**(n)**	**(n)**	**(n)**	
2004											
Burrishoole	1	WRBD	Silver	Perm Trap	3	382	382	144	0	0	MI
Owenduff	8	WRBD	Yellow	Electro	8	99	99	0	0	0	MI/RFB
Durnish L.	1	NWIRBD	Yellow	Fyke	1	150	150	150	150	Parasitology	NUIG
L Ahalia	4	WRBD	Yellow	Fyke	4	200	200	200	200	Various	NUIG
Shannon	19	ShIRFB	Yellow	Longline	19	2403	2136	870	127*	0	NUIG
Shannon	16	ShIRFB	Yellow	Fyke	16	799	799	289	0	0	NUIG
Shannon	9	ShIRFB	Silver	Coghill net	23	2158	2158	872	280*	0	NUIG
2005											
Burrishoole	1	WRBD	Silver	Perm Trap	5	586	586	580	122	Contam (10)	MI
Burrishoole	3 lks (15)	WRBD	Yellow	Fyke	20	249	249	179	0	Contam (10)	MI
Fane	1	NBIRBD	Silver	Catch	1	200	200	100	100	Contam (10)	MI/TCD
Moy/Conn	1	WRBD	Silver	Catch	1	200	200	100	100	Contam (10)	MI/TCD
Corrib/Galway	1	WRBD	Silver	Catch	1	314	314	100	100	Contam (10)	MI/TCD
Waterford	1	SERBD	Yellow	Catch	1	200	200	100	100	Contam (10)	MI/TCD
Lady's Island Lake	1	SERBD	Yellow	Fyke	1	200+	200+	200+	200+	Par/Contam	NUIG
Maigue River	1	SRFB	elver	Traps/electro	10	350	350	90	0	0	NUIG
Shannon Parteen	1	SRFB	elver-yellow	Traps	4	312	312	198	86*	0	NUIG
Mulcair River	11	SRFB	elver-yellow	Electro	11	239	239	239	0	0	NUIG
Shannon R (lwr)	13	SRFB	elver-yellow	Electro	13	528	528	148	0	0	NUIG
Castelconnel	1	SRFB	elver-yellow	Electro	3	217	217	217	0	0	NUIG
Shannon R (lwr)	3	SRFB	elver-yellow	Electro	7	551	551	65	0	0	NUIG
Shannon	12	SRFB	yellow	Fyke	15	978	978	268	0	Contam	NUIG
Shannon	12	SRFB	yellow	Longline	24	3447	3447	1120	210*	Contam	NUIG
Shannon	8	SRFB	silver	Coghill net	11	1980	1980	821	112*	Contam	NUIG
Akibbon	1	NWIRBD	Yellow	Fyke	?	7	7	7			CFB NSSHARE
Altan	1	NWIRBD	Yellow	Fyke	?	4	4	2			CFB NSSHARE
Auva	1	NWIRBD	Yellow	Fyke	?	9	9	9			CFB NSSHARE
Avehy	1	NWIRBD	Yellow	Fyke	?	2	2	2			CFB NSSHARE
Lough Barra	1	NWIRBD	Yellow	Fyke	?	15	15	15			CFB NSSHARE

Table IR.8 cont.. Summary details of the numbers of locations sampled in 2004 and 2005, and the numbers of eels sampled for length, weight, age and other elements, such as contamination and parasites.

BAWN LOUGH	1	NWIRBD	YELLOW	FYKE	?	1	1	1			CFB NSSHARE
Bunerky	1	NWIRBD	Yellow	Fyke	?	1	0	0			CFB NSSHARE
Corglass	1	NWIRBD	Yellow	Fyke	?	8	8	8			CFB NSSHARE
Deralk	1	NWIRBD	Yellow	Fyke	?	1	1	0			CFB NSSHARE
Derg	1	NWIRBD	Yellow	Fyke	14	33	33	33			CFB NSSHARE
Derrybrick	1	NWIRBD	Yellow	Fyke	?	1	1	1			CFB NSSHARE
Dunlewy	1	NWIRBD	Yellow	Fyke	?	5	5	5			CFB NSSHARE
Fad (west)	1	NWIRBD	Yellow	Fyke	?	10	10	10			CFB NSSHARE
Gartan	1	NWIRBD	Yellow	Fyke	?	29	29	29			CFB NSSHARE
Golagh	1	NWIRBD	Yellow	Fyke	?	3	3	3			CFB NSSHARE
Kiltooris	1	NWIRBD	Yellow	Fyke	?	10	10	10			CFB NSSHARE
Kiltyfanad	1	NWIRBD	Yellow	Fyke	?	15	15	15			CFB NSSHARE
Lee	1	NWIRBD	Yellow	Fyke	8	8	8	8			CFB NSSHARE
Meela	1	NWIRBD	Yellow	Fyke	?	192	192	93			CFB NSSHARE
Melvin	1	NWIRBD	Yellow	Fyke	?	123	123	106			CFB NSSHARE
Nalughraman	1	NWIRBD	Yellow	Fyke	1	1	1	1			CFB NSSHARE
New lake	1	NWIRBD	Yellow	Fyke	25	140	140	140			CFB NSSHARE
Lough Ross	1	NBIRBD	Yellow	Fyke	11	12	12	12			CFB NSSHARE
Town lake	1	NWIRBD	Yellow	Fyke	?	1	1	1			CFB NSSHARE
Veagh	1	NWIRBD	Yellow	Fyke	?	7	7	7			CFB NSSHARE
Vearty	1	NWIRBD	Yellow	Fyke	4	4	4	4			CFB NSSHARE

IR.H. Catch composition by age and length:

IR.H.1 National Synopsis

There is no national sampling programme for age and length of commercial eel catch in Ireland.

IR.H.2 Shannon Catchment Programme (Shannon IRBD)

Length measurements are taken annually (see Table IR.8).

IR.H.2.1 Shannon - Brown Eel

Annual surveys undertaken by National University of Ireland, Galway, (1992 to date) involve measurement of sub-sampled catches of authorized fishing crews, representative of all major lakes in the catchment, and the length frequency distributions are statistically analysed at lake and total fishery levels. Total length data typically involve over 2000 eels per year, and further data are available from fishery independent and research sampling. Weight and age data, which vary in numbers from year to year, are available for selected zones. Changes in population demography have been recorded. These are mostly due to poor recruitment but the overall size frequencies are mostly determined by fishing gear selectivity (i.e. fyke-net mesh size, long-line bait/hook size).

IR.H.2 .2 Shannon - Silver Eel

Annual surveys, by NUIG (1992 to date), at ESB fishing weirs and of authorized fishing crew catches provide length data for a series of sites located through out the river system. Annual length measurements involve 1500–2000 eels. Sub-samples are used for calculation of length/weight relationships and 200–250 are used for age determinations. Sex ratio changes, reflected in length, weight and age data have been detected. A recent increase in the percentage of males at Killaloe represents a reversal of a trend noted since around 1985, seems to be due to changes in fishing intensities in upper versus lower catchment and selective stocking of the lower part of the catchment.

IR.H.3 Burrishoole Catchment (Western RBD) – Silver

Monitoring of length of silver eel in the Burrishoole has taken place since 1958, with total trapping since 1970 (Poole *et al.*, 1990). Table IR.9 gives the length and weight data since 1987 for both the total annual run, and where available for the separate sexes. Age data is presented in Table IR.10. The silver eel lengths clearly fit into a bimodal distribution consistent with males and females (Figures IR.9 and 10). There is a normal distribution of females between 40 and 60 cm with a small proportion of longer females up to 100 cm. Burrishoole eels are generally considered relatively old and slow growing, typical of oligotrophic Irish waters. Growth rates in the more productive waters in Ireland are generally faster than in Burrishoole.

Table IR.9. Length and weight for migrating silver eel, Burrishoole. St Er given in brackets.

Year	Sample Type	Sample Size (Lt)	Mean Length (cm)	Min/Max Length	Sample Size (Wt)	Mean Weight (g)	Min/Max Weight (g)
1987	Total	849	44.5 (0.26)	29.7-98.8	849	190.5 (4.6)	48-2523
1988	Total	3003	45.6 (0.14)	28.9-92.9	2996	205.9 (2.3)	37-2240
	Male	1120	37.3 (0.10)	28.9-46.0	1116	97.7 (0.93)	37-210
	Female	1883	50.5 (0.11)	40.5-92.9	1880	270.2 (2.7)	90-2240
1995	Total	1547	46.4 (0.22)	29.1-100.0	263	225.3 (18.1)	45-2700
1997	Total	1022	48.9 (0.27)	25.3-95.0	-	-	-
2001	Total	850	48.9 (0.31)	24.4-95.6	72	208.6 (20.8)	60-1295
2002	Total	732	46.2 (0.35)	24.2-86.1	60	191.1 (16.3)	57-671
2003	Total	649	45.1 (0.37)	29.2-93.9	60	190.4 (15.1)	46-393
2004	Total	382	48.2 (0.45)	31.1-81.7	144	248.0 (11.2)	57-1399
2005	Total	587	48.8 (0.40)	27.3-99.6	581	237.0 (9.1)	35-2545

Table IR.10. Length and age for migrating silver eel, Burrishoole. St Er given in brackets.

Year	Sample Type	Sample Size (lt)	Mean Length	Sample Size (age)	Mean Age	Age Range Min / Max
1987	Total	80	48.6 (1.0)	58	28.6 (1.1)	12 – 57
	Male	21	38.9 (0.7)	14	21.5 (1.9)	12 – 33
	Female	59	52.0 (1.0)	44	30.9 (1.2)	21 – 57
1988	Total	128	49.2 (1.0)	97	29.0 (0.98)	8 – 55
	Male	37	39.2 (0.6)	31	21.8 (1.3)	10 – 41
	Female	91	53.3 (1.2)	66	32.4 (1.1)	8 - 55
2001	Total	72	45.5 (1.3)	61	23.4 (1.1)	9 – 45
	Male	36	36.1 (0.4)	28	17.7 (1.4)	9 – 45
	Female	36	54.9 (1.1)	33	29.1 (1.1)	12 – 44
2002	Total	60	45.2 (1.4)	54	24.4 (1.2)	7 – 41
	Male	30	36.1 (0.4)	25	18.0 (1.5)	7 – 41
	Female	30	54.3 (1.3)	29	30.0 (1.1)	21 – 41
2003	Total	60	46.1 (1.4)	56	27.5 (1.0)	11 – 46
	Male	27	35.0 (0.4)	24	22.9 (1.4)	11 – 33
	Female	33	55.3 (0.5)	32	30.9 (1.1)	20 – 46
2005	Total	122	48.4 (1.0)	116	27.6 (0.8)	8 – 58
	Male	44	36.5 (0.6)	42	22.4 (1.5)	8 – 58
	Female	78	55.0 (0.9)	74	30.5 (0.8)	16 – 45

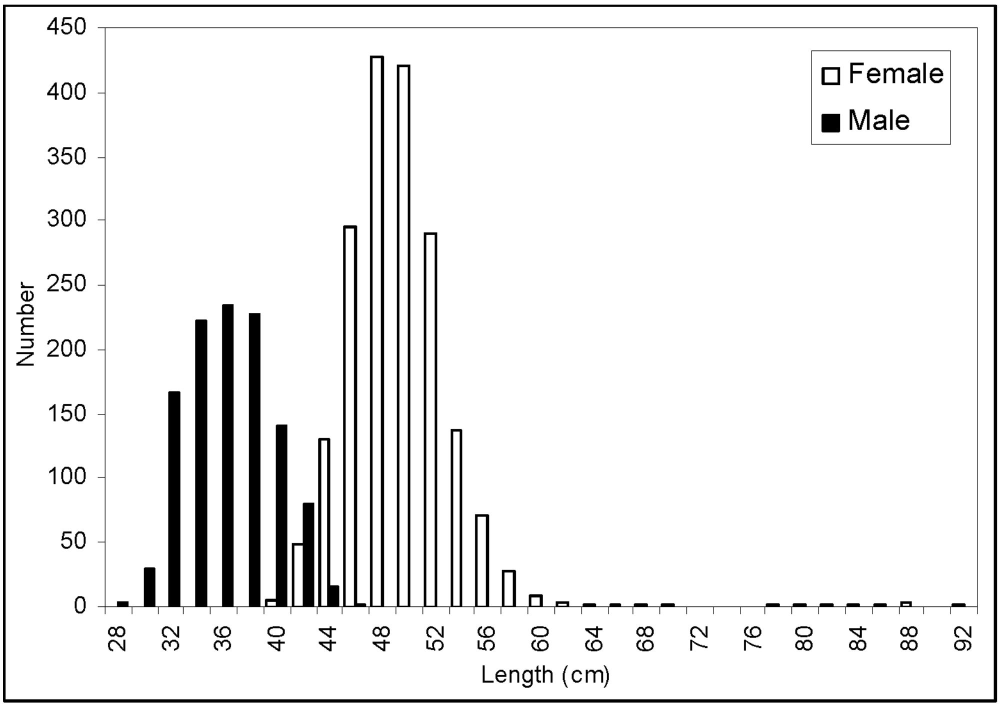

Figure IR.9. Length frequency distribution for male and female silver eels in the Burrishoole system, 1988 (n = 3003).

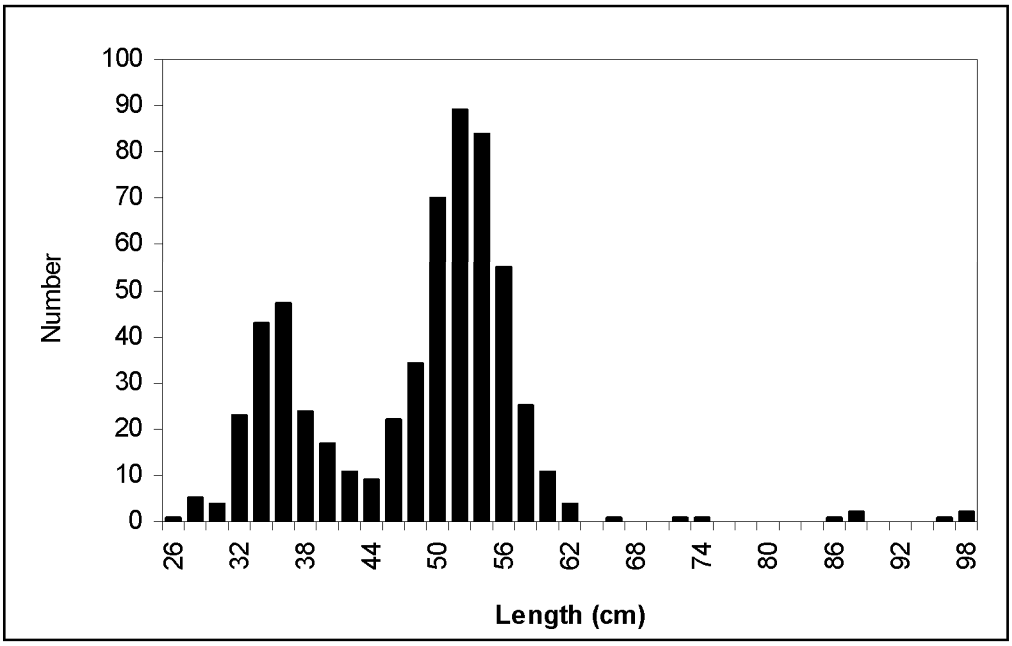

Figure IR.10. Length frequency distribution for male and female silver eels in the Burrishoole system, 2005 (n = 587).

IR.I. Other biological sampling:

IR.I National Synopsis

DCR requirement: Samples of length and weight are to be taken every three years for compliance with the DCR.

There is no national programme for sampling other biological aspects of eel in Ireland. A number of catchment based research programmes collect data which may be informative (see Table IR.8).

IR.I.1 Parasites

Anguillicola crassus was first recorded in Irish eels in the Waterford area in 1997. They were subsequently recorded in the Erne (see below) and this invasion probably occurred between 1997 and 1998, as they were apparently absent in 1996 (Copely and McCarthy 2005). *Anguillicola* has now also spread to the R. Shannon (McCarthy and Cullen 2000). A summary of the known distribution of *Anguillicola* in Ireland was compiled in 2003 (McCarthy *et al*, in press) and the data-base is currently being up-dated, following discovery of the species in small and reputedly unexploited western Irish catchments. Investigations of parasites assemblages of eels in marine, mixohaline and freshwater habitats in the Shannon and other Irish rivers are being undertaken by the National University of Ireland, Galway, as part of a research project funded by the Higher Education Authority (HEA PRTLI- 3).

IR.I.2 Shannon Catchment (Shannon IRBD) - Parasites

Annual surveys of brown and silver eels in the Shannon fisheries, undertaken since 1992, show that *Anguillicola* was first detected in 1998 at Killaloe and that since then it has become well established in the lower catchment and that it has more recently spread to lakes further up in the river system.

IR.I.3 Erne Catchment (North Western IRBD) – Length & growth

Extracted from: Matthews *et al.* (2001). An extensive fyke net survey of the brown eel stocks of the Erne lakes was carried out from May to September 1998–2000 (see also Section IR.F). Weekly samples of 5–10 eel were taken to determine age, growth, feeding patterns and parasitic burden from different sections of the catchment.

Highest catches were obtained from Upper and Lower L. Erne in the lower reaches of the catchment where the greater part of commercial fishing takes place. Mean length ranged from 42–44 cm. Mean growth rates ranged from 2.7 cm per year in Lower L. Erne to 3.4 cm per year in Upper L. Erne.

In contrast, numbers from the upper reaches of the catchment were lower and were characterised by the preponderance of large (mean length 46–64 cm), female eel. Growth rates (3.6–4.6 cm per year) confirmed brown eel from Upper Erne to have some of the fastest growth rates in Ireland.

The proportion of undersize eel (less than 42 cm) in fyke net catches declined progressively from Lower L. Erne (mean 40%) to less than 10% in the upper reaches of the Erne system. The size composition of catches from some of the Cavan-Monaghan lakes (e.g. Annalee-Dromore and Ballinamore lakes) suggests natural recruitment of juvenile eel to these lakes is negligible.

IR.I.4 Erne Catchment (North Western IRBD) - Parasites (Matthews *et al.*, 2001).

Eight parasitic endohelminth worm species (2 Cestoda, 3 Nematoda and 3 Acanthocephala) were found in the intestines of 1089 brown eel examined from throughout the Erne system, 1998–2001. The diversity of endohelminth worms contained in eel increased progressively from Lough Gowna (4 species) in the upper reaches of the Erne to Assaroe Lake (8 species) just above the Erne estuary at Ballyshannon, Co. Donegal. This distribution pattern reflects both eel feeding behaviour and the availability of intermediate hosts.

Of greatest concern was the discovery of the pathogenic blood-sucking nematode *Anguillicola crassus* in the swim-bladder of brown and silver eel from the Erne. Initially detected in the R. Barrow in 1997, the parasite has since spread to the lower reaches of the R. Shannon and was first recorded from brown eel in southern Lower Lough Erne in 1998 (Evans and Matthews, 1999). By 1999 the parasite was detected as far upstream as L. Garadice with 90% of brown eel from the Narrows, Lower L. Erne found to be infected.

IR.I.5 Burrishoole Catchment (Western RBD) - Silver

Length and weight are measured for Burrishoole silver eel on an annual basis (Table IR.9). The average weight of the silver eels in the catches has been steadily increasing from 95 g in the early 1970s to 215 g in the 1990s (Figure IR6). The increase in average weight has been caused, at least in part, by a change from a predominantly male sex ratio to more than 60% females in the more recent years (Poole *et al.*, 1990).

IR.I.6 L. Ahalia Catchment (Western RBD)

A study of eels is being undertaken in marine and mixohaline waters (McCarthy, NUIG – HEA) of L. Ahalia, a complex coastal lagoon ecosystem. Results involving the use of stable isotope ratios (Harrod *et al.*, 2005), otolith microchemistry, fatty acid profiles and variation in composition of parasite assemblages are being used to investigate movements of eels between habitats of differing salinity (McCarthy et al. unpublished). Eels have also been sampled in other coastal, estuarine and lagoonal habitats for related research (Arai *et al.*, 2006).

IR.J. Other sampling

No other sampling for such issues pertinent to eel has taken place in Ireland up to 2004. Some samples have been taken in 2005 and are currently undergoing analysis for contaminants (PCBs, dioxins, BFRs) and presence of *Anguillicola* (Table IR.8).

Many issues relating to water quality, river continuity, and physical habitat have been included in the Risk Classifications under the Waterframework Directive.

A study funded under the NDP Programme to determine the extent of usable wetted area for salmon was recently been completed, (McGinnity *et al.,* 2003). The initial study determined the extent of wetted area for all rivers and lakes in Ireland. This has been refined to establish a river inventory of 261 salmonid rivers. This habitat information is derived from remotely sensed data analysed in a GIS platform. A series of complex datasets (including topography, rivers, riverine gradient, lakes, catchments & Fishery Districts) with national coverage were required for the development of an integrated, GIS based, data model for the quantification of the freshwater habitat asset and for the determination of the quantity of habitat available to migratory salmonids. This information will be important in helping determine the potential productivity of eel in catchments throughout the country.

The EPA (Irish Environmental Protection Agency) Biological River Monitoring Programme carries out a triennial survey of the biological elements of water quality at in excess of 3,300 monitoring stations on the main river channels. These surveys derive a biological quality rating or 'Q value' of waters at each monitoring station. Within their GIS the EPA has developed a facility to map the river stretches which correspond to the different Q value classes by a form of interpolation between the monitoring stations along the river network. These data on Q value extents, recorded in the EPA River Q Value Class, were utilised to provide a classification of wetted area amounts within each Q value class.

It was proposed to update this GIS database in 2006 to include natural and man-made barriers and to ground truth it for eel but this has not been undertaken as yet.

Summary of the Report as follows (McGinnity *et al.*, 2003):

A series of datasets (including river catchment topography, riverine gradient, lakes, catchments & Fisheries Districts) with national coverage were acquired for the development of an integrated, G1S based, data model for the quantification of the freshwater salmon habitat asset and for the determination of the quantity of habitat available to migratory salmonids. 261 discrete migratory salmonid 'Fishery Systems' were identified nationally of which 173 are recorded as being 'salmon and seatrout' and 88 as being 'seatrout only'. [NOTE: It is likely that eels are present in majority of these systems although commercial fishing probably only takes places in less than 10% of them.]

The estimated total wetted area of river and stream (fluvial) habitat in Ireland is 182.4 million m^2. The 173 salmon systems were estimated to contain 160.5 million m2 of fluvial habitat of which 113.0 million m^2 of useable habitat are available. A total of 40.1 million m^2 of potential fluvial salmon habitat is located above the four major hydro-electric schemes. A further 1,056 million m2 of lake habitat was identified in the 173 salmon systems of which 446 million m2 are available for migratory salmonid production.

Habitat quality data using the Amiro (Amiro, 1993) and Rosgen (Rosgen, 1994) gradient classification systems are presented. For example, in the Kerry Fisheries District 48% of the potential salmon producing habitat has a gradient of < 0.5% (Amiro Class 1).

Poor water quality impacts on the potential of rivers to produce salmon. The Environmental Protection Agency monitor water quality at over three thousand sites nationally from which a preliminary estimation of the area of channels with inadequate water quality which has been integrated into this report. The percentage of habitat area with impaired water quality on a District basis is presented. Data are presented on the quantity of habitat with a value of Q3 (moderately polluted) or less and a value of 03/4 (slightly polluted) or less. Habitat with a Q value of Q3/4 or less has been identified as an impediment to optimal juvenile salmon production. A Q value of Q3 or less indicates a more severe impairment. Nationally, 4.5% of potential salmon habitat is estimated to have a Q value of Q3 or less and 17.3% of the habitat recorded a Q value of Q3/4 or less.

IR.K. Stock assessment:

There is no nationally co-ordinated eel stock assessment programme in Ireland and there is also no co-ordinated use of stock assessment data for the estimation of exploitation or % SPR.

Individual stock assessments are used to inform local fisheries management decisions, such as the R. Shannon Eel Fishery Programme run by the ESB and NUIG.

IR.L. Sampling intensity and precision:

Data on sampling intensity, precision, catch composition etc have not been analysed or compared. Any analysis would have been restricted to the research programme under which the data was collected.

IR.M. Standardisation and harmonisation of methodology:

IR.M.1 Survey Techniques

Fyke Nets – Standard summer fyke nets (Matthews *et al.*, 2001; McCarthy *et al.*, 1994; Moriarty, 1975; Poole, 1990, 1994; Poole and Reynolds, 1996b) have been widely used in eel surveys around Ireland since the early 1970s. The nets used have been generally similar in all the surveys, normally fished in chains of five or ten nets. A "typical" summer fyke net consists of two traps (each 3.3 m in length), facing each other, joined by a leader net (8 m in length), mesh size 16–18 mm. Each trap consists of two chambers and a cod end with knot to knot mesh sizes of 16, 12, and 10 mm respectively. The diameter of the trap entrance was 58 cm and the outer ring of each trap was 'D' shaped.

Catch per unit effort (CPUE) data are normally reported in number of eels, or weight, per net (pair of traps) per night fished.

Long-lines – Long-lines have not been extensively used as a survey tool in Ireland. On the Shannon (McCarthy and Cullen, 2000) long-lines have been standarised and the bait is restricted to earthworm allowing some comparisons to be made between fishing areas and years.

River Surveys – In deeper rivers and estuaries, fyke nets have been the standard survey tool. In smaller rivers electrofishing is generally employed, in spite of being fraught with difficulties when applied to eel, with a variety of back-pack portable and bankside generator gear being used. Single pass and three fishing depletion methods are used, but often eel assessments are carried out as a "by-product" of other surveys, in particular salmonid surveys.

IR.M.2 Sampling Commercial Catches

There is no National programme for sampling commercial catches.

Erne – The survey of the Erne catchment 1998–2001 was carried out using a semi-commercial research team of crews (Matthews *et al.*, 2001). An observer was placed with each crew at least once a week to ensure standardisation. Eels were stored in keep nets or boxes similar to those used by commercial fishermen. Eels were graded and sold to eel dealers at the lake shore. The entire catch was sampled prior to grading and the fishermen were paid full price for undersized eel, before their release.

Shannon – Commercial crews authorised by the ESB sell to eel dealers at lakeside locations on designated dates. ESB staff and NUIG researchers attend at sales points, to monitor catches and to obtain samples for length, weight, age and parasitology analyses. Dealers are required to provide advance notice of their collection schedules. Comparisons are made annually between sales statistics and cumulative catches, reported in log-books, by the fishing crews. Dealers are required to disinfect truck tanks, monitored by ESB staff, before collections begin and to ensure that no water/potential pathogens are introduced to the river system.

IR.M.3 Sampling

Catch sampling is normally carried out on anaesthetised eel, although some samples may be taken from either freshly sacrificed or frozen samples.

IR.M.4 Age analysis

Age analysis of eel in Ireland has generally followed the methodology of burning & cracking (Christensen, 1964; Cullen and McCarthy, 2003; Hu and Todd, 1981; Moriarty, 1983; Poole and Reynolds 1996a; Vollestad *et al.*, 1988). Otoliths are extracted as described by Moriarty (1973), stored dry and prepared by burning in either gas or spirit flame. There is no formal validation or quality control in Ireland. Some cross validation and double reading has been carried out between projects and this has ensured some degree of continuity between samples and surveys, (i.e. Moriarty, 1983; Poole *et al.*, 1992; Matthews *et al.*, 2001; Matthews *et al.*, 2003; Maes, unpublished). Comparisons have also been made between age derived growth (back-calculations) and tag/mark recapture determined growth, thereby validating the use of burning & cracking otoliths for age and growth determinations in slow growing Irish eel (Poole and Reynolds, 1996b; Moriarty, 1983).

IR.M.4 Life Stages

Glass Eel / Elver life stages are determined the pigmentation classification using that published by Elie *et al.* (1982).

Brown eel and silver eel are categorised by a combination of capture method and season, colouration and eye size. Silver eels are generally captured during their downstream migration, or can be recognised in the brown eel catch by the enlarged eyes and onset of coloration change.

IR.M.4 Sex Determinations

Brown eel <25 cm are problematical to sex and >25cm up to 45 cm are sexed by dissection.

Silver eel are sexed by length and some studies have carried out dissections on eels between ~38cm and 48cm in order to determine the length overlap between the sexes.

Histological verification has not been used to any extent in Ireland.

IR.N. Overview, conclusions and recommendations:

This report presents an overview of the eel in Ireland. Glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173) and this may only be carried out under Section 18 Authorisations from the relevant Regional Fisheries Boards, for the purposes of enhancement and development of the fishery.

The commercial eel fishery involves highly seasonal, small scale, scattered fisheries, harvesting both brown and silver eel in freshwater, estuarine or tidal waters. Brown eel are fished using a variety of techniques, the most common of which are baited long-line, fyke nets and baited pots. When silver eel are migrating downstream in the autumn they are caught in licensed fyke or coghill nets which are often attached to fixed structures in the river flow.

The current declared commercial eel catch in the Irish Republic averaged 101t (2001–2003), 120t in 2004, involving about 150–200 part-time fishermen (data from RFBs/MI), but inadequate reporting and illegal fishing makes this difficult to quantify accurately and may be a substantial under estimate.

National reporting of eel catch to ICES was initiated by the WGEEL in 2001 but catch reporting by fishermen has not been made a statutory regulation. Ireland has proposed to include eel in the DCR for 2006 and will produce a sampling schedule and costs before the year end, following consultation between the relevant State Agencies and advice from the EU Eel Sampling Workshop planned for Sweden in September '05.

The eel data collection programme must be structured in order to take account of the differing characteristics of individual catchments, such as productivity, channel continuity, fishery type, and also the nuances of eel biology, such as timing of migrations, sex ratios, differences in growth rates.

The EU Data Collection Regulation sets minimum standards for national data collection programmes. The obligation to register and monitor is specifically placed on the national government. Organising and implementing a centralised Data Collection Programme for eel, in which all (inland) waters are covered, will be a costly and laborious task. Integration with the DCR programme for marine species and focusing on the catchments with the main fisheries (6–12 catchments) would be more cost effective. Implementation of the DCR for eel will require support for the inland fisheries sector in both legislative and financial terms.

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Report on eel stocks and fisheries in the United Kingdom and Northern Ireland

Mike Pawson[1], Brian Knights[2,5], Miran Aprahamian[3]; Robert Rosell[4], Malcolm Beveridge[5], Tony Bark[6] and Beth Williams[6]

1 Cefas, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT. Tel: +44 (0) 1502 524330, Fax: +44 (0) 1502 513865, email: mike.pawson@cefas.co.uk

2, 5 University of Westminster, School of Biosciences, 115 New Cavendish Street, London W1M 8JS. Current address: King's College London, email: pandbknights@aol.com

3 Environment Agency, NW Region, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG. Tel: +44 (0) 1925 653999, Fax: +44 (0) 1925 415961, email: miran.aprahamian@environment-agency.gov.uk

4 Department of Agriculture and Rural Development for Northern Ireland, Agriculture and Science Div., Newforge Lane, Belfast BT9 5PX. Tel: +44 (028) 90255506, Fax: +44 (028) 90255004, email: robert.rosell@dardni.gov.uk

5 FRS Freshwater Fisheries Laboratory, Faskally, Pitlochry, Perthshire, Scotland, UK PH16 5LB. Tel: +44 (0) 1796 472060, Fax: +44 (0) 1796 473523

6 Division of Life Sciences, King's College London, 150 Stamford Street, Waterloo, London. SE1 9NN. email: tony.bark@kcl.ac.uk, beth.williams@kcl.ac.uk

Plus contributions from Derek Evans, Queens University of Belfast, Newforge Lane, Belfast, and Peter Wood, UK Glass Eels, Gloucester, England.

UK.1 TOR (a): Describe the eel stock and fisheries in Europe, focusing on improved spatial coverage (cf. Moriarty and Dekker, 1997)

UK 1.1 Stocks

UK 1.1.1. Distribution of eel within England and Wales 2001–2005

The Environment Agency (EA) uses a number of techniques to monitor coarse fish and salmonid populations within England and Wales. Electrofishing surveys are the most commonly used method and can give a good estimate of the numbers and weight of the different fish species present, the size and age structure of the population and the overall condition of the fish. However, this multi-species survey technique can underestimate elusive species, such as eel. Eel-specific surveys require multiple runs for a quantitative assessment, and only a small number of routine fisheries surveys specifically target eel. In addition, there are some inconsistencies in recording eels found on surveys, with some only recording presence or absence of the species.

Routine electric fishing surveys for both from 2001 to 2005 show eels are present in nearly all river systems in England and Wales (Figure 1). There are some notable areas of absence, such as the upper reaches and tributaries of the Rivers Thames and Trent, and some lower reaches of rivers also appear devoid of eel whilst the species is present further upstream. This may result from different survey techniques being utilized across a catchment. Eel were present in 43–51% of the fisheries surveys during this period.

UK.1.2 Fisheries

UK.1.2.1 England and Wales

All life stages of eel are exploited in England and Wales. There are approximately 1000 eel fishermen using a total of around 2500 licensed instruments. The main fisheries for glass eel are by dip-net in estuaries draining into the Bristol Channel, in particular from the Rivers Severn, Wye and Parrott, with smaller fisheries in Morecambe Bay, Cumbria (Figure 2) (Knights, 2001). The main fisheries for eel >300 mm are based in southern and eastern lowland England, with fyke nets being the preferred instrument used for capturing yellow and silver eel.

UK.1.2.2. Northern Ireland

Lough Neagh/River Bann comprises a 400 km2 lake-based system, which produces around 95% of the total Northern Ireland eel catch. The elver run to the River Erne is monitored by capture at a box at the tidal head and transported to upper and lower Lough Erne. Silver eel fisheries let by the State on Lower Lough Erne remain suspended. Two minor fisheries on the Irish Republic/NI border on the Erne river are fished, but there are no catch data.

UK.1.2.3. Scotland

There is currently no regulation of commercial eel fisheries in Scotland, no licenses are issued and there is therefore no means of collecting catch return data. There is no export of any eel product and therefore no proxy values for recruitment or home or international market trends.

UK.1.3 Breakdown of eel catches in UK and Ireland by River Basin Districts

The UK and Ireland have twenty river basin districts (RBDs): six in England (Northumberland, Humber, Anglia, Thames, Southeast, Southwest, and North west); two (Severn and Dee) that straddle England and Wales; West Wales; Scotland and Solway-Tweed that straddles England and Scotland; one (Northeastern) that is wholly in Northern Ireland, three (Neagh/Bann, Northwestern and Shannon) that straddle Northern Ireland and the Republic of Ireland, and four (Eastern, Southeast and Southwest, and Western) that are within the Republic of Ireland.

Glass eels.

Glass eels are caught in seven of these RDBs, but in the Neagh/Bann, Shannon and Northwestern RBDs in Ireland they are only used for stocking further upstream in the same RDB. Thus, glass eels are caught for commercial use only in the RDBs bordering the Severn Estuary (Severn, Southwest and West Wales), and a very small fishery in the Northwest RBD. The total catch in 2004 was estimated at 14.4 t, of which approximately 34% was exported to Hong Kong and 50% to the Netherlands for cultivation.

The distribution and intensity of glass eel fisheries in the UK remains similar to that recorded in the early 1980s (Morrice, 1989), with the exception of a small fishery that took place in the Thames Estuary between 1980 and 1982.

Yellow eels

Today there is very little fishing for yellow eels in nine of the British and Irish RBDs, and only in four RBDs (Anglia, Thames, Shannon and Neagh/Bann) was more than 10 t caught in 2004. By far the largest fishery is in L. Neagh (364 t in 2004), where eel production is enhanced by stocking with glass eels caught near the estuary of the River Bann and also imported from the R. Severn.

Table UK.1 compares these yellow eel catches in England, Wales and Scotland with those estimated for the same (or similar) geographical areas in the mid-1980s, obtained by comprehensive interviews with fishermen and merchants (Morrice, 1989) and those reported for 1994 by Moriarty and Dekker (1996). The estimate of total yellow eel catch for the mid 1980s is higher at 565 t than that estimated only from exports (around 300 t) presented in the UK national report. Moriarty and Decker (1996) provide catch data for only thee areas (Thames, Southeast and Southwest), and it is highly likely that there was additional catch, particularly in the Humber and Anglian RBDs. The value of 136 t for "southern rivers" is not dissimilar to the catch estimated in the mid-1980s.

Table UK.1. Estimates of yellow eel catch by RBD in England, Wales and Scotland in the mid-1980s (Morrice, 1989), 1994 (Moriarty and Dekker, 1996) and in 2004.

RBD	ANNUAL MID-1980S	M&D 1996	2004
Northumberland	15 t		
Humber	35 t		
Anglian	235 t		17 t in these
Thames	100 t	6.5 t	two RBDs
Southeast	90 t	136 t for	
Southwest	32 t	southern rivers	
Severn	10 t		
West Wales	2 t		
Dee	Nil		
Northwest	<1 t.		
Solway - Tweed	5 t		
Scotland	45 t		<3 t
Total	**565 t**	**>143 t**	**20 t**

Historic data on yellow eel catches are less complete for Ireland (with the notable exception of the L. Neagh fishery), but they suggest that the main decrease has occurred in the last decade and was around 40 % in the L. Neagh fishery and 50 % elsewhere.

Table UK.2. Estimates of yellow eel catch by RBD in Ireland in the mid-1980s (L. Neagh Co-operative and as reported to FAO), 1994 (Moriarty and Dekker, 1996) and in 2004.

RBD	ANNUAL MID-1980S	M&D 1996	2004
North-eastern	0 t	0 t	0 t
Neagh/Bann	600 t	597 t	364 t
Eastern		0 t	5 t
Southeastern	Approx. 200 t	10 t	7 t
Southwestern	for whole area	10 t	+ t
Shannon		55 t	22 t
Western		0 t	22 t
Northwestern		49 t	5 t
Total	**800 t**	**721 t**	**425 t**

Silver eel

Silver eel fisheries are more restricted in their distribution than yellow eel fisheries in the UK and Ireland, where the major catch is taken from fish leaving L. Neagh (100 t in 2004) with a further 37 t from the Shannon and 18 t from the Western Ireland RBD. There are silver eel fisheries in only four other RDBs (Southeast England, Scotland, Eastern and Southeastern Ireland), but these are currently taking not much more than 1 t in each case.

In the mid-980s, there were substantial silver eel fisheries in the English Southeast RBD (around 50 t each year) and smaller amounts taken in the Severn RBD (3.5 t) and Central and southern Scotland (3 t). Moriarty and Dekker (1996) included silver eels with their yellow eel catch estimates for southern England in 1994.

In Ireland, Moriarty and Dekker (1996) reported a similar catch from L. Neagh to that estimated for 2004 (100 t), whilst the L. Neagh silver eel catch was around 150 t in the mid-1980s. Silver eel catches from the Shannon and the Galway fishery in the Western RBD appear to have remained relatively stable over the last 20 years, at around 55 t in total.

Table UL.3. Estimates of silver eel catch by RBD in England, Wales, Scotland and Ireland in the mid-1980s (Morrice, 1989), 1994 (Moriarty and Dekker, 1996) and in 2004.

RBD	ANNUAL MID-1980S	M&D 1996	2004
Scotland	3 t		<1 t
Southeast England	50 t	part of 136 t	1 t
Severn	4 t		
Neagh/Bann	150 t	95 t	100 t
Eastern Ireland			1 t
Southeastern Ireland			1 t
Shannon	45 t	38 t	37 t
Western	10 t	10 t	18 t
Northwestern			5 t
Total	212 t	153 t	163 t

UK.2. TOR (b): Trends in recruitment, fisheries and the stock

assess trends in recruitment, stock, and fisheries indicative for the status of the stock

UK.2.1. England & Wales

Information and data presented in the report of the 2004 WGEEL meeting to ICES/EIFAC (ICES, CM 2004/ACFM:04) are updated below. Licence sale and catch return data for glass eel/elver and for yellow/silver eel fisheries are derived from the EA and predecessor agencies, other catch and economics information is derived from Customs & Excise import/export data for England & Wales. Analysis of these data has short-comings, but yields useful information and provides proxy estimates of recruitment and of home and international market trends (Knights *et al.*, 2001; Knights, 2002).

UK.2.1.1. Update on glass eel recruitment and fisheries in 2004

Further EA data on licence sales and catch returns have become available since last year's UK report to WGEEL, allowing estimations of CPUE in kg/, and £/licensed net for recent years. Reported catches, exports, numbers of dip-net licences and CPUE (kg/licensed net) are shown in Table 1 and in Figures 3 and 4, and discussed further below.

UK.2.1.2. Glass eel fisheries and recruitment in 2005

As in previous recent years, glass eels were imported into GB from France, Spain and Portugal before and after Christmas in 2005 for re-export, with an early start in the Biscay fishery in late November. By subtracting imports from exports and adding purchases for Lough Neagh stocking, it is estimated that the GB catch was about 8.8 t in 2005, valued at £1.04 million. The catch was down from 14.4 t in 2004 (Figure 3), but average prices were much higher (~£490 v. ~£83/kg). This was due to increased demand from the SE Asia aquaculture market, exports to Hong Kong at 8.2 t being almost twice those of 4.3 t in 2004. Even then, glass eel exports from England and Wales were only about half those of the early 1990s.

Of a gross export of 23.9 t of glass eels, ~34% went to Hong Kong and 50% to the Netherlands. Only ~1 t went to Denmark and <1 t to each of Sweden, Germany, France and Greece, illustrating the continuing decline in European eel farming. 0.7 t were purchased to stock the Lough Neagh fishery compared to only ~ 0.4 t in 2004, and small shipments went to Lithuania and Estonia for stocking.

The declining trend starting in the 1980s continued in 2005 (Table UK.4, Figure UK.3). The 2005 CPUE cannot be calculated until licence data become available. However, CPUE in 2004 increased further over 2003 (19.0 v. 10.8 kg/licensed net) and was three times higher than the 1997–2002 average (Figure UK.4). The 2004 CPUE may be an overestimate as EA licence data show no dip-net licences for the South West/Wessex area in that year. If fishing effort (no. of licences) for this area is assumed to be similar to that in 2003, the CPUE in 2004 was still relatively high (15.4 kg/net) and similar to values in the mid-1980s to mid-1990s (avg. 17.7 kg/net).

The CPUE data overall indicate that recruitment during the period 1997–2002 was at about 30% of the peak values of the early 1980s, with some recent increases towards historical levels. The decline according to MAFF/Agency estimates or catch returns is ~85%. It must be noted, however, that variations in annual glass eel catches can be very high: the largest ever catch of 100 t was made in 1979 whilst the smallest was 4 t in 1976 (Peter Wood, UK Glass Eels, personal communication): note that while the trend is reflected in the MAFF/Agency reports, the catch totals are different, and that even lower catches have been reported in subsequent years (Figure UK.3).

Sales of licences have not recovered since they fell by ~60% in 2001 due to fishing access restrictions under Foot-and-Mouth disease regulations. It is estimated that overall catches of glass eels may have decreased to 20–30% of the 1980s levels (Peter Wood, UK Glass Eels, personal communication), possibly because only the most effective fishermen remained in the fishery. However, neither declining recruitment nor changes in fishing mortality since the late 1970s-early 1980s appear to have had any significant impact on eel densities, biomass, length- and age distributions and sex ratios in the freshwater tributaries of the Severn Estuary fishery, as monitored during the on-going Defra study. Population densities are relatively high and populations are dominated by small, sexually-indeterminate or older male eels. This implies that recruitment is more than sufficient to fully colonise the Severn Estuary tributaries, despite all of these pressures.

UK.2.1.3. Yellow/silver eel fisheries and economics for 2004

[data are not yet available for the whole of 2005 for yellow/silver eels]

The total GB catch of yellow and silver eels was estimated from 2004 export data, minus N. Ireland catches (estimated at 435 t from Lough Neagh and Lough Erne), to have been ~ 171 t (Table UK.5, Figure UK.5). This was a large increase over the 46 t estimated in 2003, bringing catches back to levels similar to those pertaining since 1998. The 2003 data may, however, have been under-estimated, as discussed in the previous WGEEL Report. Export tonnages again exceeded official catch returns (by 7x), due to under-reporting. Overall, catch and total export value continued the declining trend from the peaks of the mid-1990s (Figures UK.5 and UK.6).

Whilst fyke net and other instrument license sales remained steady, average CPUE in kg/instrument appeared to increase, and catch values fell from ~£3-4/kg in 2002–3 to £1.44/kg in 2004 (Figure 7). Prices and incomes (in real terms) are very low compared to those in preceding decades and, despite some possible recent improvements in catches, landings have declined since the mid-1990s due to reduced effort because of falling prices and competition from cheaper farmed eels (Ringuet *et al*., 2002; Knights, 2003).

UK.2.1.4. Frozen yellow/silver eel imports

In 2004, ~115 t of frozen eel were imported to the UK, half from the Netherlands and half from New Zealand, compared to 84, 310, 125 and 138 t in the preceding four years respectively. Frozen exports (to France and the Irish Republic) were ~12.4 t, slightly up on the previous year but similar to 2002. Unlike previous years, there were no imports from SE Asia.

UK.2.1.5 Status of eels in the Thames Basin

Eel population distributions and structures in the Thames Region have been assessed using extensive routine multi-species survey data covering 1978–2005, supplemented by information from boom-boat electrofishing and seine, trawl and fyke netting, angling and migrant eel trapping (Knights, 2005). Data on density, biomass and eel body length per site against distance (in river km, rkm) from the tidal limit for key estuarine tributaries (Darent, Roding, Lee and Wandle), river tributaries (Mole, Wey, Colne and Loddon), the main river Thames and the Medway were reviewed.

There are no direct data on glass eel recruitment, but eel distributions in the Thames are mainly restricted to the lower catchment, where densities and biomasses are relatively high, and decline towards zero beyond 50–60 rkm. Sex ratios are strongly biased towards females in the Outer Estuary and above 20–30 rkm in the main river. No discontinuities in population distributions or characteristics were identified to indicate migration barriers, though the cumulative effects of partial barriers and river management over historical timescales has probably impacted eel stocks in the Thames. The Medway, despite being close to the North Sea, shows low densities and relatively high proportions of large female eels, possibly due to major sluice barriers and strong river regulation and abstraction pressures.

Average density, biomass and length for all sites combined for the Thames fit the data trendline for a range of catchments located at different distances from the edge of the Continental Shelf (as a measure of the migration distances for glass eels from the N. Atlantic). Mean densities and (to a lesser extent) biomasses decline with distance from the Atlantic but mean body length increases. Thus the Thames tends to produce relatively more female eels >45 cm, whereas rivers in the south west of England produce mainly males.

UK.2.1.6. Conclusions

The above review suggests that glass eel recruitment in the Severn Estuary has recovered somewhat since the low levels of the late 1990s, with some recent increases, and is now similar to that in the late 1980s-early 1990s. No relationships are apparent between changes in recruitment and the populations in the Severn Estuary tributaries. Recent Thames catchment surveys provided no evidence to suggest any change in upstream colonization or spawner escapement over the last 20–25 years. Though yellow and silver eel CPUE in England and Wales increased in 2004, landings remained low compared to historical levels (1979 to 1993, peaking from 1995 to 1997), though this may be due to economic factors rather than a shortage of eels resulting from poor recruitment or overfishing.

UK.2.2 Northern Ireland

UK.2.2.1. Lough Neagh

Annual data are available on elver/glass eel numbers stocked and those trapped naturally in the River Bann on their way upstream. Annual commercial production figures are divided into outputs of yellow eels (line or draught net catch) and silver eels (caught in traps in the River Bann when migrating downstream from Lough Neagh). The Lough Neagh Fishermen's Co-Operative Society has provided data since the 1960s (Table 3).

UK.2.2.2. Glass eel and elver data, 2005

Glass eel and elver supply to Lough Neagh in 2005, as recorded by the capture in traps and nets in the Bann Estuary, for transport to Lough Neagh, is given in Table UK.6 and Figure UK.8. In 2005, the Bann natural run was 880 kg, an improvement on last year and exceeding the previous 5 year average (691 kg). As in most years since 1984, just over 2 million glass eels (~719 kg) were bought from the Severn Estuary to stock Lough Neagh in 2005.

UK.2.2.3. Yellow and silver eel data, 2005

Yellow and silver eel catches in 2005 amounted to 318 and 117 t respectively, continuing the downward trend (Figure UK.9) associated with reducing effort in the yellow eel fishery. Catches per boat per day in the longline and draft net fisheries continue to meet or exceed daily quotas imposed by the co-operative, implying that stocks in the Lough are being maintained. Licences have fallen from 200 active boats in 1990 to around 100 boats in 2005, a significant cause of the long-term decline in catches and a response to low prices available for yellow eels rather than declining stocks.

Sex ratio in the silver eels in 2004 and 2005 were numerically close to 1:1 male:female. Taking account of differing sizes and weights of males and females, 75% of the recorded silver eel biomass is now female.

UK.2.2.4. Lough Neagh escapement estimation by silver eel tagging studies

An annual mark-recapture programme was initiated in October 2003, with the objective of estimating escapement of silver eels past the fishery (weir traps), which is subject to a trap-free gap in the river channel, a three-month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high. Maximum estimates of escapement, based on the proportion of tagged silver eels taken back upstream and re-released that was recaptured, were estimated at 75% in 2003 and 62% in 2004 (Table UK.7) (Rosell *et al.*, 2005).

To date, 750 eels have been tagged in the 2005 run and recaptures are being recorded. The 2005 tagging and upstream release occurred during one very large catch in October under ideal migration conditions, which was unusual in the context of the last decade. This may lead to an overestimation of escapement. The 2005 escapement estimate will be revised, probably somewhat downward, when complete 2005 data become available.

UK.2.2.5. Northern Ireland eel populations/fisheries other than Lough Neagh

The elver run to the Erne in 2005 was 802 kg, monitored by capture at a box at the tidal head and transported to upper and lower Lough Erne (See Republic of Ireland report)

Silver eel fisheries let by the State on Lower Lough Erne remain suspended. Two minor fisheries on the Irish Republic/NI border on the Erne river were fished, but there are no catch data.

UK.2.3. Scotland

UK.2.3.1. Glass eel fisheries and recruitment in 2004 and 2005

In a survey conducted by Williamson in the early 1970s, no elver fisheries were recorded in the Scottish Highlands and Islands (Williamson *et al.,* 1976). During the mid-late 1990s there was a short period of exploitation, estimated at 1–2 t per annum, in response to the rise in demand and thus prices. Much of the fishing for glass eels occurred on the West Coast. Fishing has since declined markedly and despite extensive enquiries, no commercial elver fisheries are believed to have operated in Scotland during 2004 or 2005.

There have been no studies of glass eel recruitment in Scotland, although there is some interest in establishing traps on some systems as a means of monitoring recruitment.

UK.2.3.2. Yellow eel and silver eel fisheries

Commercial fisheries for yellow eels are largely based in low-lying productive lochs, the eels being sold mainly to local smoke houses. There is no tradition of eel consumption in Scotland. During the 1960s–1970s, eel catches in Scotland were estimated at around 10–40 t per annum. In 1989, 17 eel fisheries were operating, with catches ranging from 0.25 to 10.76 t (total: 23 t) (I.

McLaren, FRS, unpublished data). Correspondence with proprietors of eel fisheries in 2003 indicated a catch of less than 2–3 t per annum, chiefly yellow eels, with silver eels contributing less than 100 kg, mostly from traps in mill-races. Although there are few comprehensive records, data for one silver eel fishery show a 90% decline in catches between the early 1990s and 2002, although during the same period a yellow eel fishery was established in the upstream loch. Today, catches of silver eels are largely destined for research purposes.

It is concluded that eel exploitation in Scotland is at its lowest level in the recent past, with fishing for silver eels and glass eels/elvers in particular being less than a few hundred kg per annum. Fisheries for yellow eels probably amount to little more than 2 t per annum.

UK.3 TOR (f) Monitoring and research

UK.3.1. England and Wales

UK.3.1.1. Establishment and Implementation of Biological Reference Points for the Management of the European Eel, *Anguilla anguilla* L.

This 4-year Defra-funded R&D project (2002–2006) was introduced to WGEEL in 2002, and progress updated in each subsequent report. Progress was made in 2005 against two main Project Objectives:

1) *To develop, program and test models for population dynamics, stock assessment and management strategies.*

The computer program SMEP (Scenario-based Model for Eel Populations) and its associated user guide have been amended and improved to increase its flexibility. The SMEP outputs a wide range of population variables, e.g. sex ratio, length frequency, density, biomass. The user is now able to specify observations on, e.g. the sex ratio or estimated population length frequency in a particular reach of a river in a particular year, and estimate historical and future trajectories of population abundances, given an assumed trend in annual recruitment, that best fit those observations. This greatly improves the ability to tailor scenario models to particular rivers or river systems.

2) *To research and develop methods and proxies for assessing and monitoring compliance with the proposed EC Biological Reference Point (40% spawner escapement) and to inform practical and sustainable management of eel stocks.*

The model is being parameterised using eel-specific survey data that have been collected from nine test catchments covering 14 rivers, two estuaries and a freshwater lake in the West, South and East coasts of England and Wales.

The final three catchments were surveyed in summer 2005. Eighteen sites were electrofished on the River Blyth (East), 23 sites on the River Hull (East) and a further 12 sites on two feeder streams to Slapton Ley in Devon (South). In addition, emigration into the Ley was sampled with two fixed elver ladders and traps, and the Ley itself was sampled with fyke nets.

River Blyth

The mean length (204 mm) of the 1373 eels caught was lower than expected for an east coast river (typically lower recruitment, lower densities, larger eels). However, the Blyth is similar in distance from the continental shelf as some rivers on the west coast. Recruitment of young of the year eels was comparable to that seen in the Severn and Wnion catchments, although dispersal into the catchment appeared to be hampered by a large weir (approx 3 km above tidal limit), beyond which densities fell and mean length increased to levels closer to that of an east coast river.

River Hull

The mean length of the 458 eels caught was 420 mm. The Hull is a complex system with many drainage channels, pumping stations and deep, canalised sections in the mainstem and tributaries. As expected, low numbers of relatively large eels were caught. However, preliminary analysis of the data suggest that densities are lower than expected, even for a low recruiting system.

Slapton Ley and the Rivers Start and Gara

The mean length of the 356 eels caught in the Start and Gara was 250 mm. The 19 fyke net sites in the Ley caught 351 eels, with a mean length 448mm. Elver traps on Ley outflow weir ran for 54 days from the end of March to the beginning of July 2005. These upstream traps caught both elvers (length <120 mm) and yellow eels (>120 mm). The total catch was 346 eels (45% elvers), ranging in size from 53 mm to 430 mm, with a mean length of 130 mm.

UK.3.2. Scotland

The FRS Freshwater Laboratory has two long-term, but intermittent, datasets on yellow eels, both from small, upland tributaries. FRS has operated a fish trap on the Girnock Burn, a tributary of the River Dee in Northeast Scotland, since the mid-1960s. The Girnock Burn rises at an altitude of 500 m and flows northwards, joining the River Dee some 70 km above the tidal limit. The stream channel has a largely open aspect, and is typically <5 m wide, depths ranging from a few cm to 0.5 m. Annual trap catch and electrofishing data were collected between 1967 and 1982 and again in 2004 and 2005. Since 2004, eels >200 mm have been pit-tagged in order to determine movements and growth.

Analysis of these data (Chadwick, 2005) shows that, in the late 1960s, the Girnock Burn eel population was comprised of relatively high densities of small (140–180 mm) males and with few females (320–360 mm). Both size classes have declined markedly over the time series, with mean densities falling from 17.3 to 3.0 eels per 100 m2, and biomass from 265 g to 85 g m-2. Growth rates were very low and are currently estimated to be between 8.7 and 17.4 mm y-1, chiefly in the summer months. Small eels leave the system in late spring/early summer, larger eels in late summer/early autumn, and there has been an almost 90% decline in overall numbers leaving the system between 1968 and 2004, most probably due to a combination of falling recruitment and the trap may have formed a partial barrier to eel migration.

The other monitored site is the Allt Coire nan Con Burn, which is situated in the Strontian region of western Scotland and drains into the River Polloch, an inflow to Loch Shiel. The catchment covers 790 ha and its altitude falls from some 756 m to 10 m at the sampling point, where the river is 5–6 m wide and features riffle interspersed with glides which can be deep. Riparian vegetation at the sampling sites is predominantly mature deciduous woodland. In Table 6, data from the annual electrofishing survey show no clear evidence of declines in yellow eel densities since 1992 (source: P. Collen, unpublished data).

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Table UK.4. Glass eel/elver catch and CPUE estimates for England and Wales, based on reports, import and export data, 1972–2005

	CATCH ESTIMATES BASED ON		LICENCE SALES	CPUE	
	MAFF/agency	Customs & Excise Import/Export			
Year	t/yr	t/yr	No. dip-nets	kg/net	£/net
1972	16.7				
1973	28.2				
1974	57.5				
1975	10.5				
1976	13.1				
1977	38.6				
1978	61.2				
1979	67				
1980	40.1	32.8	1367	24.0	121
1981	36.9		1303		
1982	48	30.4	1288	23.6	187
1983	16.9	6.2	1537		49
1984	25	29	1192	24.3	162
1985	20	18.6	1026	18.1	245
1986	19	15.5	917	16.9	330
1987	21.3	17.7	1162	15.2	384
1988	21.4	23.1	918	25.2	861
1989	20.6	13.5	1087	12.4	804
1990	20.9	16	1169	13.7	986
1991	1.1	7.8	960	8.1	625
1992	5	17.7	969	18.3	1335
1993	5.73	20.9	1000	20.9	1959
1994	9.5	22.3	1058	21.1	1304
1995	11.9		1530		
1996	18.8	23.9	1682	14.2	1480
1997	8.7	16.2	2450	6.6	821
1998	11.2	20.1	2480	8.1	1113
1999		18	2207	8.2	1012
2000		7.6	2100	3.6	
2001		5.4	838	6.4	1021
2002	1.5	5.1	899	5.7	
2003	1.7	10	922	10.8	1517
2004	0.97	14.4	757	19.0	896
2005		8.8	805	10.9	

Table UK.5. Yellow and silver eel data for England and Wales, 1979–2004

	Total exports	Catch returns	Export value		No. of licensed instruments	CPUE/instrument	
Year	(t)	(t)	£000	£/kg		kg/instr	£/instr
1979	162						
1980	196		670	3.41			
1981	229		759	3.31			
1982	273		850	3.11			
1983	270		888	3.29	1523	177	583
1984	283		922	3.26	2085	136	442
1985	283		1012	3.57	2624	108	386
1986	274		1190	4.35	1994	137	597
1987	381	60.41	1869	4.91	2168	176	862
1988	456	280.58	2992	6.56	2443	187	1225
1989	376	80.63	1699	4.52	2041	184	832
1990	277	48.74	1016	3.66	1589	175	639
1991	358	38.26	1724	4.82	1704	210	1012
1992	234	35.63	1383	5.92	1724	135	802
1993	232	46.62	1442	6.22	1859	125	776
1994	384	86.79	1920	5.00	2647	145	725
1995	514	103.76	2484	4.83	2648	194	938
1996	540	100.51	2532	4.69	2752	196	920
1997	526	68.04	1956	3.72	2602	202	752
1998	306	58.31	1126	3.68	1825	168	617
1999	294		1012	3.44	1670	176	606
2000	113		345	3.05			
2001	207		771	3.72	1916	108	402
2002	122	50	445	3.65	1882	65	236
2003	46	11.9	195	4.24	1831	25	106
2004	171	23.7	232	1.44	1600	101	145
2005							

Table UK.6. Lough Neagh eel fishery data, 1960–2005.

Year	Natural elver run (kg)	Additional elvers bought from R Severn (kg)	Emigrating silver eel catch (kg)	Yellow eel longline catch (kg)	Total yield yellow +silver eels (kg)
1960	7408.55				
1961	4938.69				
1962	6740.46				
1963	9076.70				
1964	3136.92				
1965	3801	0	329563.6	236759.1	566322.7
1966	6183	0	332800	284772.7	617572.7
1967	1898.77	0	242727.3	327281.8	570009.1
1968	2524.9	0	204618.2	382327.3	586945.5
1969	422.03	0	238327.3	368677.3	607004.5
1970	3991.63	0	237345.5	516504.5	753850
1971	4157.07	0	233309.1	610909.1	844218.2
1972	2905.27	0	124945.5	509090.9	634036.4
1973	2524.2	0	162400	562481.8	724881.8
1974	5859.47	0	178872.7	587904.5	766777.3
1975	4637.27	0	187527.3	576354.5	763881.8
1976	2919.93	0	144872.7	481886.4	626759.1
1977	6442.8	0	236690.9	455350	692040.9
1978	5034.4	0	280727.3	544695.5	825422.7
1979	2088.8	0	341163.6	702609.1	1043773
1980	2485.93	0	245272.7	668945.5	914218.2
1981	3022.6	0	228690.9	681545.5	910236.4
1982	3853.73	0	209890.9	705759.1	915650
1983	242	0	203636.4	662709.1	866345.5
1984	1533.93	1334.67	165890.9	807672.7	973563.6
1985	556.73	3638.51	135054.5	616668.2	751722.7
1986	1848.47	5935.16	129854.5	522359.1	652213.6
1987	1682.8	4584.07	121345.5	503777.3	625122.7
1988	2647.4	2107	150981.8	503236.4	654218.2
1989	1567.53	0	152436.4	643395.5	795831.8
1990	2293.2	0	123600	613231.8	736831.8
1991	676.67	0	121381.8	578868.2	700250
1992	977.67	785.87	148036.4	533240.9	681277.3
1993	1524.6	0	90327.27	535150	625477.3
1994	1249.27	771.87	95200	597418.2	692618.2
1995	1402.8	686	138581.8	659050	797631.8
1996	2667.93	33.19	112290.9	594045.5	706336.4
1997	2532.6	70.47	109418.2	554750	664168.2
1998	1283.33	17.27	104545.5	531968.2	636513.6
1999	1344.93	1200	113054.5	556213.6	669268.2
2000	562.8	150.33	101963.6	486595.5	588559.1

Table UK.6. Lough Neagh eel fishery data (cont.).

Year	Natural elver run (kg)	Additional elvers bought from R Severn (kg)	Emigrating silver eel catch (kg)	Yellow eel longline catch (kg)	Total yield yellow +silver eels (kg)
2001	315	0	84000	451309.1	535309.1
2002	1091.53	1007	95963.64	432313.6	528277.3
2003	1155.93	1368.03	114327.3	413763.6	528090.9
2004	334.6	427.09	99636.36	363522.7	463159.1
2005	880.13	718.67	116727.3	317800	434527.3

Table UK.7. Results of mark-recapture estimation of silver eel escapement from the Lough Neagh fishery.

Note that the 2005 figure (as of 12 December 2005) is provisional, and that the escapement estimate will be revised downward as more tags are recorded.

		Recaptures						
Year	No. tagged	Toome	Kilrea	Carry over to catch T+1, T+2y	Total	Rate (%)	Total annual silver catch (t)	Max. possible escapement estimate (t)
2003	189	26	7	7	42	22.2	114	399.0
2004	838	302	15	4	321	38.3	99	159.4
2005	750	109	0	N/A	109	14.9	117	688.0

Table UK.8. Current and historical sex ratios in silver eels emigrating from Lough Neagh.

	Males					Females			
year	%	mean L (cm)	mean Wt (g)	Age		%	mean L (cm)	mean Wt (g)	Age
1927	0					100		567	
1943	27					73			
1946	40					60			
1956	61					39			
1957	62					38			
1965	10		180			90		330	
2004	51	40.6	122	11		49	58.6	386	18
2005	52	41.4	126			48	58.1	393	

Table UK.9. Relative population density of eels in electrofishing surveys in a small stream in north Argyll, 1990–2004

YEAR	POPULATION DENSITY (NO.S/100M^2)
1990	41
1991	30
1992	16
1993	14
1994	11
1995	15
1996	18
1997	12
1998	14
1999	8
2000	10
2001	14
2002	15
2003	3
2004	14

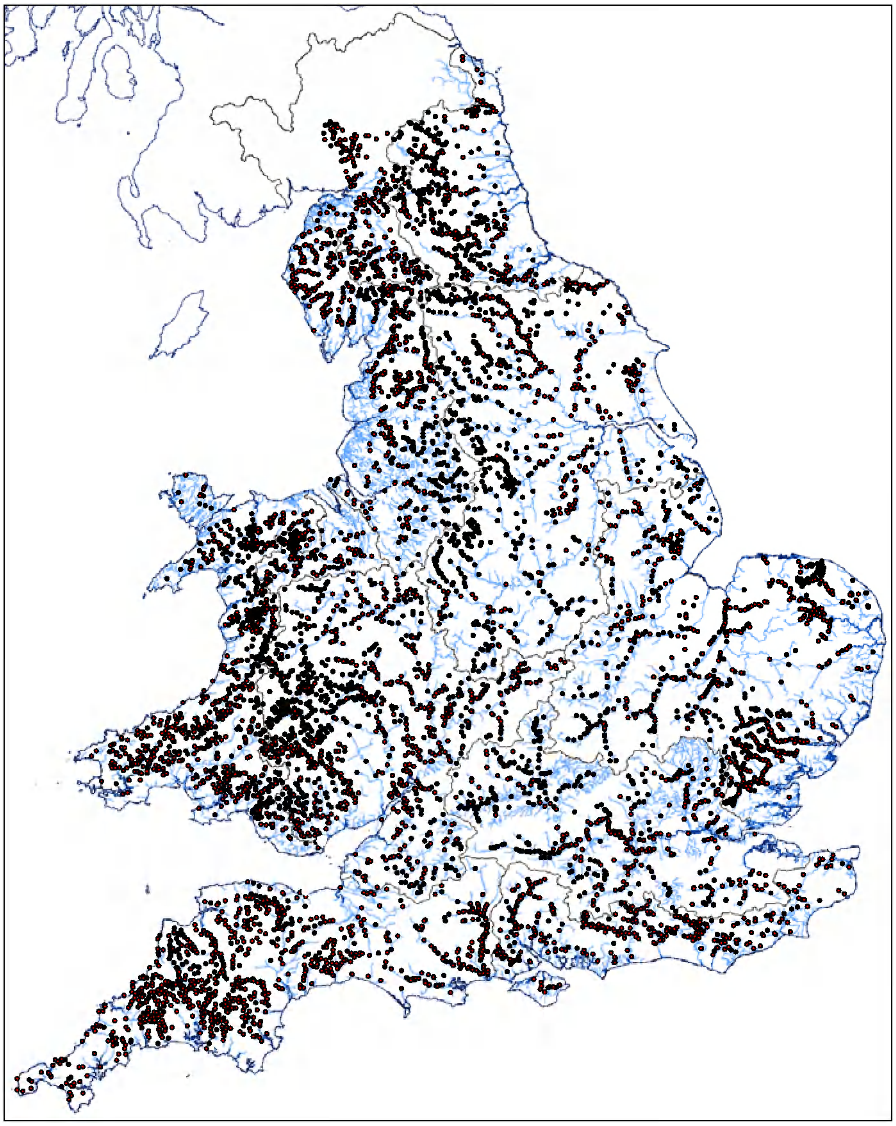


Figure UK.1. Eel presence and absence in England and Wales, 2001–2005.

Main Rivers
River Basin Districts
Eel Present
Eel Absent

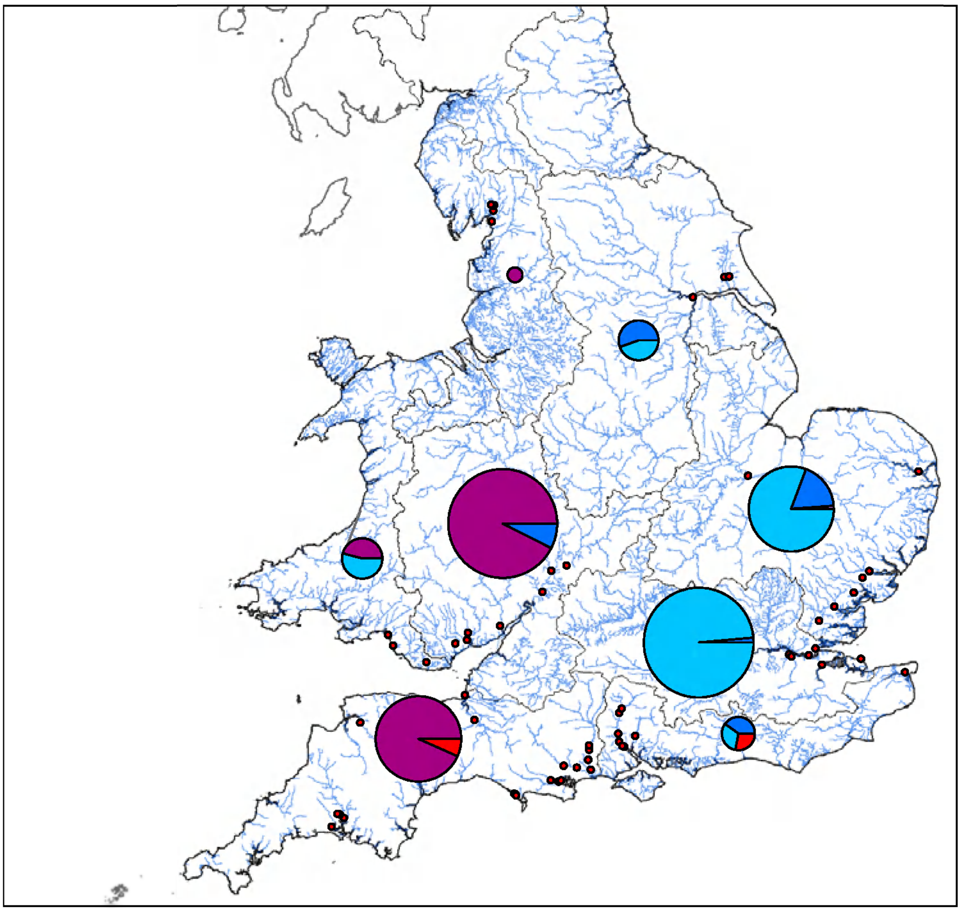
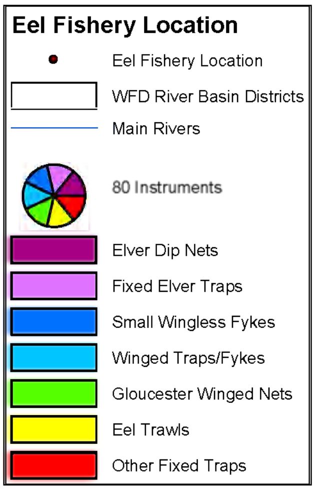


Figure UK.2. Eel and Elver Fisheries in England and Wales

Proportional size pie charts representing number of each instrument type in each WFD River Basin District.



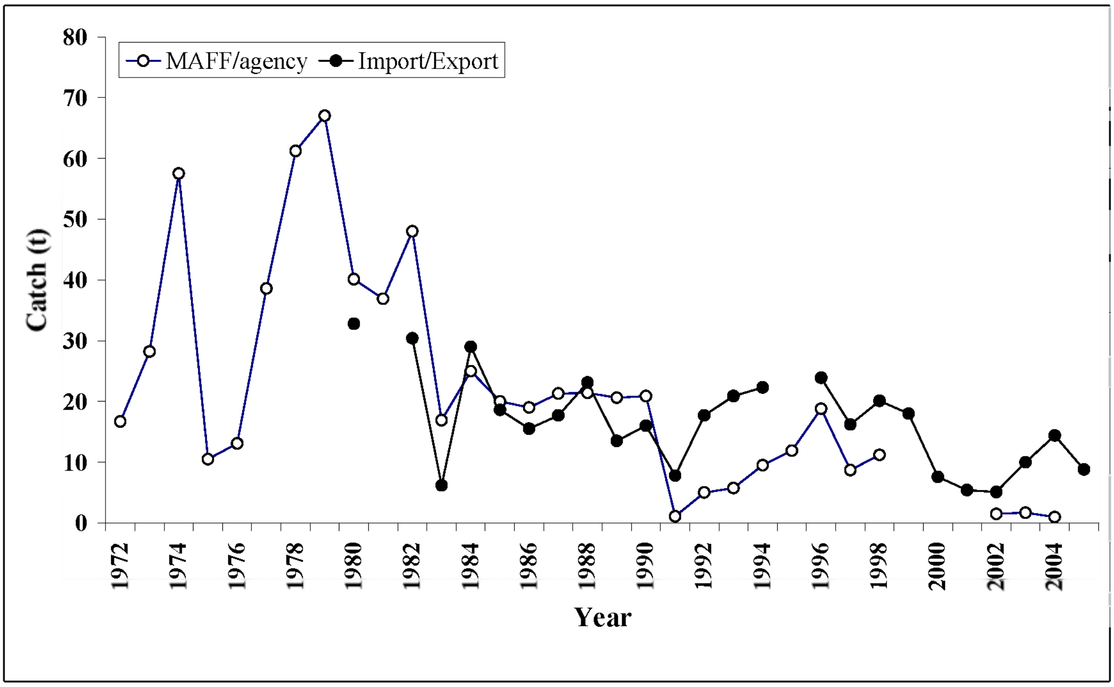


Figure UK.3. England & Wales annual catch of glass eel (t) from MAFF/agency data and nett export estimates (Customs & Excise), 1972–2005.

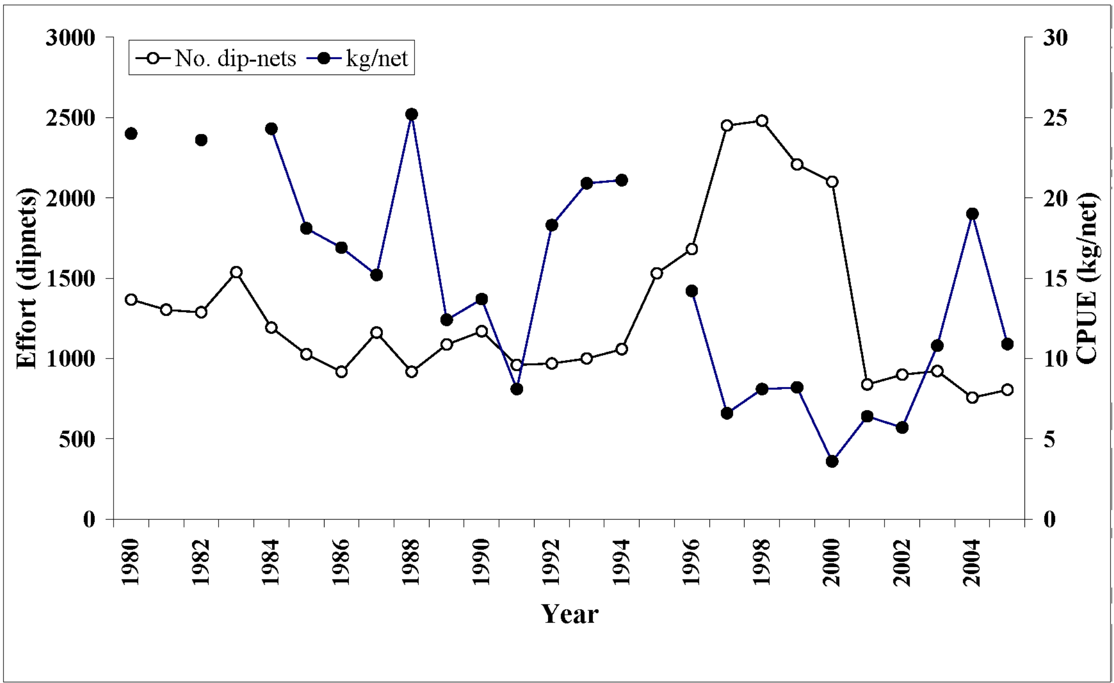


Figure UK.4. England & Wales glass eel fishery effort as number of licensed dip-nets per year and CPUE (from export estimates) in kg/net, 1980–2005.

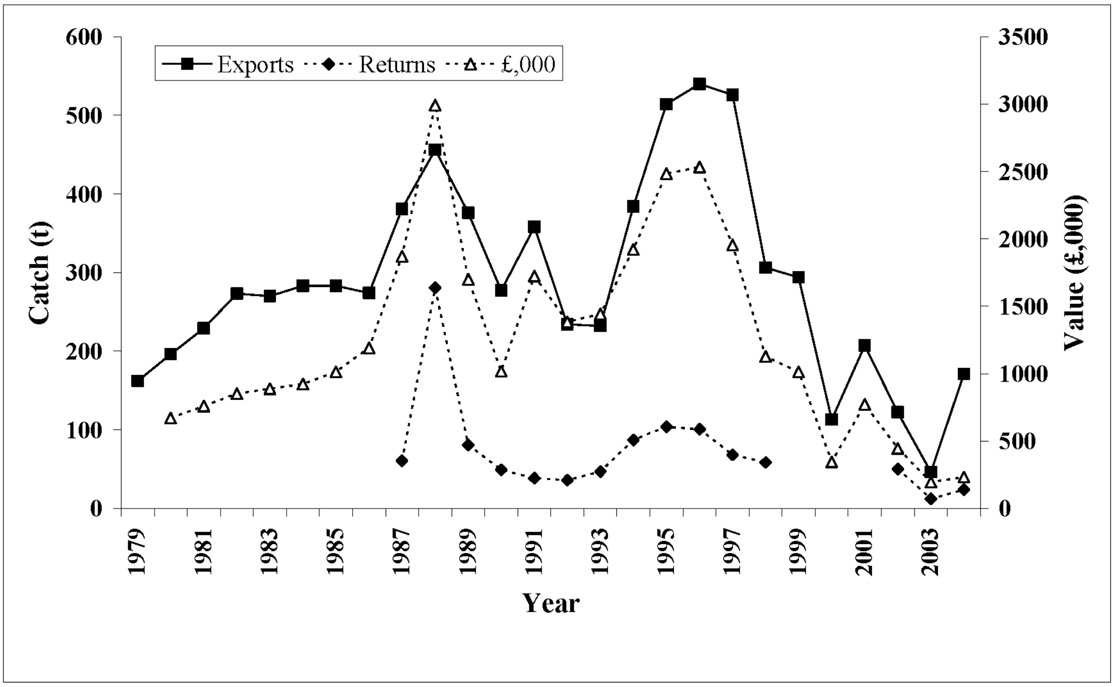


Figure UK.5. England & Wales yellow and silver eel catches (t) from exports and catch returns, and export value, 1979–2004.

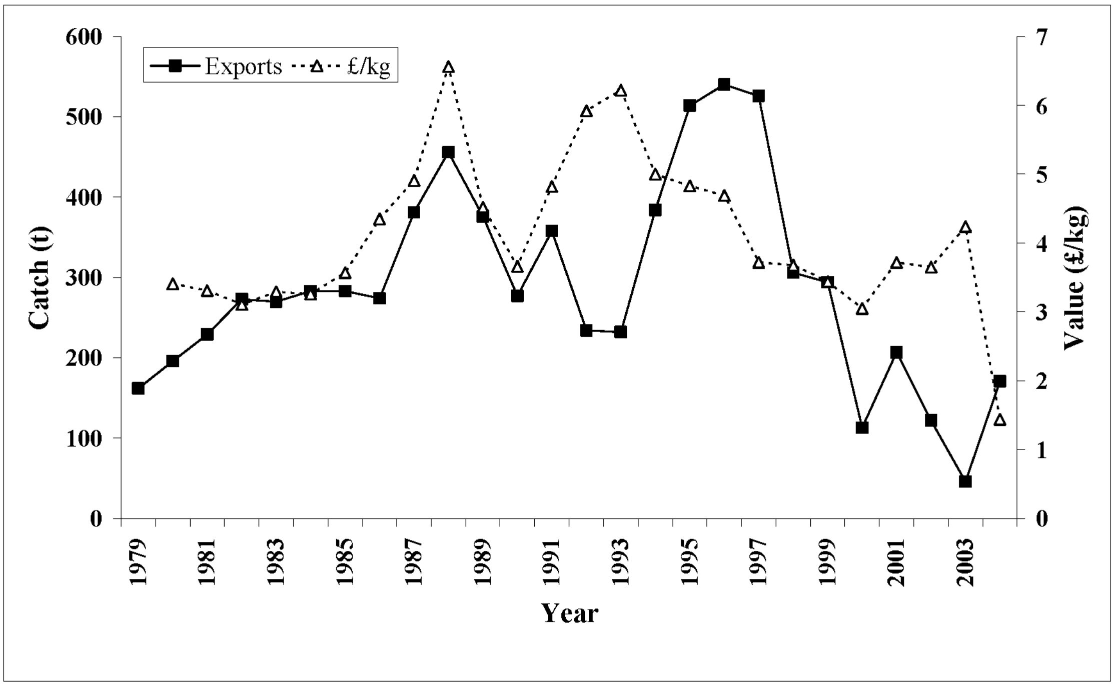


Figure UK.6. England & Wales yellow and silver eel catches (t) from exports and unit value in £/kg, 1979–2004.

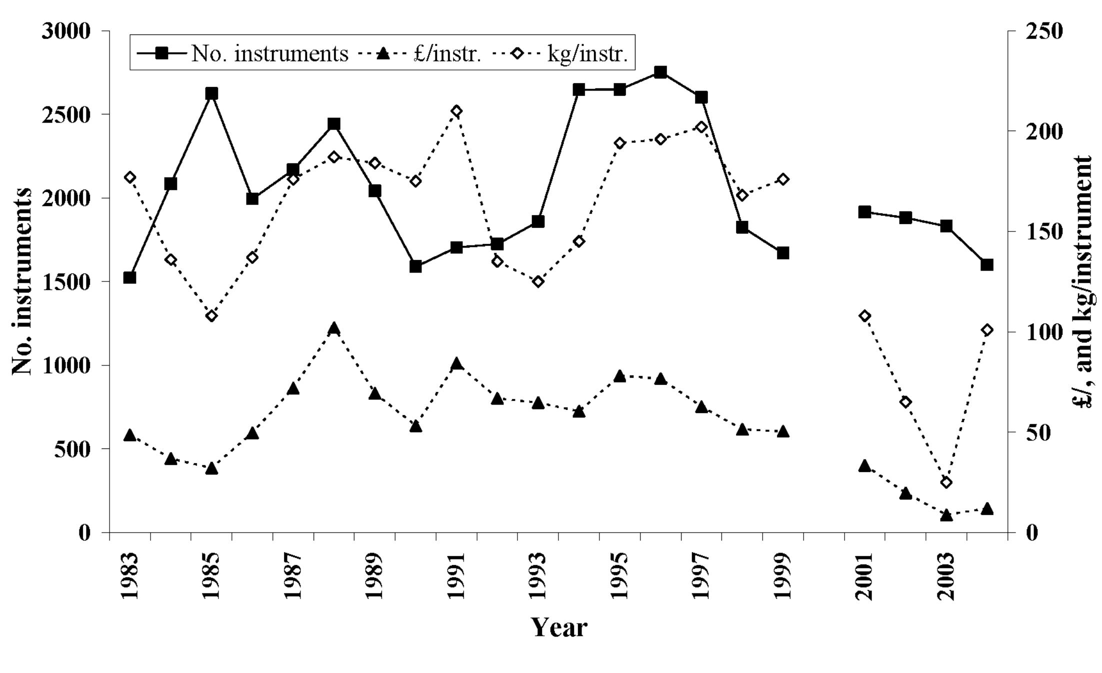


Figure UK.7. England &Wales yellow and silver eel fisheries: number of instruments, kg/ and £/instrument (from exports), 1983–2004.

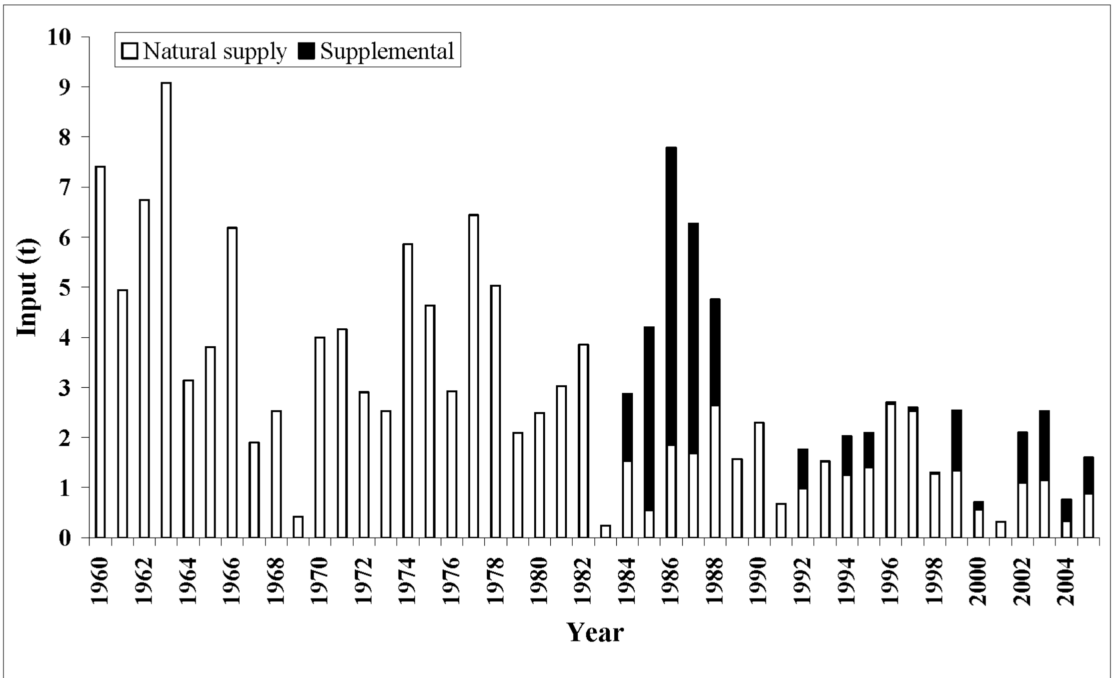


Figure UK.8. Elver supply to Lough Neagh, 1960 to 2005.

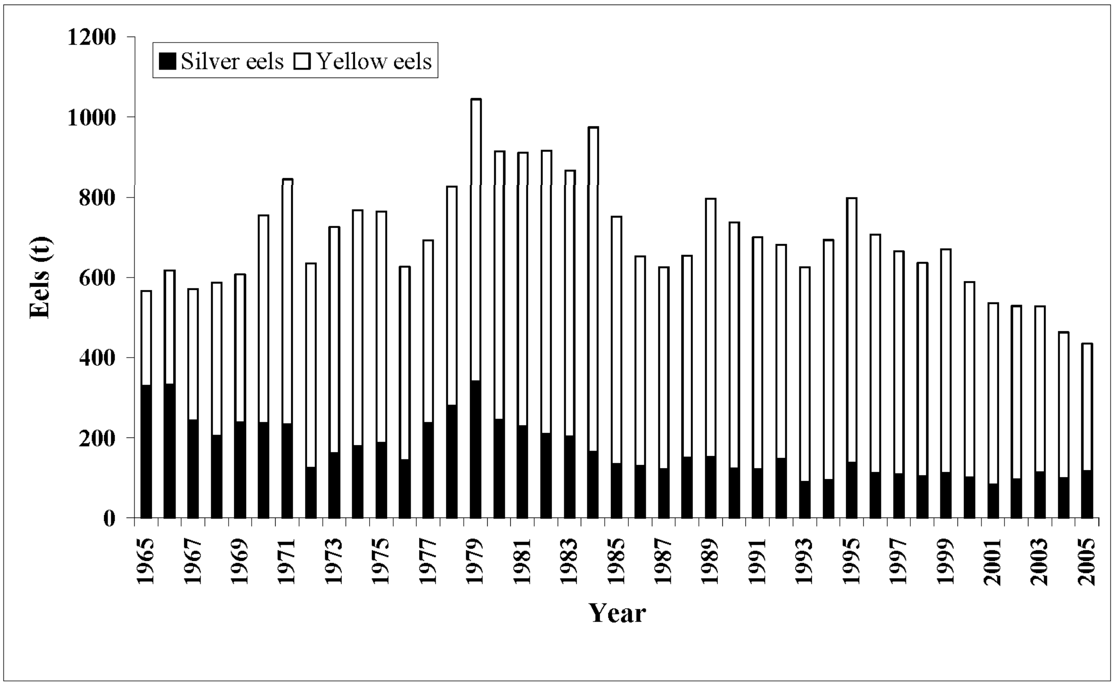


Figure UK.9. Yellow and silver eel catches – Lough Neagh, 1965 to 2005.

Report on the eel stock and fishery in France 2005

FR.A. A uthors

Gérard Castelnaud
Cemagref
50, avenue de Verdun
33616 Cestas Cedex-France
gerard.castelnaud@cemagref.fr

Cédric Briand
Institution d'Aménagement de la Vilaine
56 130 La Roche Bernard-France
cedric.briand@lavilaine.com

Laurent Beaulaton
Cemagref
50, avenue de Verdun
33616 Cestas Cedex-France
laurent.beaulaton@cemagref.fr

Thomas Changeux
Conseil Supérieur de la Pêche
16 avenue Louison Bobet
94132 Fontenay-sous-Bois Cedex-France
thomas.changeux@csp.ecologie.gouv.fr

Patrick Prouzet
IFREMER
Technopôle Izarbel
Maison du Parc
64210 Bidart
Patrick.prouzet@ifremer.fr

Marie-Noelle de Casamajor
CERECA/ADERA
Technopôle Izarbel
Maison du Parc
64210 Bidart
Marie.Noelle.De.Casamajor@ifremer.fr

This report was revised and completed in January 2006. Llast data year depends on location, mostly 2003 but some 2005 (trends)

FR.B. Introduction

The French eel fisheries occur mainly in inland waters (rivers, estuaries, ponds and lagoons) and, for a part (amateur fishermen and poachers), in coastal waters(see Figure FR.1 and table

FR a). The most important glass eel fisheries are found in the Bay of Biscay region. The yellow eel fisheries are found in the same areas, and in addition in some rivers of the Manche region, in the Rhine and tributaries and also in the Mediterranean region where bootlace eel are targeted for exportation towards Italy. Silver eel fisheries are limited to some rivers, mostly in the Loire watershed

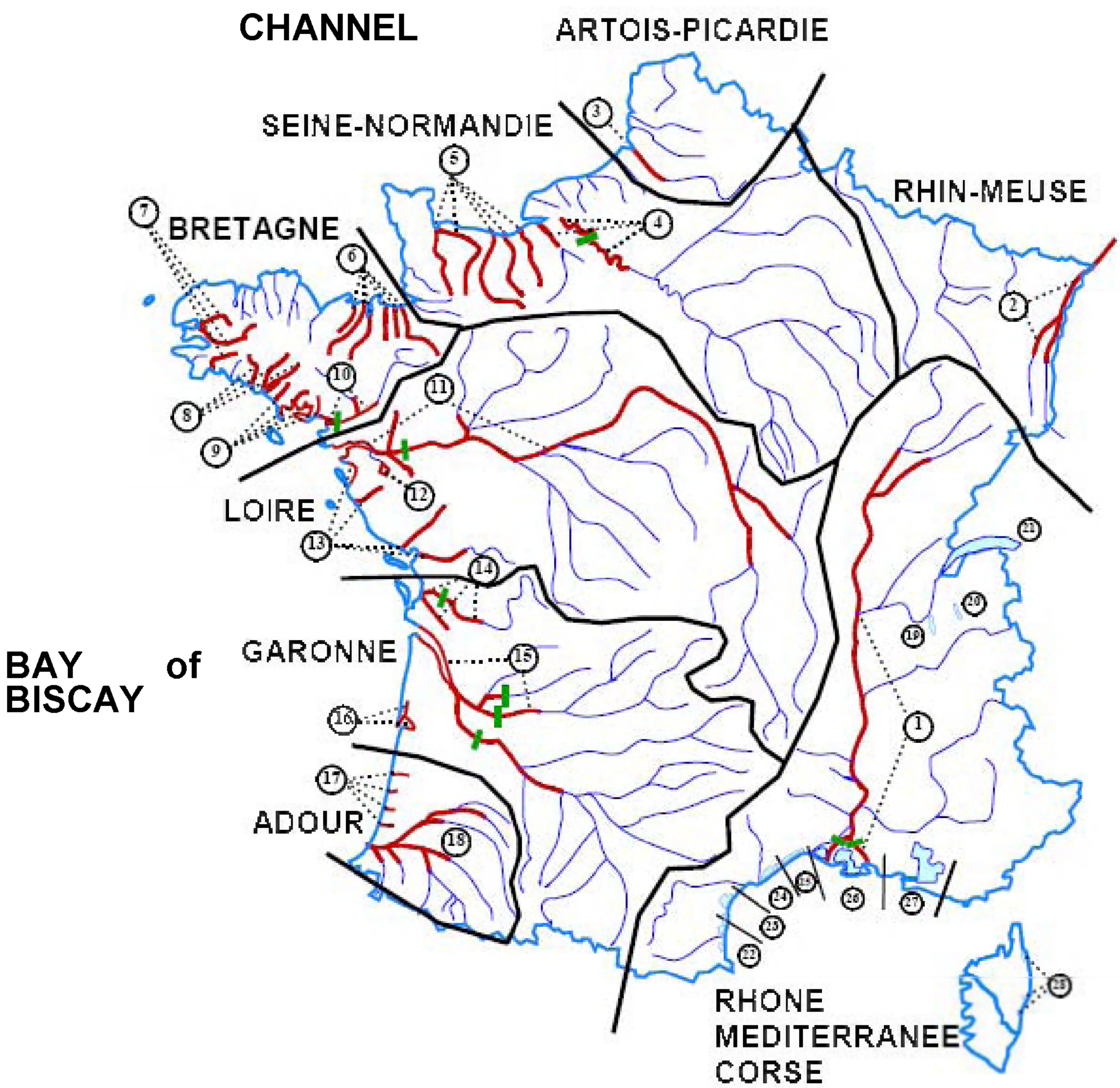
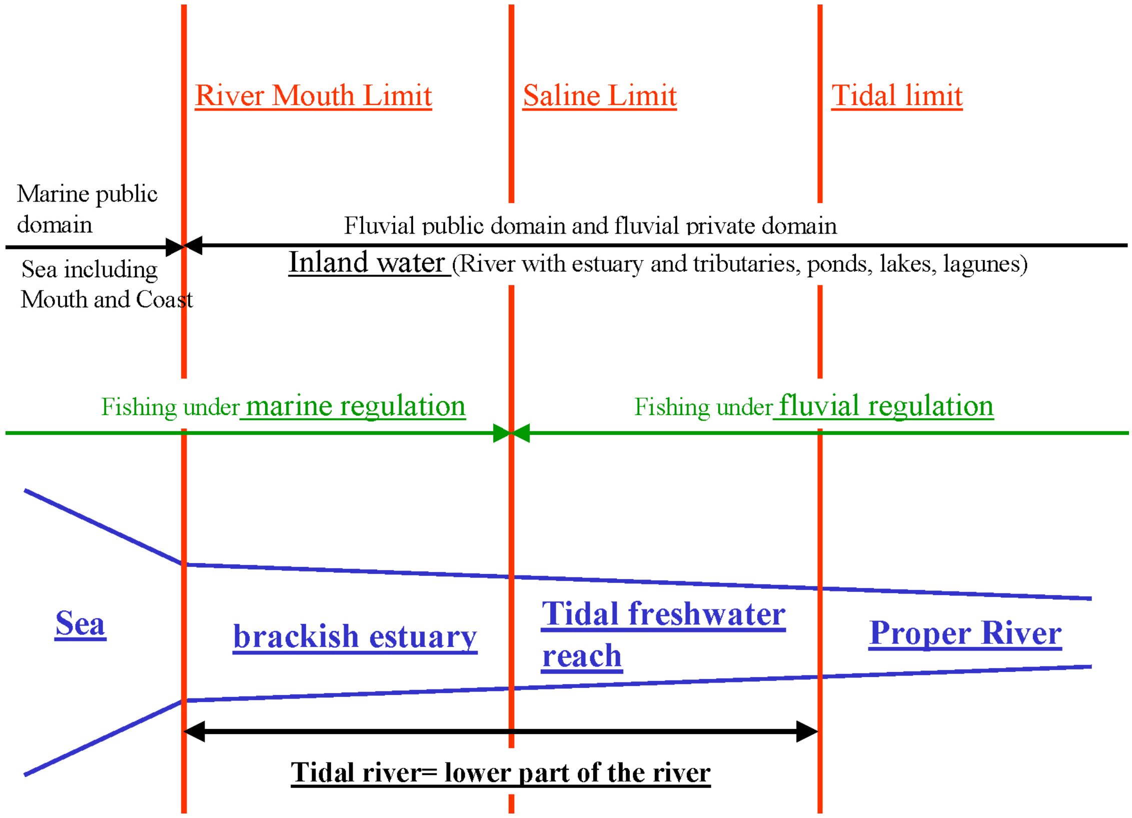


Figure FR.1. Inland waters in France (eel fisheries in red; tidal limits in green). The numbers correspond to the list of fishing zones in Table FR.a.. The COGEPOMI names and limits are in black (redrawn from (CASTELNAUD, 2000)).

Table FR.a. Fishing zones in French inland waters related to the height COGEPOMI (modify from (CASTELNAUD *et al.*, 2000), unpublished data).

(Number from (Figure FR.1) Fishing zone – Surface for lagoons	COGEPOMI
(1) Delta du Rhône	Rhône-Méditerranée Corse
(1) Fleuve Rhône aval et amont, Saône, Doubs	Rhône-Méditerranée Corse
(2) Fleuve Rhin, Ill	Rhin Meuse
(3) Estuaire Somme	Artois-Picardie
(4) Estuaire Seine, Fleuve Seine aval	Seine Normandie
(4) Fleuve Seine amont, Risle	Seine Normandie
(5) Estuaires Touques, Dives, Orne, Aure, Vire	Seine Normandie
(6) Estuaires Couesnon, Rance, Fremur, Arguenon, Gouessan, Gouet	Bretagne
(7) Estuaires Elorn, Aulne, Odet	Bretagne
(8) Estuaires Laïta, Scorf, Blavet	Bretagne
(9) Rivières d'Etel, d'Auray, de Penerf, Golfe du Morbihan	Bretagne
(10) Estuaire Vilaine aval	Bretagne
(10) Estuaire Vilaine amont, Fleuve Vilaine aval, Oust, Chere, Don	Bretagne
(11) Estuaire Loire, Loire aval, Erdre, Sèvre Nantaise	Loire
(11) Fleuve Loire amont, Maine, Mayenne, Allier	Loire
(12) Lac de Grand-Lieu	Loire
(13) Baie de Bourgneuf, Estuaires Vie, Lay, Sèvre Niortaise	Loire
(14) Estuaire Charente, Fleuve Charente aval, Estuaire Seudre	Garonne
(14) Fleuve Charente amont	Garonne
(15) Estuaire Garonne, Garonne aval, Dordogne aval, Isle	Garonne
(15) Fleuve Garonne amont, Dordogne amont	Garonne
(16) Canal de Lège	Garonne
(16) Delta d'Arcachon	Garonne
(17) Courants de Mimizan, Contis, Huchet, Vieux-Boucau	Adour
(18) Estuaire Adour, Fleuve Adour, Nive, Bidouze, Gaves de Pau et d'Oloron, Luy	Adour
(19) Lac du Bourget	Rhône-Méditerranée Corse
(20) Lac d'Annecy	Rhône-Méditerranée Corse
(21) Lac Léman	Rhône-Méditerranée Corse
(22) Etang de Canet - 480 ha	Rhône-Méditerranée Corse
(22) Etang de Salses Leucate - 5800 ha	Rhône-Méditerranée Corse
(23) Etang de Lapalme - 600 ha	Rhône-Méditerranée Corse
(23) Etang de Bages-Sigean - 3700 ha	Rhône-Méditerranée Corse
(23) Etang de Campignol – 115 ha	Rhône-Méditerranée Corse
(23) Etang de l'Ayrolle – 1320 ha	Rhône-Méditerranée Corse
(23) Etang de Gruissan – 145 ha	Rhône-Méditerranée Corse
(24) Etang de Thau – 7500 ha	Rhône-Méditerranée Corse
(25) Etang d'Ingril – 685	Rhône-Méditerranée Corse
(25) Etang de Vic – 1255 ha	Rhône-Méditerranée Corse
(25) Etang de Pierre- Blanche – 371 ha	Rhône-Méditerranée Corse
(25) Etang du Prévost – 294 ha	Rhône-Méditerranée Corse
(25) Etang de l'Arnel – 580 ha	Rhône-Méditerranée Corse
(25) Etang du Grec – 270 ha	Rhône-Méditerranée Corse
(25) Etang Latte-Méjean – 747 ha	Rhône-Méditerranée Corse
(25) Etang de l'Or – 3200 ha	Rhône-Méditerranée Corse
(26) Etang du Ponant – 200 ha	Rhône-Méditerranée Corse
(26) Petite Camargue gardoise – 1200 ha	Rhône-Méditerranée Corse
(26) Etang du Vacares et des Impériaux – 12000 ha	Rhône-Méditerranée Corse
(27) Etang de Berre – 15500 ha	Rhône-Méditerranée Corse
(28) Etang de Palo – 210 ha	Rhône-Méditerranée Corse
(28) Etang d'Urbino – 790 ha	Rhône-Méditerranée Corse
(28) Etang de Diana – 570 ha	Rhône-Méditerranée Corse

From 1999 to 2001, the total number of professional fishermen fishing eel, seeking one or several stages, was about 1,800 with an estimated total catch of 200 tons of glass eels and 900 tons of yellow or silver eels (Castelnaud and Beaulaton unpublished data). Eel is also exploited by a part of the recreative fishermen whose total number is estimated at 3.5 millions (1 million in coastal waters, 2.5 millions in inland waters) (Changeux, 2001). Among them, 20 000 persons (amateur fishermen and anglers) are allowed to use fishing gears targeting eel in freshwater. An unknown number of anglers is also involved in eel exploitation, but their contribution have only been locally assessed (CHANGEUX, 2003). Illegal fishermen are targeting glass eels in the tidal parts of rivers for commercial purpose. Their number and the amount of their catches had never been clearly quantified.



Fishermen category	Marine professional fisherman=MP Marine amateur fisherman with or without boat =MA	Marine professional fisherman=MP River professional fisherman =FP River amateur fisherman with gears with or without boat =FA Anglers (with rods and sometines with gears) =AN
Fishing rights	MP : quota of licences CIPE (quota of glass eels stamps) MA : no licences, gears limited by rules	MP et FP : quota of licences (quota of glass eels stamps) FA : quota of licences AN : rod licence and quota of licences for gears

Figure FR.2. Inland waters and fisheries limits, fishermen categories and fishing rights by zones (Castelnaud and Beaulaton, 2005, unpublished data).

The administrative saline limit separate two different fishery regulations (see Figure FR.2), marine and fluvial (freshwater). The marine fisheries are located in coastal water, in brackish estuaries and in the Mediterranean lagoons. The freshwater fisheries are located upstream from the saline limit and comprise rivers, lakes, ponds, ditches and canals. In large estuaries there is a special zone, called the "tidal freshwater reach", located between the saline limit and the tidal limit, where some marine professional fishermen can fish along with river fishermen while these are not allowed to go downstream the saline limit.

A system of licenses and glass eel stamps with quotas is set up for marine fishermen and river fishermen in inland waters. In coastal waters, recreative fishermen are not controlled by licenses. In the Mediterranean lagoons, there are also limitations in the number of marine professional fishermen and fishing capacities but no system of licences.

In the rivers under fluvial regulation, the licenses are delivered to fishermen by the local Fisheries Administrations in connection with the fishing authority "Conseil Supérieur de la pêche". The regulation systems in brackish estuaries and Mediterranean lagoons are the result of a long term process of negotiation between fishermen organizations (respectively "Commission des poissons Migrateurs et des Estuaires" and "Prud'homies") and Fisheries Administrations.

To manage the migratory species and their fisheries all along the watershed (under marine and fluvial regulation), special organizations, called "Comités de Gestion des Poissons Migrateurs" (COGEPOMI), have been created in 1994. There are 8 COGEPOMI, one for each important group of basin: Rhine-Meuse, Artois-Picardie, Seine-Normandie, Bretagne, Loire, Garonne, Adour and Rhone-Méditerranée-Corse (see Figure FR.1 and Table FR.a). They gather representatives of fishermen organizations, administrations and research centers. Each COGEPOMI propose a management plan and funding every five years and has to monitor them. The plan determines conservation and management actions, restocking operations, propose fishing regulations, etc for both recreational and professional fisheries.

Until now, these management plans did not aim at achieving a particular escapement rate for eel, and the results of management actions have not really been evaluated. While this system allows a global approach, and tries to solve environmental problems such as dam or turbine mortality, it does not give for the moment, a consistent management basis for eel at the national level by lack of central regulation and designing of practical management rules. Recently, the ministers in charge of eel management have asked the scientific community to propose the basis of a national plan on eel management, suitable at the River Basin District level.

FR.C. Fishing capacity and fishing effort

FR.C.1 Fishing capacity and fishing effort of the glass eel fisheries

Glass eel amateur and professional fisheries are authorized only in the Bay of Biscay and Manche regions. They are forbidden in the Mediterranean region.

Fishing capacity

The professional glass eel fishing gear is variable from an estuary to another (**see Table FRc**). The glass eel fisheries involve pure estuarine or river professional fishermen, coastal professional fishermen and some shellfish farmers (Champion and Perraudeau, 2000).

The river and estuarine professional fishermen have small boats, 18 years old, 6.5m long, 2.5 TJB de jauge, 41 kW. They are handled by a mean number of 1.1 fishermen. Others types of boat are used by coastal marine professional fishermen for glass eel like "trawlers", "scrappers". Those are larger and more powerful boats (Caill-Milly, 2001).

The main part of river, estuarine and coastal amateur fishermen are fishing from the banks with small handed scoop nets but some river amateur fishermen use boats (**see fishing effort section D for more details).**

Licenses and number of fishermen

For marine professional fishermen the quota of seasonal license for glass eel has been limited to 1137. Between 1999 and 2005, the total number of licenses delivered was comprised between 900 to 1,000. There were 930 marine professional fishermen fishing glass eel in 1997 (Castelnaud *et al*., 2000) and around 1050 in the last evaluation (Table FR.b: the total number of marine professional fishermen is higher than 1000 licences, probably because one licence permit with stamps to fish in several estuaries or because some fishermen fish without licence). For river professional fishermen, during the same period, the number of seasonal licenses has decreased from 430 to 360 (from (Briand *et al.*, 2005), 432 licences in 2000 were distributed as: 186 Adour, 147 Loire, 26 Charente, 77 Gironde). In fact there were 300 river professional fishermen fishing glass eel in 1997 (Castelnaud *et al.*, 2000) and 241 in the last evaluation (Table FR.b; the difference between number of licences and number of river fishermen is the number of licences delivered to marine professional fishermen who can fish in the tidal freshwater reach under fluvial regulation; see Figure FR.2).

For legal river amateur fishermen, the number of licenses has decreased from 541 to 312 from 1999 to 2004.

Finally a total mean number of about 1300 professional fishermen has been evaluated during the period 1999–2001 and this figure has not changed much these last years (**table FRb**).

Table FR.b. Mean number of glass eel professional fishermen per basin from 1999 to 2001. Source CSP, CRTS, Cemagref; except [a] year 1989 Castelnaud *et al.*, 1994; [b] year 1997, Castelnaud *et al.*, 2000; [c] year 2000, Cuende *et al.*, 2002.

COGEPOMI	FISHING ZONE	MARINE PROFESSIONAL	FLUVIAL PROFESSIONAL	TOTAL
Artois-Picardie/Seine-Normadie	Manche - Seine-Normandy	10[a]		**10**
Bretagne	Bretagne (Vilaine excluded)	86[a]		**86**
Bretagne	Vilaine	131		**131**
Loire	Loire	278	50[b]	**328**
Loire	Vendée	209		**209**
Garonne	Charente-Seudre	163	24	**187**
Garonne	Gironde	75	75	**150**
Garonne	Arcachon	42		**42**
Adour	Adour + courants landais	57	92[c]	**149**
	Total France	**1051**	**241**	**1292**

Fishing effort

The classical and basic gear used to fish glass eel is the scoop net of different sizes and shape, handed from the river bank for amateur fishermen (1 scoop net of small size), handed from a boat for professional fishermen (1 scoop net of large size and oval) or pushed by a boat (2 scoop net large size and circulars). They are called “pibalour” when they are rectangular, wider and pushed by a boat.

For amateur fishermen, the scoop net dimension is 0.19 m^2 in all basins. (Table FR.c).

Fishing effort is determined by the number of boats/ fishermen and the size of nets which varies with the fishermen categories and the fishing zone.(Table FR.g) (CASTELNAUD, 2002). It depends also on the speed and power of the boat and the fishing duration.

Table FR.c. Size and dimensions of the nets allowed in the French inland waters to professional fishermen. The numbers in bracket correspond to the COGEPOMI in Figure FR.1 (source Castelnaud, 2002).

TYPE	SHAPE	TOTAL FISHING SURFACE (2 NETS)	BASINS AND REGULATIONS, M=MARINE , F=FRESHWATER; COGEPOMI
Push net	Circular	2.262 m²	Nord pas de Calais (m), ARTOIS-PICARDIE Picardie (m), ARTOIS-PICARDIE Normadie (m), SEINE-NORMANDIE Bretagne (m), BRETAGNE Loire (m + f), LOIRE Baie de Bourneuf (m), LOIRE Garonne, Dordogne, Isle (f), GARONNE Adour (f), ADOUR
Large push net (Pibalour)	Rectangular	8 to 14 m²	Gironde (m), GARONNE Charente (m), GARONNE Seudre (m), GARONNE
Handed scoop net	Oval	Close to 2.262 m	Arcachon (m), GARONNE Garonne, Dordogne, Isle (f), GARONNE Courants Landais, Adour (m), ADOUR
Push net	Square	2.88 m²	Lay (m), LOIRE
Push net	Rectangular	4.32 m²	Sèvre Niortaise (m), LOIRE
Push net	Rectangular	3.60 m²	Vie(m), LOIRE

The poachers can use the different gears and techniques described but also special poaching devices like very large nets called “chaussette” or passive traps called “caisse à civelles” (see (Luneau *et al.*, 2003) for more details).

FR.C.2 Fishing capacity and fishing effort of yellow eel fisheries

Yellow eels are not under specific quotas. Fishermen often target yellow and silver eels indistinctly.

Mediterranean fisheries

Since 1988, the number of 400 to 500 marine professional fishermen targeting eel in the Mediterranean lagoons has been regularly announced. Nevertheless, a strong decrease of the population has been noticed: 63% between 1969 and 1994 on the Palavasiens lagoons (25, see Table FR.a) (Ruiz, 1994) and 33% between 1986 and 1996 on the Gruissan and Bages-Sigean lagoons (Loste and Dusserre, 1996; Dusserre and Loste, 1997). The most reliable data are collected by the Cépralmar in the Languedoc-Roussillon region which yield the main part of French Mediterranean eels and totalise 430 marine professionnal fishermen targeting eel in 2002 (Loste and Dusserre, 1996; Dusserre and Loste, 1997; Cepralmar, 2003)

The more recent evaluation (Castelnaud *et al.,* 2000) estimates that 513 marine professional fishermen were fishing for eel in 1997, in all the French Mediterranean lagoons (table FR e).

Atlantic coastal fisheries

On the Atlantic coast, (Désaunay and Aubrun, 1988) described in the past an important fishery of yellow eel by trawling This activity nowadays is unreported or has collapsed (Table FR.d). Recently, there might have been changes in eel exploitation in connection with the new use of fyke nets.

Table FR.d. Number of boats fishing eels on the Atlantic and Channel coasts. Source 1 Désaunay nd Aubrun, 1988; 2 Champion and Perraudeau, 2000; 3 Sauvaget *et al.*, 2001.

COGEPOMI	FISHING ZONE	1986 NB BOAT (1)	1997 NB BOAT (2)	2000 NB BOAT (3)
Artois-Picardie	Manche	9	?	
Seine-Normandie	Seine-Normadie	7	2 to 3	
Bretagne	Bretagne-Sud	5		9
Bretagne	Vilaine	3		
Loire	Loire	115		
Loire-Garonne	Vendée-Charente	80 to 90		
Garonne	Arcachon	2		

Among the one million of coastal anglers (Changeux, 2001), an unknown number is supposed to catch eel.

Inland fisheries

The inland fisheries are scattered and involve professional fishermen, amateur fishermen with gears and anglers with rods.

Whatever the category, the number of fishermen has been decreasing since 1987 (Briand *et al.*, 2005).Only a part of the 450 professionals fishermen fishing diadromous species in inland waters target eel at yellow and silver stages (Castelnaud, 2000), their number is evaluated at 227 marine and 99 riverine professional fishermen (Table FR.e). Among this number, 128 marine professional fishermen and two third of fluvial fishermen also target glass eel.

Table FR.e. Mean number of yellow eel professional fishermen per fishing zone from 1999 2001(Source CSP, CRTS, Cemagref; except [a] 1997, Castelnaud, 2000;[b] 2000, Sauvaget, 2001).

COGEPOMI	FISHING ZONE	MARINE PROFESSIONAL	FLUVIAL PROFESSIONAL	TOTAL
Artois-Picardie/Seine-Normadie	Manche - Seine-Normandy	5(a)	1	**6**
Bretagne	Bretagne (Vilaine excluded)	13(b)		**13**
Bretagne	Vilaine	2	1	**3**
Loire	Loire	16	28	**44**
Loire	Grand Lieu			**0**
Loire	Vendée	5		**5**
Garonne	Charente-Seudre	1		**1**
Garonne	Gironde	30	42	**72**
Garonne	Arcachon	42		**42**
Adour	Adour + courants landais	14	10	**24**
Rhône-Méditerranée-Corse	Rhone		4	**4**
Rhin-Meuse	Rhin		8	**8**
Rhône-Méditerranée-Corse	Méditerranée	513	5	**518**
	Total	**641**	**99**	**740**

FR.D. Fishing effort

The main fishing gear used in Mediterranean lagoons is a fyke-net (mesh size 10 mm) transformed with wings (“ganguis”) and with three chambers (“capéchade”). In some places, fixed fisheries are made of batteries of fyke nets. These fixed fisheries have to let a passage for the migration from the lagoons to the sea of euryhalines species which are mostly captured (sea-breams in particular).

In inland waters, the eel pot (10 mm mesh size minimum, last entrance larger than 40 mm) is the common fishing gear used by all categories of fishermen The shapes are very diversified according to the basin and also the fishing zone; the eel pots are not always baited. The fyke-net is also used by the professionals only, with a 10 mm mesh size minimum. A barrier can be associated. Others gears exist: deep-lines, lift nets, "vermée" for anglers….

FR.C.3 Fishing capacity and fishing effort of sivler eel fisheries

If we do not consider the Mediterranean fisheries, the only significant fishery of silver eel is in the Loire basin, with 11 fishermen using a special gear called "dideau". This gear was introduced in large rivers from the Netherlands in the early 20th century. It is a sort of trawl used from a fixed boat. The net measures 25 m of length with a mouth of 10 m width and 5 m height. The mesh size starts at 16 cm at the mouth and ends at 10 mm.

In 2002 the special five years authorizations for fishing silver eel in private waters were stopped by the local fishery administration (extinction in 2006; more than 200 authorizations existed yet in 2000 from Changeux, 2001).

FR.E Catches and Landings

FR.E.1 Catches and Landings for glass eels & yellow eel

In 1999 the production of glass eels was estimated at 255 tons, with a turnover of 35.2 millions euros in the whole French basins (Table FR. f).The historical analysis of the series of captures concerning the main landing areas of the Atlantic coast highlights a fall of the glass eel productions starting in the eighties.

Table FR. f Estimation of the total glass eel production and the number of fishermen in France from 1970 to 2000. (MP: Marine professional fishermen, PF: professional river fishermen, River and Marine non-pro: river and marine amateur fishermen); (1) unknown number of marine amateur fishermen to be added; (2) marine amateur fishermen included; (3) comprising 110 t from marine amateur fishermen; (4) number of licenses delivered; (5) unpublished data.

YEAR	1970	1979	1986	1989	1999	2000
Production MP (t)	450	1175		300	225	180
Production PF and river non-pro f(t)	895	675		110	30	16,6
Total Production (t)	1345	1850	500	520 (3)	255	196,6
Mean price /kg (€)	2,75	5,65		61	138	120
Total value (M€)	2,74	10,44	12,5	30,5	35.2	
Number MP(1)	648	964	850	886	936	970 (4)
Number PF and River non-professionals	2424	2588	4000(2)	1512	761	671
Number Marine non-pro	(1)	(1)		2055	109	(1)
Origin of the data	Popelin (1971)	CIPE (1982)	Desaunay et Aubrun (1988)	Castelnaud et al (1989)	Castelnaud (2002) Castelnaud et al (2003) (5)	Castelnaud et al (2003) (5)

In addition, as gaps and under-evaluated figures were found in the FAO database, a more realistic temporal series was built by biological stages (glass eel, yellow+ silver eel) and sectors. It was based on the annual results produced by the punctual scientific investigations (years available in Table FR.g) and the extrapolation of the results obtained in the main basins monitored (Adour, Gironde, Loire and Vilaine).

Table FR.g. Glass eel catches in the large French basins. MP: marine professional fishermen, PF: river professional fishermen, Non professional: amateur fishermen; (1) numbers in black= estimations by extrapolation.

	Professional fishermen catch (tons)								Non professional fishermen catch (tons)			
Season	Adour		Gironde		Loire		Vilaine	Total (1)	Adour	Gironde	Loire	Total (2)
	MP	FP	MP	FP	MP	FP	MP					
1978			27	83	514	12	106	**1484**		108		**647**
1979			28	90	620	22	209	1850		116		**697**
1980			46	167	508	18	95	**1667**		217		**1303**
1981			45	78	288	15	57	**967**		151		**904**
1982			50	37	261	13	98	**917**		36		**219**
1983			49	26	241	19	69	**808**		27		**161**
1984			31	26	168	15	36	**550**		26		**156**
1985			16	12	145	9	41	**446**		12		**71**
1986	8		26	14	113	10	53	**432**		14		**87**
1987	10		32	25	131	14	41	**486**		29		**172**
1988	12		25	7	165	12	47	**511**		7		**40**
1989	9		38	16	78	9	37	410		17		110
1990	3	4	29	9	81	16	36	**338**		9		**54**
1991	2	4	36	10	31	5	15	**193**		14		**87**
1992	8	12	17	8	32	7	30	**188**		13		**77**
1993	6	7	30	12	80	11	31	**325**		22		**130**
1994	3	7	35	7	95		24	340	18	12	0	**74**
1995	8	4	47	10	127	6	30	**439**	10	19	0	**113**
1996	4	3	21	4	73	8	22	**257**	12	4		**25**
1997	5		33	11	67	4	23	**276**	6	6		**39**
1998	2	7	14	2	61		18	**189**	7	1		**6**
1999	4	2	41	8	80	7	15	255	2	3	1	**16**
2000	10		21	4	74	6	14	197		0	1	**2**
2001			9	0	33	3	8	106		0	0	**1**
2002			28	9	42	8	16	206		6		**37**
2003			**9**	**1**	53	4	9	151				
2004			**9**	**1**	20		8	76				
2005			**11**	**6**	**17**	3	7	88				

This work leads to the following **Error! Reference source not found.** providing data of professional and amateur fishermen (anglers excluded) corresponding to:

- glass eel landings in inland waters from 1978 to 2001,
- yellow and silver eel landings in inland waters from 1986 to 2001 and in the Mediterranean lagoons from 1983 to 2001;
- eel production in France compared to uncorrected data registered by FAO.

Table FR.h. Estimate of capture of glass eels and yellow eels (few silver eel fisheries) in France and comparison with FAO database (Fishstat).

stage	glass eel	yellow eel (+silver)	yellow eel (+silver)	yellow eel (+silver)	all stages	all stages
area	inland water	inland water	mediterranean lagoons	France	France	France - FAO
1978	2 131					
1979	2 547					
1980	2 970					
1981	1 871					
1982	1 135					
1983	969		1 700			
1984	706		1 810			
1985	516		1 501			
1986	518	720	1 224	1 944	2 462	2 687
1987	658	700	1 362	2 062	2 720	1 978
1988	551	700	1 565	2 265	2 816	2 109
1989	520	440	1 306	1 746	2 266	1 672
1990	392	380	1 398	1 778	2 170	1 674
1991	280	380	1 265	1 645	1 925	1 450
1992	264	380	941	1 321	1 585	1 164
1993	456	380	900	1 280	1 736	864
1994	414	380	900	1 280	1 694	607
1995	552	380	900	1 280	1 832	320
1996	282	380	900	1 280	1 562	403
1997	314	323	900	1 223	1 537	1 782
1998	195	250	900	1 150	1 345	449
1999	248	105	900	1 005	1 253	289
2000	214	86	900	986	1 200	399
2001	101	102	900	1 002	1 103	415

FR.E. Landings per sector

The mean production of glass eel is given for the recent period 1999-2001 by fishing sectors in **Table FR. i.**

Table FR. i . Mean landings in tons of Glass eel per sectors of the period 1999–2001 (Sources: CSP-SNPE, CRTS, Cemagref, Affaires maritimes except for *, period 1994–1998).Number of fishermen corresponding in table section C.

COGEPOMI	Fishing sectors	Marine and river professionals	River amateurs
Artois-Picardie/Seine-Normandie	Manchel - Seine-Normandie	2.7*	
Bretagne	Bretagne (Vilaine excluded)	?	
Bretagne	Vilaine	12.5	
Loire	Loire	70.3	0.6
Loire	Vendée	26.4	
Garonne	Charente-Seudre	18.9	
Garonne	Gironde	27.6	1.0
Garonne	Arcachon	?	
Adour	Adour + courants landais	15.5	0.4
	Total	**173.9**	**2**

The mean production of yellow eel is also given per fishing sectors globally for the same period (Table FR.j).

The catches of angler's are considered in a single area (Lower part of the Loire river (Changeux, 2003). They also seemed important when studied in Normandie (Marais de la Douve) (Michelot, 2005).

Table FR.j . Mean landings in tons of Yellow eel per sectors of the period 1999–2001 (Source CSP, CRTS, Cemagref; except for [a] 2000–2002, Changeux, 2003a,[b] 1997, Robion et Adam, 1997 (unpublished),[c] 1997, (Castelnaud, 2000), [d] 1996, CRTS com pers. Number of fishermen corresponding in table section C.

COGEPOMI	FISHING SECTORS	MARINE AND RIVER PROFESSIONALS	RIVER AMATEURS	ANGLERS
Artois-Picardie/Seine-Normandie	Manche- Seine-Normandie	? + 0.5		
Bretagne	Bretagne (Vilaine excluded)			
Bretagne	Vilaine	0.8	2.7	
Loire	Loire	49.6	30.2	39[a]
Loire	Grand Lieu	36.0[b]		
Loire	Vendée	15	2.4	
Garonne	Charente-Seudre	3.3	2.1	
Garonne	Gironde-Garonne-Dordogne	27.1	7.3	
Garonne	Arcachon	21		
Adour	Adour + courants landais	3.3	1.1	
Rhône-Mediterranée-Corse	Rhone	18.8	0.6	
Rhône-Mediterranée-Corse	Méditerranée (lagoons)	900	?	
Rhin-Meuse	Rhin	2.7	0.3	
	Total	**>1078**	**46.7**	**>39**

Some historical data on yellow eel landings are available for 1986 (**Table FR.k**).

Table FR.k. Historical Yellow eel landings of the coastal eel fishery, Atlantic and Manche régions (Désaunay and Aubrun, 1988).

COGEPOMI	FISHING ZONE	1986
Artois-Picardie	Manche	25
Seine-Normandie	Seine-Normadie	40 to 60
Bretagne	Bretagne-Sud	10
Bretagne	Vilaine	10
Loire	Loire	?
Loire-Garonne	Vendée-Charente	60
Garonne	Gironde	
Garonne	Arcachon	2
Adour	Adour et Courants landais (d)	

Concerning Mediterranean lagoons the eel catches have reached 2000 t/yean during the 1980's (Table FR.l). They have decreased progressively to 900 tons in 1998 (200 t for Camargue and Corsica and 700 t for Languedoc-Rousillon) and now seem to be stable. The table FR gather the data available on marine professional fishermen and productions of eel (yellow and silver) in the different lagoons. The total of captures registered was around 730t, which is less than the total announced by (Vergne *et al.*, 1999) because these authors also referred to commercial data.

Table FR.l. Total production from Mediterranean lagoon fisheries from various authors. (Ximenes *et al.*, 1990; Ruiz, 1994; Loste and Dusserre, 1996; Dusserre and Loste, 1997).

Sectors	Lagoons	Number of fishermen	eel captures	References
Etangs du Roussillon	(22) Etang de Canet	10	?	Prud'homie
	(22) Etang de Salses Leucate	40	100t	Prud'homie
Etangs du Narbonnais	(23) Etang de Lapalme	2	?	Loste et Dusserre (1996), Prud'homie
	(23) Etang de Bages-Sigean	28	120t	
	(23) Etang de Campignol	22	50t	Dusserre et Loste (1997)
	(23) Etang de l'Ayrolle			
	(23) Etang de Gruissan			
Etang de Thau	(24) Etang de Thau	290	120t	Vergnes et al. (1999), Mazouni (1999)
Etangs Palavasiens	(25) Etang d'Ingril	38	47t	Ruiz (1994)
	(25) Etang de Vic			
	(25) Etang de Pierre- Blanche			
	(25) Etang du Prévost			
	(25) Etang de l'Arnel			
	(25) Etang du Grec			
	(25) Etang Latte-Méjean			
	(25) Etang de l'Or			
Etangs Camarguais	(26) Etang du Ponant	8	?	Prud'homie
	(26) Petite Camargue gardoise	15	?	Prud'homie
	(26) Etang du Vacares et des Impériaux	20	40t	Vergnes et al. (1999)
Etang de Berre	(27) Etang de Berre	30	150t	Vergnes et al. (1999)
Etangs de Corse	(28) Etang de Palo	10	87t	Ximenes et al. (1990), Ximenes (com. pers.)
	(28) Etang d'Urbino			
	(28) Etang de Diana			

FR.E.2. Restocking

No restocking recorded at the central level

FR.E.4. Aquaculture

No data

FR.E.5. Catch of Recreational Fisheries

See FRE1 table FR.h

FR.F. Catch per Unit of Effort

FR.F.1. Glass eel CPUE in the Gironde basin

The Gironde basin is the tidal part (see Figure FR.2) of the Garonne basin, comprising the brackish estuary and the tidal freshwater reach of the Garonne river, Dordogne river and of its tributary, the Isle river.

One of the notable features of the glass eel fishery in the Gironde during the 1978–2003 period is the major shift from scoop net catches in favor of large push net catches (). The fishery is presently very largely a large push net fishery in the estuary, whereas formerly it was a mixed-gear fishery in both the brackish and fresh estuary.

After a strong decrease of the glass eel abundance in the Gironde basin between 1981 and 1985, the situation at present seems stationary, at a very low level (Figure FR.3). The 2003 season is close to the worst historical level (2001).

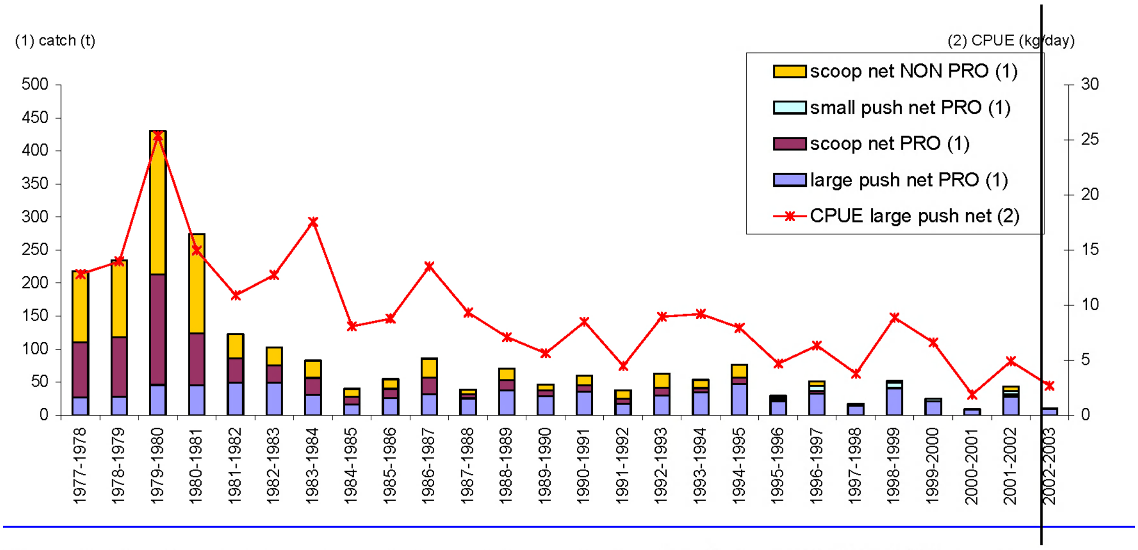


Figure FR.3. Cumulated capture of glass eel for professional and non professional fishermen, CPUE on the Gironde basin for1978–2003 (Source: Cemagref)

The use of GLM model with these fishery data has permitted to correct the variation of catches and effort between fishermen. The glass eel CPUE in the Gironde is a valid abundance index, the same trend is obtained for two metiers (large push net and scoopnet) and two zones (brackish and fresh estuary) (Beaulaton and Castelnaud, in press-b). This result confirm the decreasing trend of glass eel in the Gironde basin (Figure FR.4)

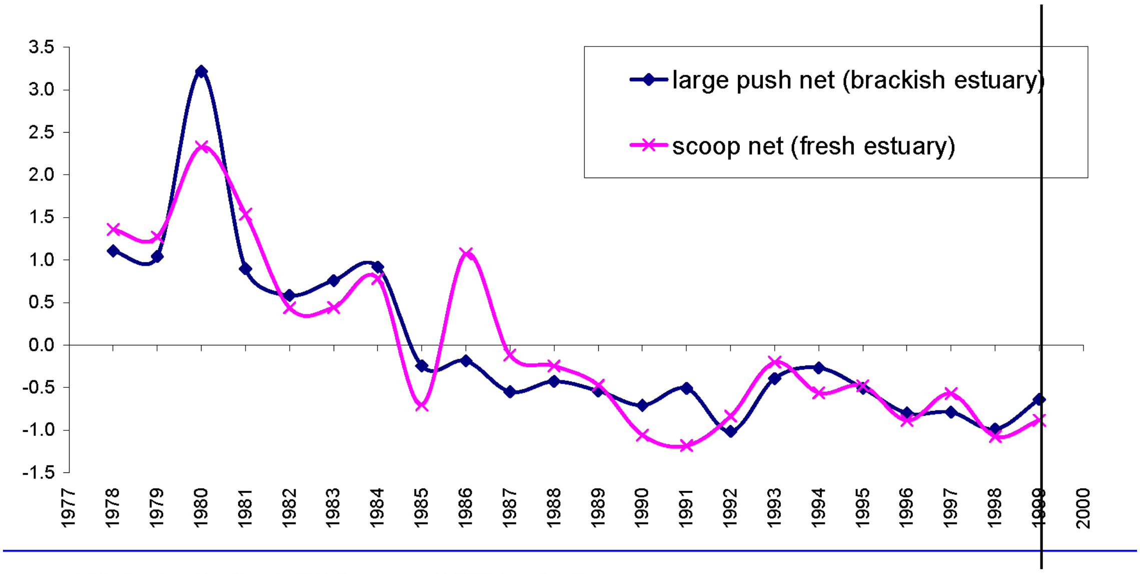


Figure FR.4. Standardized CPUE (from GLM) for the large push net (*Pibalour*) and the scoop net (*Tamis*) metiers for the period 1978–1999 (Beaulaton and Castelnaud, in press-a)

FR.F.2. Yellow eel CPUE in the Gironde basin.

The eel pot CPUE for yellow eel has falled down between 1988 and 1989, slightly increased until 1998 before decreasing again until 2003 (Figure FR.5). The total catches have decreased while the number of fishermen has also decreased. But changes in the fishing power and in the tactics have increased the real effort and our effort unit does not reflect these changes. Consequently, this CPUE is not fully representative of the real current tendency of the abundance which presents certainly a more marked decrease.

To analyse this situation, we are setting up a biological sampling through the professional fishery (2004 and 2005). This sampling will permit to precise the effort parameters, the stock structure and the fishing impact on the stock. If this study is maintained during several years, it will be possible to evaluate the magnitude of the yellow eel stock with VPA methods (Sparre, 1979; Ardizzone and Corsi, 1985; Gascuel and Fontenelle, 1994; Dekker, 2000).

We will also apply GLM methods on eel pot CPUE, to precise and verify the tendency of yellow eel abundance.

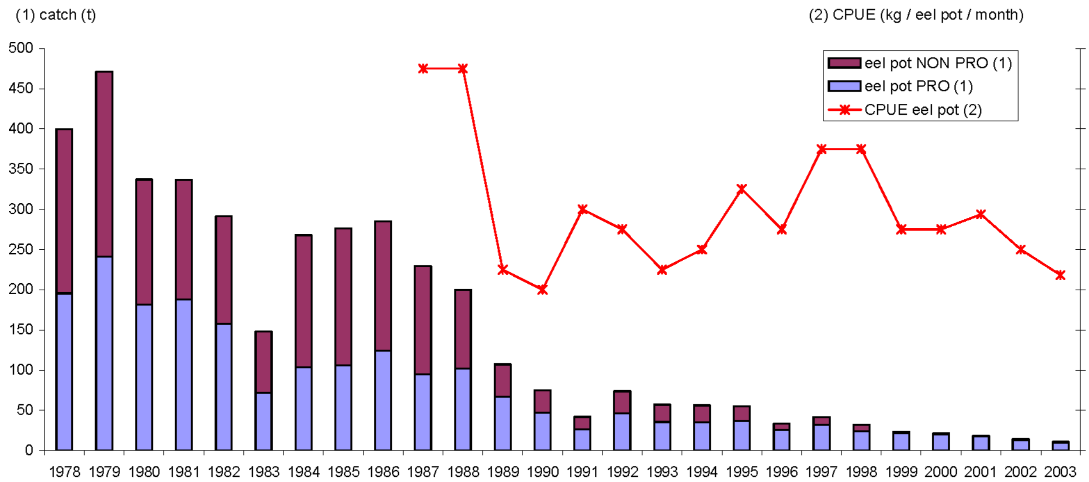


Figure FR.5. Cumulated catch of yellow eel for professional and non professional fishermen, CPUE on the Gironde basin for 1978–2003 (Source: Cemagref).

FR.F.3. Glass eel CPUE in the Adour basin.

Table FR.m. Mean, maximum minimum annual CPUE (Kg/trip) for the glass eel fishery (hand nets) in the Adour estuary.

YEAR	CPUE MEAN	CPUE MIN	CPUE MAX	YEAR	CPUE MEAN	CPUE MIN	CPUE MAX
1927/1928	5	4.7	5.3	1984/1985	2.4	1.5	3.3
1928/1929	5.5	4.4	7	1985/1986	1.5	0.6	2.1
1929/1930	6.7	4.3	9.9	1986/1987	3.3	0.3	5.3
1930-1931	18.7	10.1	35.2	1987/1988	3.7	1.4	5.6
				1988/1989	4.1	0.9	6.2
1965/1966	5.1	1.3	8.8	1989/1990	1.2	0.2	2.1
1966/1967	6.4	4.1	9.7	1990/1991	0.7	0.15	1.1
1967/1968	10.1	3	23.3	1991/1992	2.9	0.4	4.4
1968/1969	5	0.9	7.8	1992/1993	2.4	1.3	2.3
1969/1970	7.5	3.6	11.2	1993/1994	1.4	0.8	1.9
1970/1971	4.6	2.9	5.6	1994/1995	2.6	0.85	3.9
1971/1972	4.4	1.5	7.8	1995/1996	1.53	0.75	1.8
1972/1973	4.5	3.5	6.8	1996/1997	1.6	1.13	1.97
1973/1974	7.4	4.3	12.3	1997/1998	1.07	0.49	1.31
1974/1975	5	2.2	7.9	1998/1999	1.82	1.05	2.21
1975/1976	11	3.3	16	1999/2000	4.43	2.77	4.34
				2000/2001	0.49	0.53	1.05
1978/1979	10			2001/2002	0.89	0.48	1.23
1979/1980	5			2002/2003	0.31	0.09	0.45
				2003/2004	0.6	0.9	0.2

FR.F.4. Comparison of yellow eel CPUE between the Adour and the Gironde basins.

The exploitation of the yellow eel in the Adour and the Gironde basins can be compared with two long historical series (Figures FR.6 and 7). The Adour data concern marine professional fishermen (source: Ifremer) and the Gironde data correspond to marine and river professional fishermen (source: Cemagref). Catches have significantly decreased from 1978 to 1986 (Gironde data) mainly because of a strong decrease in nominal effort, the CPUE (ratio between catch and nominal effort) has shown a great variability during this period. From 1987 onward (Adour and Gironde data), the nominal effort decreased only slightly whereas catches fell. In the Adour basin, CPUE decreased sharply in a first period (1987–1990) and then decreased but more slightly (from 1990 onward). In the Gironde basin, the decrease is more continuous since 1986. The overall decrease of CPUE (1987–2003) in both basin seems to be of the same order of magnitude.

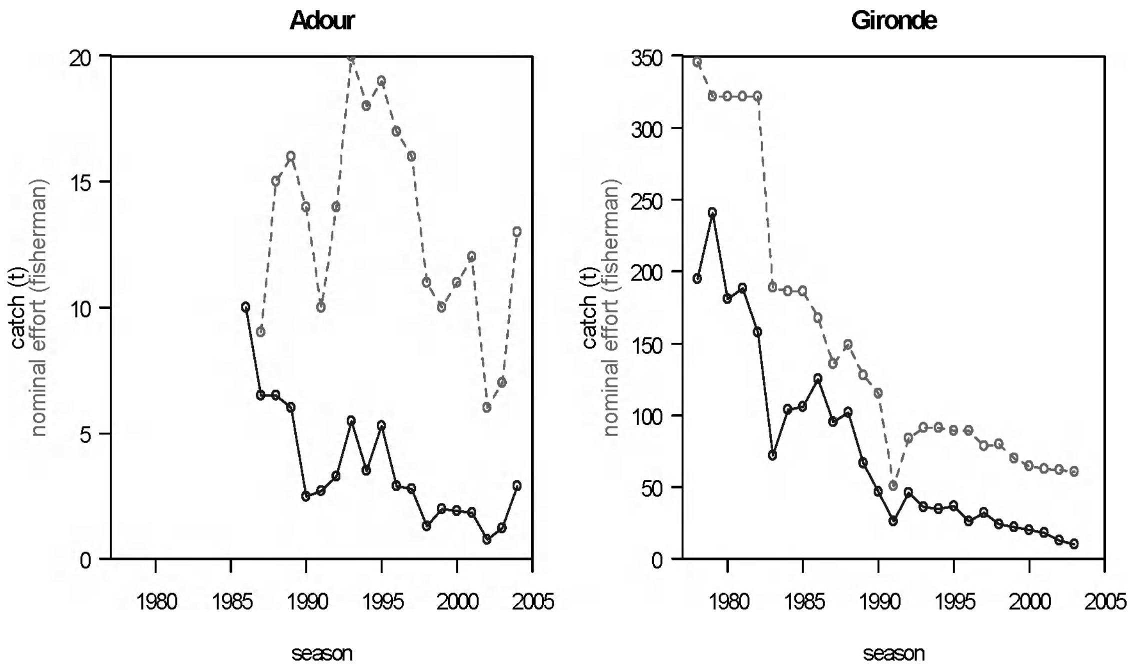


Figure FR.6. Catch (solid line) and nominal effort (dashed line) in the Adour (left panel) and Gironde (right panel) basins over the period 1978–2004. Source: Adour = Ifremer; Gironde = Cemagref.

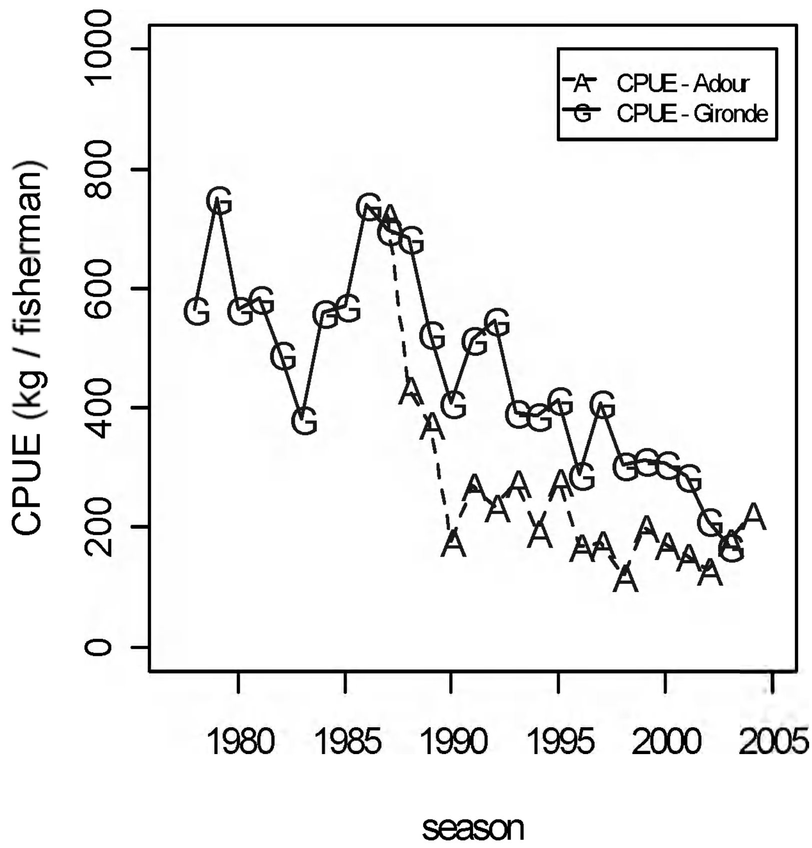


Figure FR.7. CPUE in the Adour (dashed line) and Gironde (solid line) basins over the period 1978–2004. Source: Adour = Ifremer; Gironde = Cemagref.

FR.G. Scientific surveys of the stock

FR.G.1. Recruitment surveys, glass eel

The recruitment surveys occur in the Gironde the Adour from 1998 and in the Loire and Isle (tributary from the Gironde) from 2004 as part of the Indicang project. The methods are described in (Feunteun *et al.*, 2002). A fishery and trap based survey is also conducted in the Vilaine from 1996. The Loire time series is based on catches.

FR.G.1.1. The Gironde

The Gironde survey consists in a monthly sampling of 24 stations (surface + deep) distributed along 4 transects. This monitoring uses a research vessel (Figure FR.8) and aims at evaluating the abundance variations of the juveniles of fish and crustacean and the adults of small species.

Figure FR.8. The "Estuarial" boat used for scientific survey in the Gironde (Source: Cemagref).

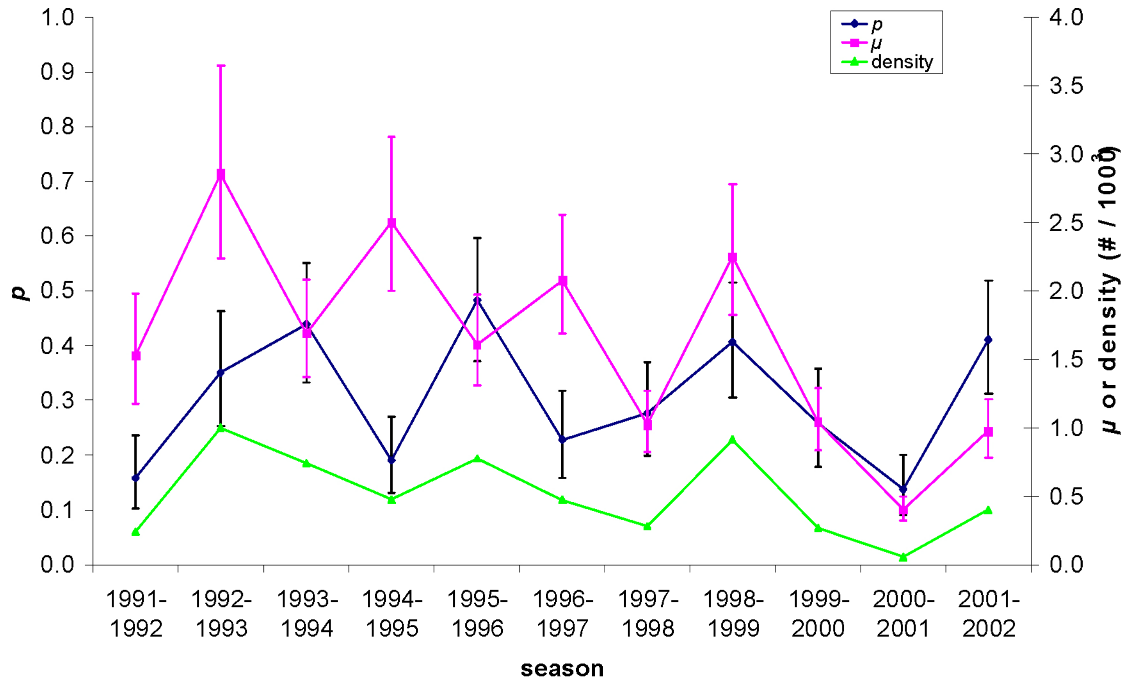


Figure FR.9. Results of a delta-gamma analysis for season effect (p=probability of positive capture, μ=mean capture for only positive capture, density=p*μ) (extracted from Lambert, 2005).

These data were recently analysed by (Lambert, 2005) using a delta-gamma approach (Stefánsson, 1996). This method allows separate analyses of the presence probability (p) and positive capture (μ) and joint analyse through overall density. The delta and gamma approaches were both performed thanks to generalized linear models (GLM; (Mccullagh and Nelder, 1989) with spatial and temporal effects. Only results on season effect are presented in figure X (for more details see Lambert, 2005). All combinations of p and μ are encountered. However, we can notice some peculiar seasons like 2000–2001 for which glass eels were rarely caught (low p) and when caught, in low number (low μ), resulting in a very low density. In the main, this analysis confirms results coming from fishery data (see FR.F.1) even if some little differences remain to analyse.

FR.G.1.2 The Adour

The Adour survey aims at estimating the glass eel flux transported during flood tide in the estuary. The protocol is based on the simultaneous catch of glass eels located at the surface (see Figure FR.23) and in full water along three longitudinal transects. These catches are done downsteam from the dynamic tide reversal area, at a fixed station and during the entire flood.

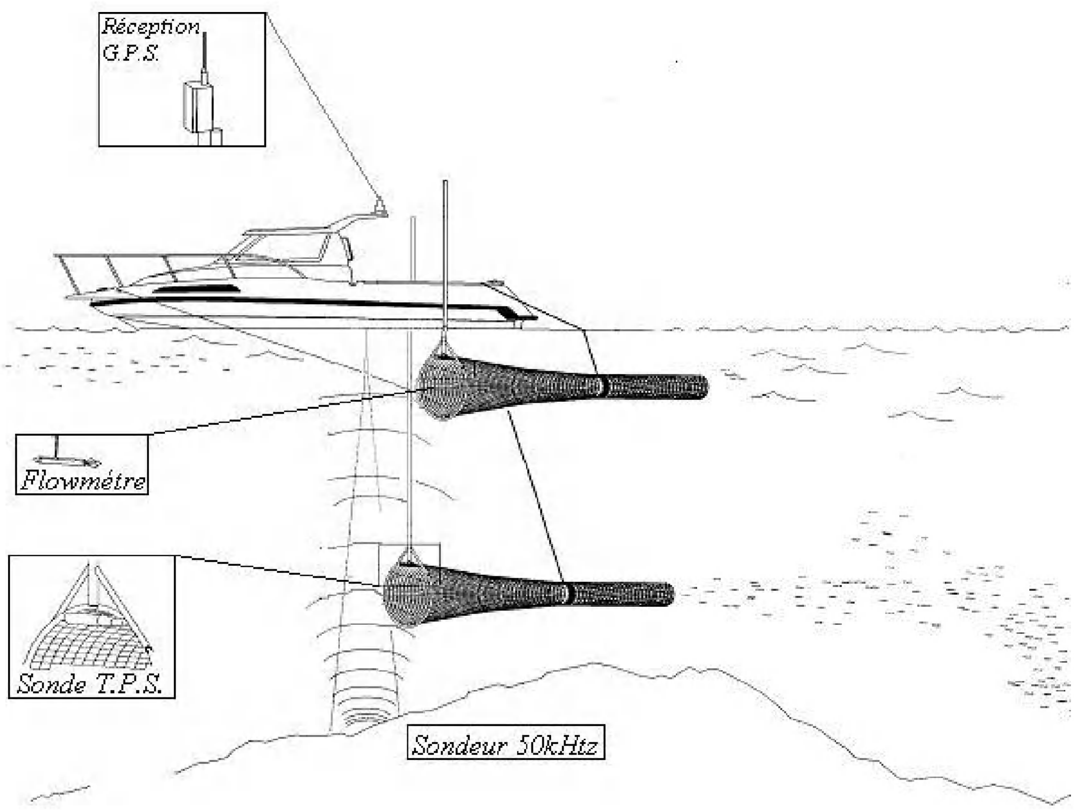


Figure FR.10. Descriptive diagram of the materials of catch and positioning used in the Adour protocol (Source: Ifremer).

The variability of the glass eel captures over the recent period (1985–2002) seems especially related to the fluctuations of hydro-climatic conditions.

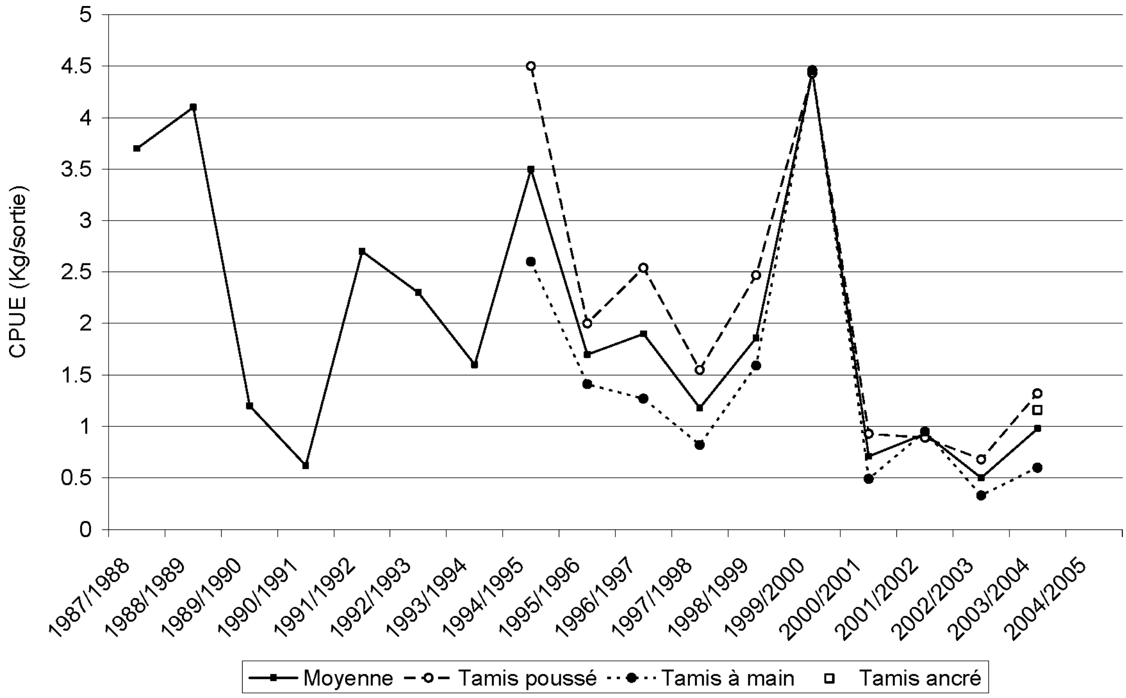


Figure FR.11. Variations of glass eels captures per type of fishing gears in the Adour estuary. Moyenne = mean, tamis poussé = pushed net, tamis à main = hand net.

Table FR.n. Total catches for the glass eel fishery (combining pushed nets and hand nets) in the Adour estuary.

DECADE	1970	1980	1990	2000
Season (n-1,n)				
0			3.2	10
1			1.5	4
2			8	6
3			5.5	1.24
4			3	2.67
5			7.5	3.5
6		8	4.1	
7		9.5	4.6	
8		12	1.5	
9		9	4.3	

FR.G.1.3 The Vilaine

The Vilaine time series is collected from total catches of the fishery. As the fishing closure has been modified from 1996, those catches are corrected from the evaluation of the standing stock after the closure of the fishery. These evaluations are based on marking recaptures surveys performed in April and May.

Table Fr.o. Time series for the Vilaine glass eel recruitment (corrected from late arrivals).

SEASON (N-1,N)	1970	1980	1990	2000
0		95	35.9	14.45
1	44	57	15.35	8.46
2	38	98	29.57	15.90
3	78	69	31	9.37
4	107	36	24	7.49
5	44	41	29.7	7.36
6	106	52.6	23.286	
7	52	41.2	22.85	
8	106	46.6	18.90	
9	209	36.7	16	

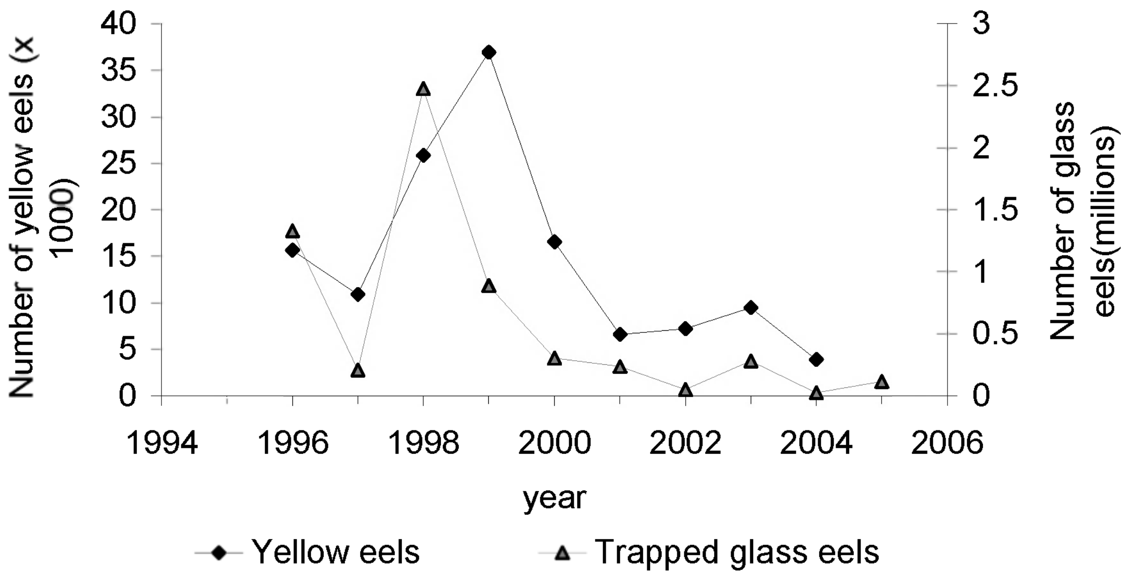


Figure FR.12. Number of glass eel and yellow eel collected and counted at the Vilaine trapping ladder.

FR.G.1.3 The Loire

Table FR.p. Time series for the Loire fishery (* an assumption was made for catches of fluvial fishermen, not available at the moment).

DECADE	1950	1960	1970	1980	1990	2000
Season (n-1,n)						
	86	411	453	526	96	80
1	166	334	330	303	36	33
2	121	185	311	274	39	42
3	91	116	292	260	91	*53**
4	86	142	557	183	*103**	*27**
5	181	134	497	154	133	
6	187	253	770	123	81	
7	168	258	677	145	71	
8	230	712	526	177	66	
9	174	225	642	87	87	

FR.G.2. Stock surveys, yellow eel

Specific stock surveys were performed in small basin (Frémur, Oir). The result are in previous ICES reports.

The "*Reseau hydrobiologique et piscicole*", called *RHP,* is a survey of 761 stations yearly sampled with electrofishing. These samples are used to determine the ecological status request by the Water framework directive. The abundance of eel distribution shows a classical downstream increase in density (Figure FR.13). No peculiar trend can by given by the first analysis of the 1995–2003 chronicle (see p. 21 of Anon., 2004.). A detail observation of the stations of higher density in 1995 shows significant erosion during the first year of the monitoring. A program starting in 2006 will analyses the data more deeply.

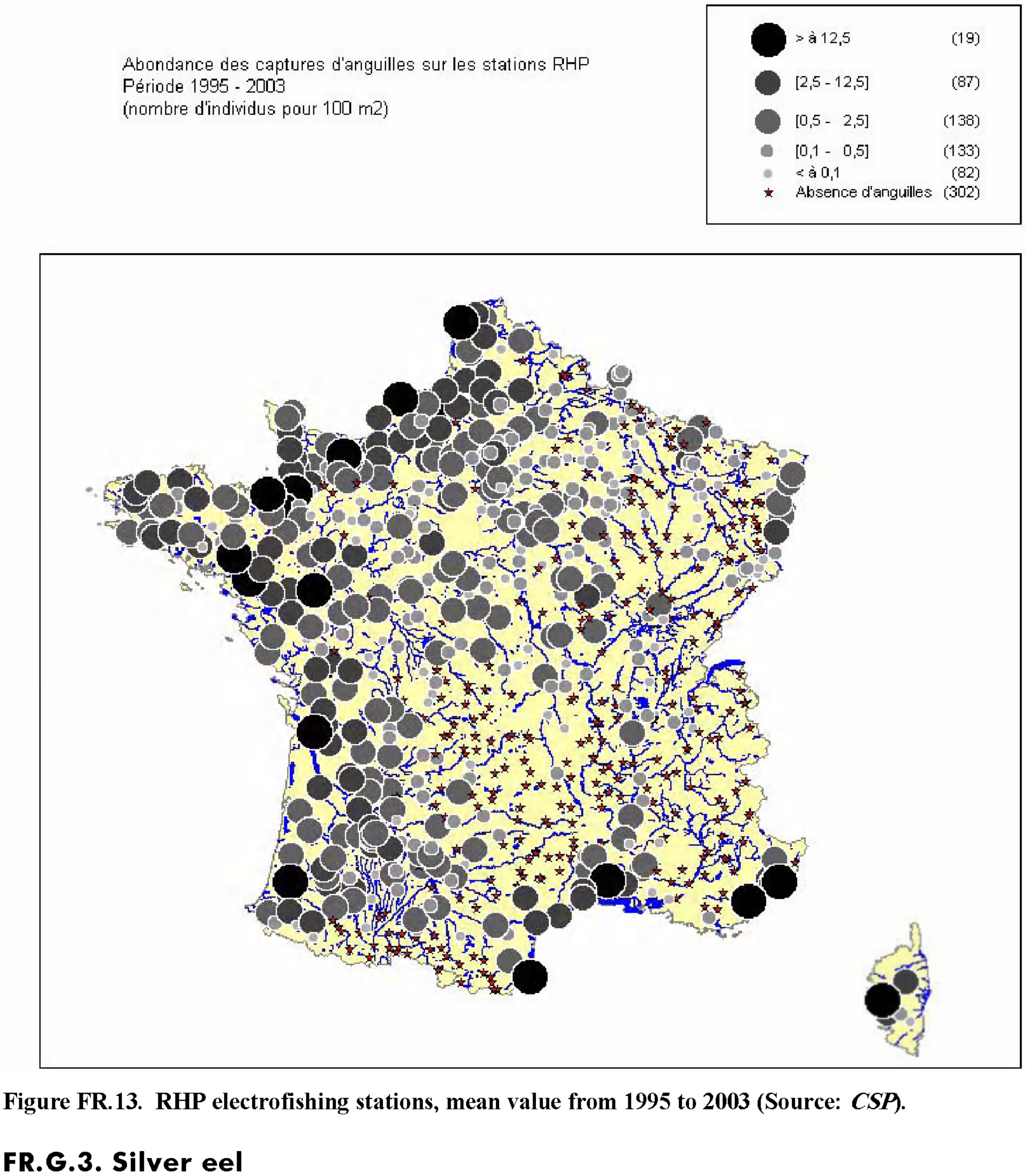


Figure FR.13. RHP electrofishing stations, mean value from 1995 to 2003 (Source: *CSP*).

FR.G.3. Silver eel

Thes silver eel influx to the see was assessed using the sequential fishery in the Loire basin following a mark-recapture protocol (Boury and Feunteun unpublished).

No other information is available on silver eel stock.

FR.H. Catch composition by age and length

There is no routine program measuring the catch composition by age and length in France.

FR.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

There is no routine program measuring parameters of the eel population dynamics at the national level in France.

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Report on the eel stock and fishery in Spain

ES.A. Author:

Estibaliz Díaz, Jaime Castellanos
AZTI - Tecnalia / Itsas Ikerketa Saila
Txatxarramendi Ugartea z/g
48395 Sukarrieta (Bizkaia)
Tel: 94 6029400 - Fax: 94 6870006
e-mail: ediaz@suk.azti.es

This report was completed in January 2006; and contains data up to December 2005.

Contributors to the report :

Lucía García Flórez and Fernando Jiménez Herrero	*Fisheries General Direction. Rural and Fishery Department of the Principality of Asturias*
Francesc Cases Armengol and Ricard Casasnovas	*Fisheries and Maritime Affairs General Direction. Agriculture, ranching and Fishery Department of the Generalitat from Catalonia*

ES.B. Introduction

In Spain, practically only glass eel fishery exist, and each autonomous region (Figure ES.1) has its own regulation concerning eel fisheries, and in some cases it even does not exist. That fact creates great differences among the autonomies (Table Esa):

- The amplitude of the historical data series is variable depending of the date the regulation was issued.
- In some autonomies the same regulation is applied to all the river basins while in others each basin has its own regulation, or in some river basins fishery is regulated and not in others.
- In some autonomies fishermen are professional and have to sell the catches to the fish market, while in others they are non-professional. That way the precision of the information of catches and landing differs greatly among those autonomies.
- Each autonomy has its own way of managing the stock: different fishing techniques are allowed, and some of them use quotas, while others control the effort.
- Besides, in many cases, the organizations that are involved in the management of each stage in the same autonomy could differ.

Table ES.a. Ell fishery regulation of Spanish coastal autonomies.

		GLASS EEL						YELLOW AND SILVER EEL						
		Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational		Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational		Observations
Andalucía		L	All the year	Squared sieve (Max.: 0,80x0,80m^2).	No	Catches sale allowed		L	All the year .	Rods and 5 ring creel. First, second and third mesh size of creel 12, 8, and 6 mm respectively.	From 1 hour before sunrise until 1 hour after sunset. 2 rods/fishermen. Eels>35 cm.	Catches sale allowed		
Asturias		L. Fishermen from the Nalón River can fish just in the Nalón River, and the rest of fisher-men can fish in all the rivers except from in the Nalón river.	October 30th-April 30th.	Squared sieve (Max.: 200 x 60 cms). Boat trawling allowed only in Nalón river basin.	No fishing during weekend. In Nalón river number of licences:70 from land and 50 from boat.	P		L	Changes every year.	Rods.	1 hour before sunrise until 1 hour after sunset. 2 rods/fishermen.	R		Very dynamic, changes every year and can change within the season. Glass eel recrea-tional fishery forbidden since 2001.
Basque Country		L. Only to be used in one river basin.	New moon October-New moon March.	Sieve and Hoe. Boat trawling allowed.	No	R		L	All the year.	Rods.	From sunrise until sunset. Forbidden fishing on Tuesdays. 2 rods/fishermen. Eels > 20cm.	R		Regulation for glass eel issued n 2003. It is obligatory to fill in the Daily Catches report with effort and catches.
Cantabría		L.	October 10th - March 31st.	Squared sieve (Max.:1,2 m^2)	Fishing forbi-dden between Saturday 14:00 and Sunday 18:00. At least 10 ms between fishermen. Catches <250 gr in recreational.	P & R (Catches <250 gr)			March 17th-July 21st.	Rods.	Max: 20 eels/ fisherman/day	R		

		GLASS EEL						YELLOW AND SILVER EEL						
		Control system	Fishing season	Allowed fishing gears	Effort of Catches control	Professional/ Recreational		Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational		Observations
Catalonia		L	October 20th - March 10th.	Fyke nets.	Max.340 Fyke nets and at least 50 ms between them.	P		L	Changes every year	Rods.	During all the day. No light sources allowed. 2 rods/fishermen Eels > 35 cm.	R		
Galicia		L	Five days before and after the new moon from November until March.	Boat fishing is forbidden and the only allowed gear is a Max. 70 cm opening sieve.	No	R & P		L	March 19th - August 21st.	Creels. Fixed gears are forbidden.	During all the day. Max. Of 10 creels	R & P (Catches sale allowed)		The glass eel fishing normative can change during the fishing season depending on the evolution of the fishing season.
Murcia		No specific legislation						L	All the year	2 rods/fishermen.	From 1 hour before sunrise until 1 hour after sunset. Eels >20 cm.	R		
Valencia		Fishermen must be member of a fishing association and have a special permission.	November 18th - March 31st.	Fyke nets (Mouth max 1,5m^2 and mesh size 1 mm).	From sunset to sunrise of Sunday, Monday, Wednesday and Thursdays. Tuesdays are reserved to take glass eels for restocking and experimentation. The Fyke net can not take up more than a third of the river width.			L	In waters with trouts from March 21st - August 31st. In waters without trouts all the year.	Rod, with and without hook.	Rod with hook: from 1 hour before sunrise until 1 hour after sunset. Rod without hook: all the day. 1 rod /fishermen. Eels >25 cm.	R		Very dynamic, fishing season changes every year .

- L: Licence / P: Professional / R: Recreational

Figure ES.1. Autonomies from Spain.

That way, and as a national fish stock management plan for eel does not exist a compilation of all the data from different autonomies, in order to give a national overview of the eel fisheries in Spain is a very complicated task that has not been done until now.

The RBD of Spain had not been definitively defined. However on December 20th a proposition was made by the Environmental Ministry (Figure ES.2) that will be used in the present report.

Figure. ES.2. Spanish RBDs.

In Spain the glass eel fishery exists in all the RBDs. In the Atlantic, the most important glass-eel fishery basins are the Miño (North I RBD), the Asturian (North II) and Basque river basins (Basque internal rivers), and the Guadalquivir. In the Mediterranean, the most important glass eel fishing points are the Delta of the River Ebro and the Valencian Albufera (Jucar RBD) and they also have an important eel fishery. However, for this report only the following information regarding catches has been obtained:

ASTURIAS: There is not a specific yellow neither silver eel fishery in Asturias and the catches are insignificant. As glass eel is concern, the Fisheries General Direction of the Rural and Fishery Deparment of the Principality of Asturias has provided the data concerning glass eel catches in Asturias using fish auctions. There are 18 fishermen guilds in Asturias. For the

San Juan de la Arena fisherman guild (Nalón river basin) data is available since 1952; for the other 17 data is available since 1995. During last fishing season, the 63.82% and 22,25% of the catches were obtained in the Nalón and Sella rivers. The rest of rivers only accounted for 13,93% of the catches so they have been grouped in *Others*. All the river basins from Asturias are included in Demarcation North 2 (Figure ES.2).

BASQUE COUNTRY: As in Asturias, there is no an specific yellow neither silver eel fishery . The glass eel fishery is a very traditional fishery in the Basque Country which affects to zones associated to river mouths, including beaches, estuaries and river banks. Glass eel fishery is located in most of the river basins of Bizkaia (Artibai, Lea, Oka, Butrón and Ibaizabal) and Gipuzkoa (Bidasoa, Oiarzun, Urumea, Oria, Urola, Deba). All those river basins are included in the Basque Inner river basins RBD (Figure ES.2).

However, due to the inexistence of any managing plan for eels, there is no data in recruitment from last years. In 2001, the Basque Government with the advice of AZTI launched a fisheries monitoring plan. In 2003 a new regulation for glass eel fisheries was issued that stated that there must be only a license per person and fishing basin and that it is obligatory to fill in the Daily Catches report with data regarding catches and effort. Basque fishermen can not sell the catches and therefore should be classified as non professional. However**,** the traditional classification of fishermen as "non - professional" and "professional" is not useful for the Basque Country glass eel fishery. First, most of the fishermen sell their catches. In a second place, professional fishermen at sea, fish glass eel as a supplementary activity, during the winter nights at harbour and using a small "recreational" boat. For this reason, is necessary to admit the presence of glass eel fishermen who carry this secondary activity to their job, usually in order to obtain complementary incomes selling their catches. However, as the available information is very complete the information is given complementing all the points regarding catches.

CATALONIA: There is glass and yellow and silver eel fishery in Catalonia. The most important fishing point is the Ebro Delta. Nevertheless, only information regarding glass eel catches in the Catalonian Interior River Basins since 1999 has been obtained.

GALICIA: In Galicia, both glass eel and yellow and silver fishery exists and the Miño river is the most important fishing point. In this case, data regarding silver and yellow eel fish auctions since 1997 from Galicia have been obtained. All the Galician river basins mentioned in this report belong to the Galician coast RBD (Figure ES.2).

ES.C. Capacity

In Asturias 240 and 230 licences were issued in 2003–2004 and 2004–2005 fishing season respectively.

In the Basque Country, in Aginaga (Oria river basin) there are 6 companies dedicated to the commercialization, and one among them to growth, of glass eels. However, the Basque Fishermen cannot sell the catches, and although some of them do, this is not enough to feed those enterprises. That way, this companies have hatcheries in Asturias, Valencia, Catalonia, and the Atlantic coast of France to maintain the glass eels they buy to local fishermen until they are transported to the hatcheries in Aginaga.

The number of fishermen has decline during the last three decades following the decline of the recruitment. As there is no any fishermen list until 2003, there is no way to determine this decline in fishermen population but the oldest ones assert that since 70ies the decline is important. It seems that this decline has conditioned fishermen activity, giving up their activity in some cases, or reducing the fishing nights in those who still keep fishing since the catches are lower.

During 2004/2004 fishing season, the first year that licences were obligatory, 573 fishing licences were received in the local fisheries administration and there was an increase of received licences last fishing season reaching the 682 licences.

ES.D. Fishing Effort

In Asturias most of the licences are issued in Nalón and Ribadesella rivers, and boat fishing is only allowed in the Nalón river (Table ES.b). In the Basque Country, more than a half of the fishermen did not clarify in the licence the fishing gear they used. In that sense some meetings with the fishermen have took place in order to make them aware of the importance of filling correctly the catches report. The river basin with more licences was Butron and in all the rivers, except in the Oria and the Urola, most of the licences were for Sieve (Table Esb). Although the number of licences is higher in the Basque Country, it must be taken into account that the fishermen is Asturias are professional and in the Basque Country they are recreational.

Table ES.b. Number of glass eel fishing licences per basin and fishing gear in 2004 / 2005 season.

		NUMBER OF LICENCES						
	River basin	Land trawling	Hoe	Sieve	Boat	Wave	Unfilled	Total
Asturias	Nalon	67			44			111
	Ribadesella	66						66
	Others	53						53
Total Asturias		186			44			230
Basque Country	Artibai			1			5	6
	Barbadun			2			3	5
	Bidasoa			1			1	2
	Butrón	1	3	41	2	21	164	232
	Deba	31		38			53	122
	Lea			6			11	17
	Nervion-Ibaizabal	6		40			64	110
	Oka		1	1			9	11
	Oria	12		47	25	4	56	144
	Urola	3		4	20		6	33
Total Basque Country		53	4	181	47	25	372	682

In the Basque Country there has been a slight increase in the effort during last fishing season which has always been between 12.000 and 13.000 hours and the river basin with more fishing hours is the Oria (Table ES.c). Most of the effort in the Basque Country happens during the months of December and January (Figure ES.3).

Table ES.c. Glass eel fishing effort per river basin during last fishing seasons.

	FISHING EFFORT (HOURS)	
River basin	2003 2004	2004 2005
Artibai	118,73	96,00
Barbadun	36,07	51,67
Bidasoa		12,50
Butrón	1686,97	2142,48
Deba	2602,87	2396,58
Lea	521,28	129,83
Nervion-Ibaizabal	2097,15	3104,18
Oka	87,42	144,88
Oria	3638,97	3533,95
Urola	1411,90	1119,60
Total	**12046,55**	**12571,52**

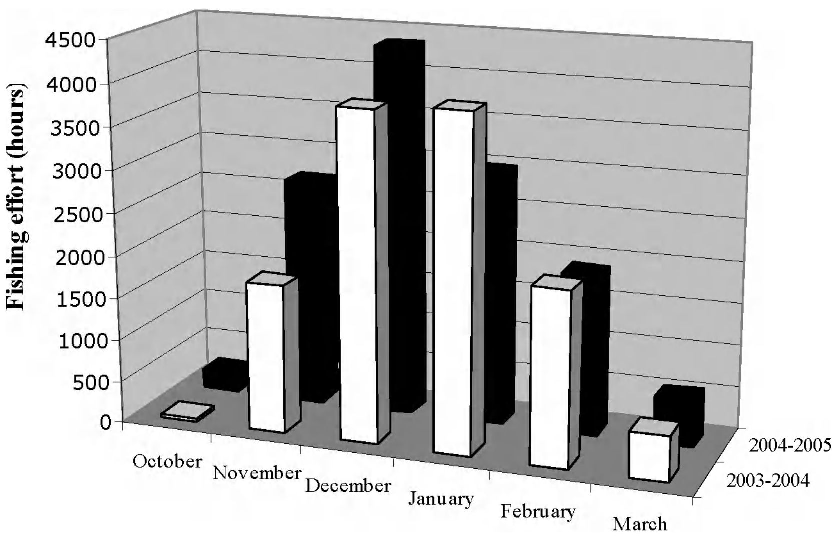

Figure ES.3. Glass eel fishing effort along the fishing season in the last two fishing seasons.

ES.E. Catches and Landings

ES.E.1. Catch of glass eel

The data series from San Juan de la Arena fish market demonstrates the important decrease of the glass eel population starting in the 80ies decade (Figure ES4).

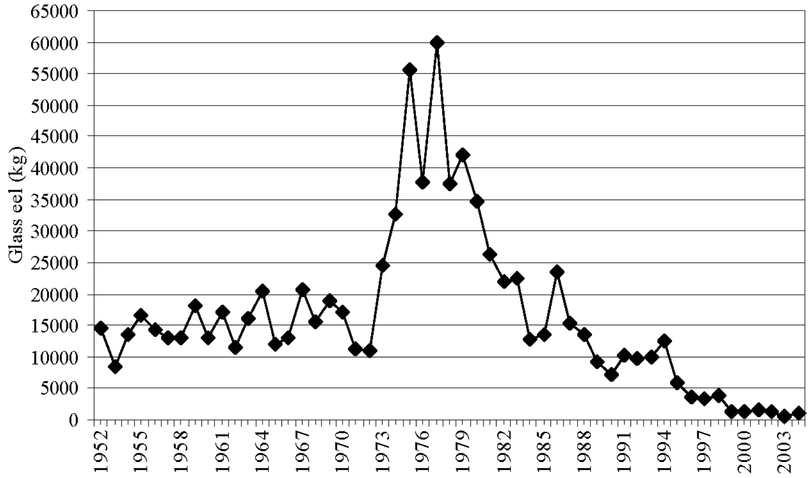

Figure ES.4. Glass eel catches in San Juan de la Arena since 1952.

The catches in Asturias are higher than in Basque Country, which is normal considering that in Asturias there is a professional fishery. In Catalonian Interior basins catches are low, but it must be considered that the most important fishing point (Ebro Delta) is missing. Data of all the autonomies show an increase in the catches of last fishing season (Table ES.d).

Table ES.d. Glass eel catches per river basin during last fishing seasons

			GLASS EEL CATCHES (KG)		
AREA	RBD	Water body	2003-2004	2004-2005	Data source
Asturias	North II	Nalón	763,6	1834,8	Auctions
		Sella	435.4	639.7	Auctions
		Others	152.36	400.59	Auctions
	Total Asturias		**1351.4**	**2875**	
Basque Country	Basque Interior Basins	Artibai	4,525	5,130	Capture books
		Barbadun	2,196	2,696	Capture books
		Bidasoa	-	0,777	Capture books
		Butrón	78,879	116,535	Capture books
		Deba	158,637	200,792	Capture books
		Lea	20,958	7,854	Capture books
		Nervion-Ibaizabal	101,602	175,160	Capture books
		Oka	6,530	9,839	Capture books
		Oria	391,388	530,372	Capture books
		Urola	93,585	123,805	Capture books
	Total Basque Country		**858,300**	**1172,960**	
Catalonia	Catalonian Interior Basins	Fluvia		23,35	Auctions
		Ter	94,15	236,8	Auctions
		Muga	40	25	Auctions
	Total Catalonia		**134,2**	285,1	

Although 6 different gears are used, most of the catches in the Basque Country are obtained by boat trawling and sieve (Figure ES.5).

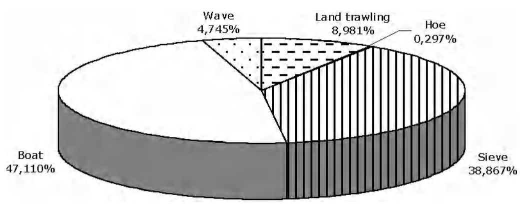

Figure ES.5. Percentage of the obtained catches with each fishing gear during the 2003-2004 and 2004–2005 fishing seasons.

ES.E.2. Re-stocking

There is not re-stocking in the Basque Country. In Catalonia, a percentage of the glass eels catches should be conserved for re-stocking.

ES.E.3. Catch of yellow and silver eel

In Galicia captures have drop during last years (Table ES.e).

Table ES.e. Yellow and silver eel catches (Tons) in the Galician rivers.

Area	RBD	River Basin	2001	2002	2003	2004	2005	Data source
Galicia	Galician Coast	Arousa	7,439	13,563	11,171	10,997	8,861	auctions
	Galician Coast	Eo	0,467	0,643	0,180	0,460	0,843	auctions
	Galician Coast	Landro	0,479	0,213	0,266	0,734	0,052	auctions
	Galician Coast	Lérez	?	0,030	0,016	0,014	?	auctions
	Galician Coast	Verduxo	42,159	25,252	19,708	22,014	14,548	auctions
	Galician Coast	**Total**	**50,543**	**39,699**	**31,341**	**34,219**	**24,305**	auctions

ES.E.4. Aquaculture production

In the Basque Country, among the 6 enterprises in Aguinaga, one of them grows glass eels to yellow eels.

ES.E.5. Catch of Recreational Fisheries

The situation in the Basque Country is explained in the Introduction.

ES.F. Catch per Unit of Effort

In the Basque Country the CPUEs of the 2004–2005 were higher than in the 2003–2004 season. Besides, the temporal trend was different due to the high values in November 2004 (Figure ES.6).

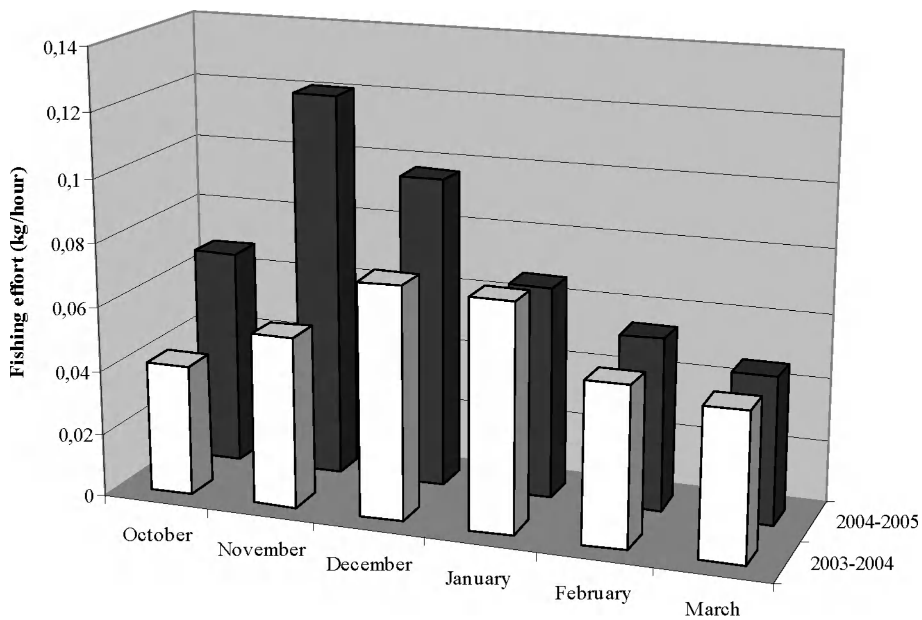

Figure ES.6. Intraseasonal trends in the CPUE in the 2003–2004 and 2004–2005 fishing seasons.

The most effective fishing gear was boat during both seasons and the difference with the other gears was even larger in the 2004–2005 fishing season (Table ES.f) .

Table ESf. vGlass eel CPUE per fishing gear during last fishing seasons

	CPUE (KG/H)	
	2003 2004	2004 2005
Land trawling	0,045	0,075
Hoe	0,055	0,042
Sieve	0,056	0,064
Boat	0,099	0,164
Wave	0,041	0,060

ES.G. Scientific surveys of the stock

According to the compiled information those are the surveys that are being carried out in Spain:

ES.G.1. Recruitment surveys

In the INDICANG framework Javier Lobón Cervia together with the Consejeria de Medio Ambiente, Ordenacion del Territorio e Infraestructuras and the Consejeria del Medio Rural y Pesca (Dr. Lucia Garcia Florez) will estimate the abundance and recruitment index of glass eels of Nalón and Esva in Asturias. In the Basque Country, when the INDICANG project finishes data regarding glass eel recruitment per river basin and their migratory patterns in the Oria river basin (a PhD is being carried out at this moment) will be available . Besides, glass eel fisheries effect on eel abundance thanks to a eel trap installed in the Oria river basin will be estimated.

ES.G.2.3. Yellow and silver eel surveys.

In Asturias**,** Javier Lobón has been monitoring the yellow and silver eel in the Esva basin since 1986 (Lobon-Cervia, *et al.*, 1990; Lobon-Cervia and Carrascal,.1992; Lobon-Cervia *et al.*, 1995; Lobon-Cervia, 1999). Besides, in the INDICANG framework the monitoring of silver and yellow eel in the Esva and Nalón river basins and relation with environmental parameters will be performed. In the Basque Country, also in the INDICANG framework, some specific eels surveys are being carried out in the Oria river by EKOLUR and the Deputation of Gipuzkoa. Thanks to those samplings, characterization of yellow and silver eel population in the Oria river basin and the effect of the dams in the migration is being studied.

In Catalunia, the CERM (Center for the Study of Mediterranean Rivers) will sample in five sections of three different rivers (Ebro, Ter, Riera del Port de la Selva) with eel populations between 2006 and 2008 with the principal aim of studying the connectivity. Besides they have applied for a research project that aims to improve the situation of migratory fishes, specially the eel, in the Mediterranean area. This project would include 12 research teams, Universities and administrations from the EU and 4 more from Magreb and Near East.

In Castilla la Mancha, the Historic Evolution of the eel has been studied (Marin *et al.*, 1994**).**

ES.H. Catch composition by age and length

No information available

ES.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

No information available in the Basque Country. In Asturias, in the Esva river information regarding sex-ratio, mortality, and feeding activity is available (Lobon-Cervia *et al*,, 1995).

Unknown in the other autonomies.

ES.J. Other sampling

In the Basque Country, the Deputations of Gipuzkoa and Bizkaia and the Basque Government have a very complete environmental sampling net in the rivers and coast. Unknown in other autonomies.

ES.K. Stock assessment and its use for management advice

There is no any formal advice on fisheries management in Spain. Each autonomy has his own regulation regarding eels fisheries and some autonomies don't have any regulation. However, following the release of the propose of the eel regulation on October, the Spanish Fishery Secretary ordered the autonomies to start designing the management plans required by the regulation in November. In the case of the Basque Country, AZTI has give advice in the launch of the fisheries monitoring plan and in the design of the regulation of glass ell fisheries issued in 2003 and now the Government has ask advice to the design of the management plan required by the new regulation.

ES.O. Overview

Table ES.g. Overview of the eel fisheries in Spain in 2004 (in the case of glass eel 2004–2005 fishing season).

	Geographical area							C		D Effort								E Catch (tons)			F CPUE (kg/h)	
												Licences										
	RBD	Water body	Latitude (N°)	Longitude (E°)	Drainage area (km^2)	River length (km)		Number of Companies		Fishing Hours		Land trawling	Hoe	Sieve	Boat	Wave		Glass eel	Yellow and silver eel		Glass eel	Yellow and silver eel
ES	North II	Nalón	48,28	2,5	3692	142		?		?		67			44			1,8348	NF		?	NF
		Sella	48,14	3,31	1246	52.6		?		?		66						0,6397	NF		?	NF
		Others						?		?		53						0,4006	NF		?	NF
	BIB	Artibai	43,35	2,48	104,28	26,3		0		96				1				0,0051	NF		0,054	NF
		Barbadun	43,40	3,32	128,92	26,89		0		51,67				2				0,0027	NF		0,081	NF
		Bidasoa	43,37	1,78	700	69		0		12,5				1				0,0008	NF		0,064	NF
		Butrón	43,40	2,93	172,22	44,34		0		2142,48		1	3	41	2	21		0,1165	NF		0,052	NF
		Deba	43,28	2,35	530,28	60,31		0		2396,58		31		38				0,2008	NF		0,082	NF
		Lea	43,35	2,50	99,27	26,11		0		129,83				6				0,0079	NF		0,050	NF
		Nervion	43,33	3,03	1798,77	72,22		0		3104,18		6		40				0,1752	NF		0,062	NF
	CIC	Fluvia			973,8	70		?		?								?	?		?	?
		Ter			3010	208		?		?								0,094	?		?	?
		Muga			1050	58		?		?								0,04	?		?	?
		Oka	43,40	2,93	183,21	27,05		0		144,88			1	1				0,0098	NF		0,071	NF
		Oria	43,28	2,12	881,99	77,29		6		3533,95		12		47	25	4		0,5304	NF		0,144	NF
		Urola	43,30	2,23	342,19	64,91		0		1119,6		3		4	20			0,1238	NF		0,076	NF
	G.C.	Arousa	43,07	8,08	2964	132		?		?								?	10,997		?	?
		Eo	43,06	7,00	819	78.5		?		?								?	0,460		?	?
		Landro	43,07	7,06	268	42		?		?								?	0,734		?	?
		Lérez	42,04	8,07	594,5	57		?		?								?	0,014		?	?
		Verduxo	42,03	8,06	176	40		?		?								?	22,014		?	?

NF: No Fishery / ?: Unknown / BIB: Basque Interior basins / CIC: Catalonian Interior Coast / GC: Galician Coast

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Report on the eel stock and fisheries in Italy

IT.A. Author

Eleonora Ciccotti
Dipartimento di Biologia, Università degli Studi "Tor Vergata"
Via della Ricerca Scientifica s.n.c.
00133 Rome Italy
Tel. +39 (0)6 72595969 Fax +39 (0)6 72595965
Email ciccotti@uniroma2.it

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IT.B. Introduction

Eel (*Anguilla anguilla* L.) exploitation in Italy has a long standing tradition, and it concerns all continental stages, i.e. glass eel, yellow and migratory silver eel.

The most distinctive exploitation pattern for eel in Italy is coastal lagoon fishery, that yields most of yellow and silver eel extensive culture and fishery production (Ciccotti, 1997; Ciccotti *et al.*, 2000; Ciccotti, 2005). A case apart is eel intensive aquaculture, that played a major role within the national and European context up to a few years ago (Ciccotti *et al.*, 2000; Ciccotti and Fontenelle, 2001).

Lagoons cover around 1500 km^2, 610 of which are exploited at the present moment. Of the exploited area, about 300 km^2 are located in the upper Adriatic and 120 in the Po delta, the rest being scattered in Apulia, Campania, Latium, Tuscany, Sicily and Sardinia (Ardizzone *et al.*, 1988).

In the upper Adriatic lagoons a typical form of management, the *vallicoltura*, is practised, that slightly differs from other lagoon management and fisheries because it is based on artificial fry stocking and active hydraulic management.

Inland eel fisheries are found in main rivers and lakes. Most of the eel catches are from the great Alpine lakes in the northern regions, but the eel is also an important target species for professional fisheries in some volcanic lakes of Central Italy. Professional eel fisheries in rivers are confined today to a very small number, while professional glass eel fisheries take place in a higher number, and in many channel mouths as well. At the moment, most of the glass eel yield comes from the Central and Southern Thyrrenhian area. The main sites of glass eel catches are the estuaries of rivers such as the Arno and Ombrone in Tuscany, the Tiber and the Garigliano in Latium, and the Volturno and Sele in the Campania region. Those sites are frequented not only by local fishermen but occasionally also by fry fishermen from other regions, who reach those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry. Local fishermen are usually single or Co-operative fishermen that are equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site.

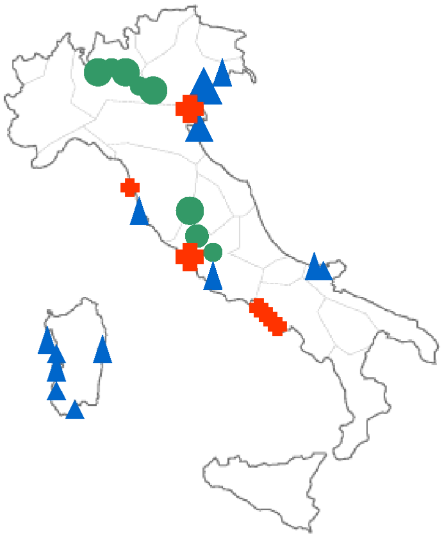

Figure IT.1. Distribution of main eel fisheries in Italy (O Lakes, Δ Coastal lagoons, + Rivers)

Governmental management framework for eel results disjointed, because in Italy the Ministry of Agriculture and Forestry Politics controls salt and brackish waters, while inland waters are under the control of local Administrations, i.e. Regions or Provinces. Therefore the only eel fisheries under a central Administration are the glass eel fisheries practiced in estuaries, as no marine adult eel fishery exists in Italy. In most cases, anyway, central and regional regulations are in agreement, glass eel fishery regulation being joined always to the regulation of fishery of finfish and bivalve fry for aquaculture. In both departments, a licence is necessary, which has to be renewed annually, in which quantities to be fished have to be declared. Fishermen must notify their catches and sales. Destination of glass eels ought to be restricted to aquaculture and restocking purposes. However, poaching and black market in some regions remain a problem. In absence of counterchecks, collection of data can prove to be partial, and their reliability doubtful.

With regards to inland fisheries, each Region has its own regulations. As a rule, individual professional fishing licences are issued, which are valid for 6 years, by the Region, and are enlisted in registers kept by the Provinces. The permitted gears vary from region to region, also in relation to local traditions, and are specified by each Administration, together with authorised times and places. For the nets, mesh sizes and minimum and maximum dimensions of gears are listed.

In the present report an overview on the eel stock and fisheries in Italy is presented, based on information gathered for the Workshop on National Data Collection for the European eel held in Stockolm, Sweden, 6–8 September 2005. At the present moment, Italy has not established yet its Data Collection Framework for eel, nor has developed a proposal for a national management plan, but debate on those important actions is currently going on at the administrative levels as well as within the scientific community, also in view of the Proposal for a Council regulation establishing measures for the recovery of the stock of European Eel (COM(2005) 472 final) presented by the Commission.

With regards to the WFD and its transposition into national legislation, Italy has undertaken a number of actions, but has not yet adopted the necessary dispositions to comply with the Directive 2000/60 neither has performed the step of identifying river basins and assigning them to the River Basin Districts. Therefore, in this report data are referred to the national level or environmental typology (such as inland or coastal waters) and not even tentatively evaluated at the river basin or district level.

IT.C&D&E. Fishing capacity and fishing effort, catches and landings

No estimates of fishing capacity can be given because there is no central registration of fishing companies per fishing typology nor per region, apart the Province Registers of fishing licences mentioned above, that are not specific. For glass eel fisheries in marine waters, the number of licenses issued annually by the Ministry for coastal waters shows a sharp drop in the course of the '90s, also due to the fact that from 1998 a pecuniary charge is due by the fry fishing companies, but it must be borne in mind that the license is not restricted to glass eel. A rough estimate of fishing companies dedicated to glass eel amounts to less than ten.

For adult eel, there is no possibility to evaluate the number of companies dedicated to eel fishing at the present moment.

Fishing equipment for eel catching in lagoons, lakes and rivers includes a variety of instruments ranging from single fyke nets to groups of fyke nets (see Figure IT.2, left), traps, baskets and fish hooks. Systems consisting of arrangements of nets and fykenets, constituting barriers that close the lagoon from one shore to the other, are used in some lagoons, such as the "paranze" from the lagoon of Lesina in the Southern Adriatic, Italy.

Most of silver eel captures take place at fish barriers (*lavoriero*), devices based on the principle of V-shaped traps (Figure IT.2 right) that intercept the fish when moving to reach the sea: in the case of silver eel, most captures take place in winter in coincidence with seaward migration. Fishing efficiency by these devices can be considered to attain 100%.

For glass eel fishing, dip nets are used often in Tuscany, but usually glass eel fishing is carried out with fyke nets of varying dimensions, which are often provided with wings.

There are no log-book systems to record type and number of nets, neither obligatory nor voluntary, at any level, neither central nor local. Considering the large heterogeneity of the fishing devices, no other measure of fishing effort, fuel consumption or other, seems applicable at the present moment.

Figure IT.2. Fyke nets for eel catch used by the river Tiber (Rome) fishermen (left); typical fish barrier, lavoriero, at the Caprolace coastal lake in Latium (right).

No obligatory registration of landings exist, at any level, at the present moment, for eel, apart the catch declarations required by the Ministry for issuing annual glass eel fishing licences, that seem purely indicative.

Official statistics to which it is possible to make reference for eel are those gathered by the Istituto Nazionale di Statistica, Servizio Statistiche sull'Agricoltura. Statistics are grouped on a annual basis, by region and by species or species group. Data are given separately for marine and brackish waters (lagoon and sea fisheries) and for inland (lakes and artificial basin fisheries). Riverine catches are not considered, being probably worthless. It must be borne in mind that statistics referring to eel consider only adult eel, yellow and silver cumulated, deriving only by professional fisheries. However, catches from anglers are possibly quite significant.

Eel total landings from lagoon fisheries in Italy from 1969 to 2004 are reported in Figure IT.3. Data refer to coastal lagoons only, no marine fisheries existing, while extensive culture productions such as the *vallicoltura* yields ought not to be considered, falling within the aquaculture productions. It is possible, however, that a certain overlap has occurred in the past.

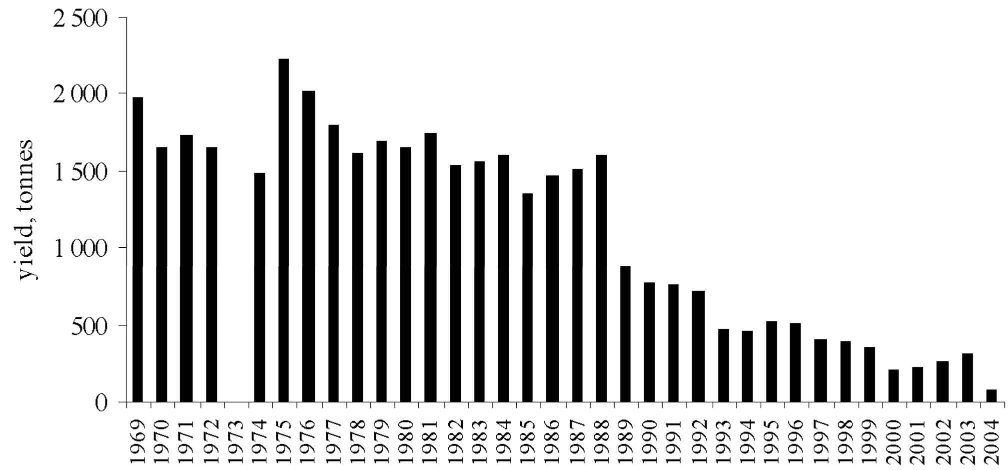

Figure IT.3. Eel landings (yellow and silver cumulated) in Italy, period 1969–2004, from coastal lagoon fisheries (Istituto Nazionale di Statistica).

Inland waters eel landings from 1969 to 2003 (2004 figures were not available) are reported in Figure IT.4; statistics refer only to lakes and artificial basins.

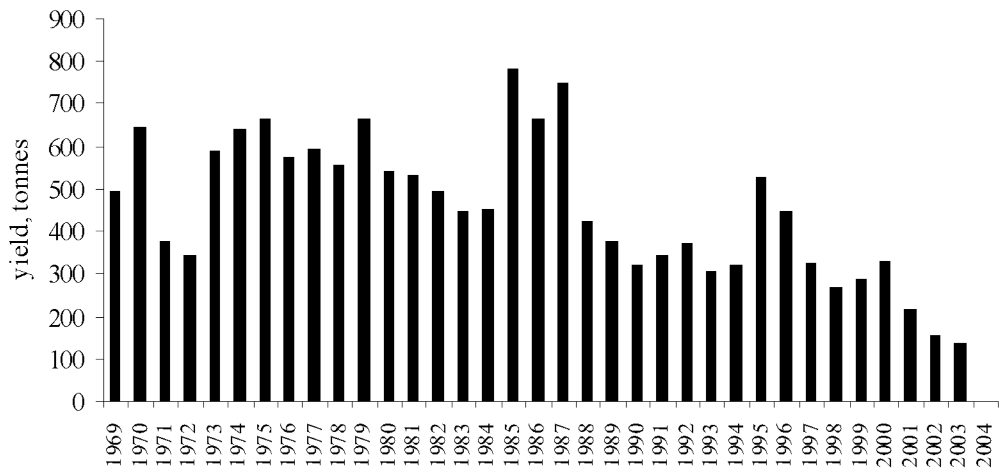

Figure IT.4. Eel landings (yellow and silver cumulated) in Italy, period 1969–2004, from lakes and artificial basins (Istituto Nazionale di Statistica).

The above statistics refer to yields cumulated for all Italy, but landing data splitted at the Regional level are also available, not given in the present report.

IT.E2. Restocking

Glass eel and bootlace eels, as well as yellow eels, have always been used for restocking inland water bodies, mostly with the aim of sustaining fisheries or lagoon yields. Most lake fisheries, in the north of Italy as well as the volcanic lakes of Latium (Bolsena, Bracciano), rely on restocking with yellow eels. Lagoon management, especially valliculture, is also based on restockings. In the past, also rivers were restocked by local Administrations, but this practice has progressively disappeared along with the scarcity of the resource and the rising in prices. No central recording of restocking quantities exist, therefore no data can be given.

IT.E3. Aquaculture

Up to the mid 1990s, Italy was the leading country in eel aquaculture, covering half of total European production, but today the Italian productive capacity and the market seem both to have reduced to about 1500 t/year (Table IT.a). Nowadays, only a very small quota of the production comes from the extensive culture in the Northern Adriatic (*valli)* and in other coastal lagoons.

Table IT.a. Aquaculture production in Italy from different sources (FW: Feshwater culture, BW: Brackishwater culture, MC: mariculture, Int: Intensive culture. Ext: extensive culture; API: Associazione Piscicoltori Italiani, MIPAF: Ministero delle Politiche Agricole e Forestali).

	FAO				*API*			*MIPAF*			
year	*FW*	*BW*	*MC*	*Total*	*Int*	*Ext*	*Total*	*FW*	*BW*	*MC*	*Total*
1985	2.000	800	.	*2.800*							
1986	2.500	800	.	*3.300*							
1987	2.700	800	.	*3.500*							
1988	3.000	1.000	.	*4.000*							
1989	2.500	1.200	.	*3.700*							
1990	2.500	1.550	50	*4.100*							
1991	2.000	1.550	35	*3.585*							
1992	1.950	1.305	10	*3.265*							
1993	1.985	1.005	10	*3.000*							
1994	2.080	910	10	*3.000*							
1995	2.280	710	10	*3.000*							
1996	2.500	450	50	*3.000*							
1997	2.500	500	100	*3.100*							
1998	2.800	350	-	*3.150*							
1999	2.950	250	-	*3.200*							
2000	2.450	250	-	*2.700*							
2001	2.300	200	-	*2.500*							
2002	1.618	77	4	*1.699*				1.618	77	4	*1.699*
2003	1.350	200	-	*1.550*	1.450	100	*1.550*	1.132	2	192	*1.326*
2004								1.033	186		*1.219*

IT.E4. Recreational Fisheries

Recreational fisheries for eel at the yellow and possibly silver eel stage occur in all inland waters, but are not recorded. No inquiries about licenses could be performed, nor about catches. As said above, catches from anglers are possibly quite significant.

IT.F. Catch per Unit of Effort

Considering that no estimate of fishing effort can be given, it is not possible to estimate CPUE for eel, for any of the fishing tipologies.

IT.G. Scientific surveys of the stock

IT.G.1. Recruitment surveys, glass eel

The monitoring of glass eel recruitment in Italy has been carried out since the mid '80s within research programmes supported by the Ministry of Agriculture and Forestry Politics, aimed at the assessment of euryhaline finfish fry used for aquaculture and restocking (Ciccotti, 2002; Ciccotti, 2004). Methodology has been extensively described in Ciccotti, 2002.

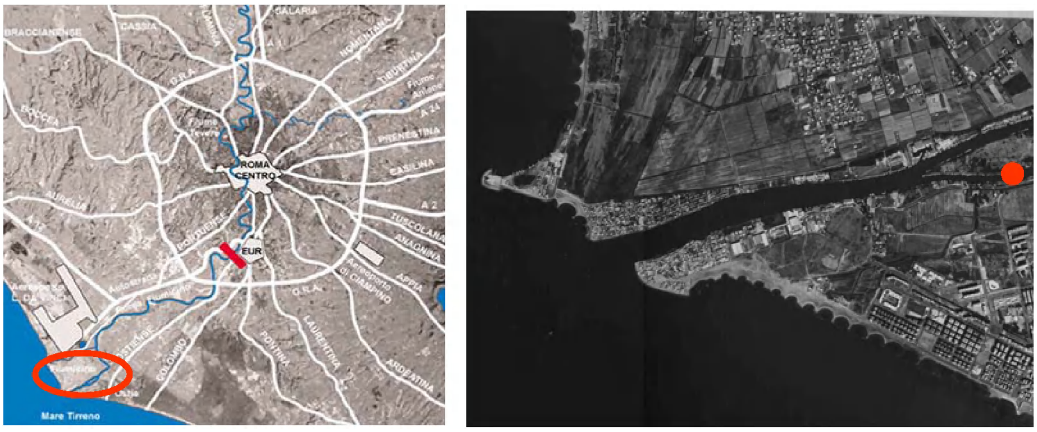

Figure IT.5. Location of the monitoring site at the Tiber river estuary (left) and aerial view of the main channel, where the monitoring site is located (right).

Figure IT.6. View of the monitoring site at the Tiber river estuary (left), and view of a fyke net installed near the river bank (right).

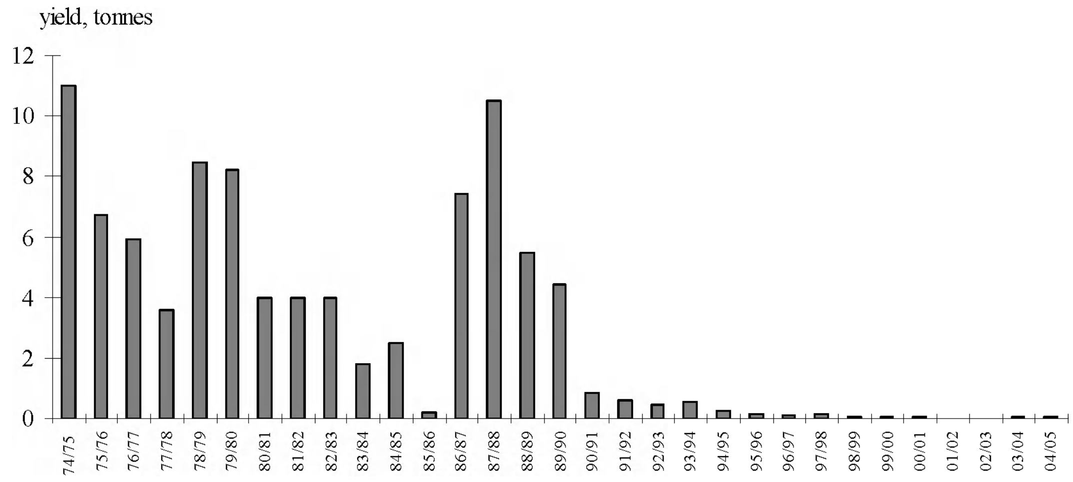

Figure IT.7. Time series of glass eel fishery production at the river Tiber (from Ciccotti, 2004, updated to 2005).

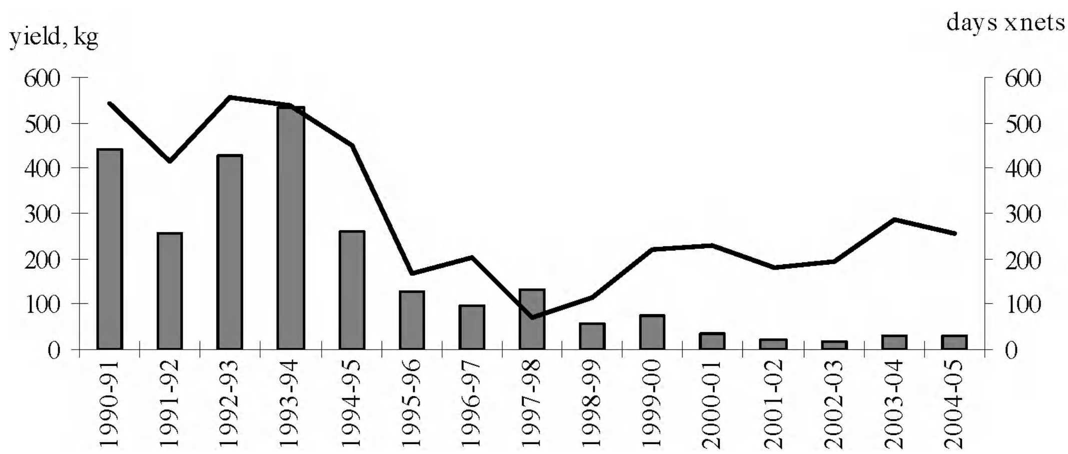

Figure IT.8. Glass eel recruitment trend (landings, left axis; fishing effort, right axis) at the river Tiber estuary during the 15 years monitoring (from Ciccotti, 2004, updated to 2005).

The monitoring method set up in the Tiber appears completely reliable in recording catches of the local fishery. In relation to its peculiar organization (daily basis of the fishery, detailed recording of fishing effort, implementation due to investigations on the basic features of migration), the monitoring has proved to be an effective method, representative of recruitment to the Tiber eel stock. Catch data from the Tiber, and the fishing indicators obtained within the monitoring, have also allowed, up to now, to figure out an overview of recruitment at a national scale, because of a general coherence of recruitment trends among sites. Nevertheless, the picture is incomplete, because of gaps regarding regions where the glass eel fishery seems to continue with good results (Campania, Toscana), and because of a general lack of information in relation to poaching and black markets.

From some years, a series of shortcomings have arisen, related mainly to the evolution of the situation in the Tiber. As a consequence of an unquestionable drop in recruitment, but also of a local environmental situation (unpredictable floods, water quality), the glass eel fishery has progressively reduced. For the fishermen co-operatives, the activity is not economic because costs exceed profits, notwithstanding the high prices, and fishermen tend to shift toward other activities. Therefore, it has been progressively difficult to carry out the monitoring, and some doubts have arisen that the Tiber might not be so representative of recruitment on the

Thyrrhenian coast any more. Therefore, an implementation of the monitoring has been actuated by adding a second monitoring site, located on the river Marta estuary, also in Latium, on the Thyrrenian coast. Its mouth is a small estuary, about 10 m large and 0.5–2 m deep, strongly influenced by tidal movements. Despite its small dimensions, in this estuary glass eel recruitment has always been present and in fact a small fishery is present. From 1999, a monitoring station has been set up here, that takes advantage of the collaboration of two fishermen authorized for glass eel fishing by the Province of Viterbo. The methodology is similar to the one set up in the Tiber, with data recorded on a daily basis during the ascent period, and stored in a book set up jointly with fishermen. Time series for a six years period (1999–2005) are reported in Figure IT.9.

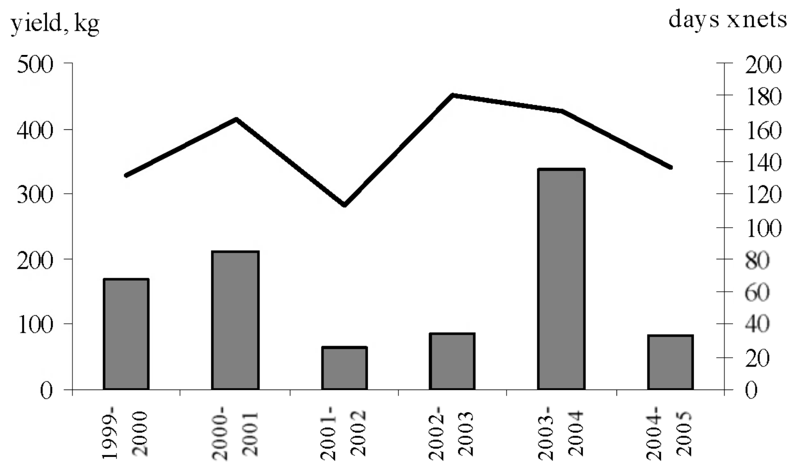

Figure IT.9. Glass eel recruitment trend (landings, left axis; fishing effort, right axis) at the river Marta estuary during the 6 years monitoring (from Ciccotti, 2004, updated to 2005).

The comparison between the respective performances of the two monitoring sites, besides allowing to draw a more complete picture of recruitment situation, highlights the fact that a higher level of organization in the fishery can turn out in a major obstacle for the monitoring .

At the present moment, anyway, the major constraint seems to be linked to the possibility of continuation of the monitoring, because the present research program (6th Three-years Plan) is finished November 15, 2005, and no prosecution has been foreseen nor financed. Changes in the research financing system are under way at the Ministry of Agriculture and Forestry Politics, that shall modify law 41/82, and that involve also research for monitoring and resource assessment. A breakdown of monitoring work, that would ensue also a weakening of the monitoring framework set up in the course of the years, at the present moment is not recommended both in relation to the necessity to follow recruitment trends and in relation to the DCR setting up.

IT.G.2 Stock surveys, yellow and silver eels

Scientific surveys of eel stock in Italy has been carried out on a continuative basis only for recruitment. For yellow and silver eels, a number of researches on population dynamics were carried out between 1973 and 1985, for some northern Adriatic valli populations as well as for some other coastal lakes in the southern Adriatic (Lesina, Varano, Acquatina) and Thyrrhenian (Monaci, Orbetello, Sardinian ponds) as well as for the Tiber river. Most of those were published in scientific journals, while some remained as grey literature (see Ciccotti, 1997 for a review). Subsequently, as interest, also in research, shifted towards intensive aquaculture, investigations on wild stock were abandoned, apart for some modelling applications investigated more recently, that focus on eel population structure and body growth, and its applications for the resource management (De Leo and Gatto, 1995; De Leo and Gatto, 1996; De Leo and Gatto, 2001).

Anyway, all these investigations rely on scattered, in space and time, samplings, and therefore cannot be defined scientific surveys. Nothing is actually being executed on a continuative basis.

IT.H. Catch composition by age and length

In Italy there is no sampling programme foreseen in any national or regional framework for adult eel, and therefore no samplings are taken from commercial catches, within any fishery tipology. It must be borne in mind that landing data are collected for statistical purposes, linked therefore to the characterization of social, economic and environmental conditions of the country, and only secondarily related to fishery management. A number of rearches were carried out in the past (see above section), but no information is available for recent years.

IT.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

As specified above, only incidental samplings within specific researches have been performed, and not recently, and this represents a major gap, because for many local stocks it appears clear that strong changes have occurred, regarding productivity, age structure, length composition, sex ratio. Unfortunately, no routine programme for any population parameter is executed.

Within the surveys carried out for recruitment monitoring, regular samplings have always been performed, on a weekly basis within most seasons and at both sites, for life stage evaluation and characterization.

Among the samplings and examinations performed within specific research projects, other features have been occasionally examined, such as parasitic infestations –in particular regarding *Anguillicola* sp. infection rates- and contaminants loads. Probably, occasionally some analyses for these features related to human health or to veterinary aspects have been monitored by official sanitary or veterinary services, but no information is ever made available, and most probably also in this case only scattered sporadic samplings have been actuated.

With regards to parasitic infestations, some data have been provided by the group of fish parasitology of the University of Rome “Tor Vergata” (F.Berrilli, D. di Cave, C. Liberato and P. Orecchia), that has monitored a number of years eel populations in Italy, and that foresees some new investigations in the ear future.

Data are presented relative to the Tiber river population (Table It.b) and to some coastal lagoons on the Adriatic and Tyrrhenian coast (Table It.c). For the Tiber levels of infestations in 1980 and in 1996 can be been compared, that show a higher infestation rate and the appearance of *Anguillicola crassus*, observed here for the first time in the early ‘90s. Data on parasitic infestations in Italian coastal lakes refer to 1997. *A. crassus* was found in North Adriatic *valli* and in the Burano coastal lakes, while other coastal lakes were still free at that date: this difference can be related to the restocking practices practiced in the former basins and absent in the others.

Table IT.b. Prevalence (%) and relative abundance of parasites in the eel population in the Tiber river, respectively in 1980 and in 1996. (Legend:G=gills; I=intestine; SB=swimbladder; Sp=specialist; Ge=generalist; Pi=relative abundance as a proportion of the total number of all helminths of all species in eels).

			1980		1996	
Parasite species	Site	Status	Prevalence	Pi	Prevalence	Pi
Monogenea						
Gyrodactylus anguillae	G	Sp	12.6	0.06	-	-
Pseudodactylogyrus sp.	G	Sp	-	-	16.8	0.02
P. anguillae	G	Sp	-	-	55.1	0.13
P.bini	G	Sp	-	-	28.7	0.07
Digenea						
Nicolla gallica	I	Ge	-	-	1.0	0.001
Cestoda						
Bothriocephalus claviceps	I	Sp	2.2	0.004	1.0	0.001
Proteocephalus macrocephalus	I	Sp	0.8	0.002	1.0	0.015
Caryophyllaeidae	I	Ge	0.4	0.001	-	-
Nematoda						
Anguillicola crassus	SB	Sp	-	-	66.3	0.352
Pseudocapillaria tomentosa	I	Sp	-	-	1.0	0.001
Raphidascaris acus	I	Ge	3.0	0.007	-	-
Acanthocephala						
Acanthocephalus clavula	I	Sp	52.6	0.9	65.3	0.405
Pomphorhynchus laevis	I	Ge	-	-	1.0	0.001
Total number of parasites			1163		980	
N° of eels examined			230		101	
Mean length of eels (±SD)			26.9 (±6.0)		25.8 (±6.4)	

Table IT.c. Prevalence (%) of parasites in samples from coastal lagoons in Italy (Valli di Comacchio and Valle Figheri: Northern Adriatic; Acquatina coastal lake: Southern Adriatic; Burano coastal lake: Tuscany, Central Tyrrhenian; Fogliano, Monaci and Caprolace costal lakes: Latium, Central Tyrrhenian). Reference year: 1997.

	Sites						
Species	Comacchio	Figheri	Acquatina	Burano	Fogliano	Monaci	Caprolace
	P(%)±ES	P(%)±ES	P(%)±ES	P(%)±ES	P(%)±ES	P(%)±ES	P(%)±ES
MONOGENEA							
Pseudodactylogyrus anguillae		54,5 ± 8,6	4,8 ± 4,6	33,7 ± 3,4			
P. bini		3,0 ± 2,9					
Gyrodactylus anguillae		3,0 ± 2,9					
DIGENEA							
Bucephalus polymorphus	2,4 ± 2,3	45,4 ± 8,6	47,6 ± 10,9	6,4 ± 1,7	40,0 ± 10,9	27,3 ± 6,7	5,3 ± 3,6
Deropristis inflata	73,8 ± 6,8	93,9 ± 4,1	19,0 ± 8,5	32,1 ± 3,4	40,0 ± 10,9	36,4 ± 7,2	44,7 ± 8,0
Lecithochirium musculus	69,0 ± 7,1	36,4 ± 8,3	4,8 ± 4,6		45,0 ± 11,1	34,1 ± 7,1	18,4 ± 6,2
Helicometra fasciata	73,8 ± 6,8						
Limnoderetrema sp.				0,5 ± 0,5			
CESTODA							
Proteocephalus macrocephalus		9,1 ± 5,0		8,5 ± 2,0			
Tetraphyllidea (larvae)			4,8 ± 4,6				
NEMATODA							
Contracaecum sp. (larvae)	9,5 ± 4,5	69,7 ± 7,7	61,9 ± 10,6		10,0 ± 6,7	4,5 ± 3,1	
Goezia anguillae				2,7 ± 1,1			
Anguillicola crassus	11,9 ± 4,9	9,1 ± 5,0		37,4 ± 3,5			
Cosmocephalus obvelatus (larvae)	4,8 ± 3,3						
ACANTHOCEPHALA							
Acanthocephala (larvae)		12,1 ± 5,6					
Telosentis exiguus				3,7 ± 1,3			
CRUSTACEA							
Ergasilus gibbus		3,0 ± 2,9					

IT.J. Other sampling

For inland waters, most Regional laws in Italy contemplate the accomplishment of Fish Maps by the Provinces, instruments aimed at the planning and management of fish populations and of fishing activities. The reference unit for the Fish Maps is the catchment basin, investigation levels are actuated or at different levels (environmental characteristics of water habitats, anthropogenic effects, structure and dynamics of fish populations, fisheries). Methodologies should follow in most cases standardized guidelines, and differ depending on the habitat. Thus, Fish Maps, when correctly compiled, represent the only standardized methodology for fish samplings, and a useful amount of available information that could be integrated with the DCR actions, in consideration of the fact that fishery exploitation is considered in Fish Maps. Up to now, only a certain number of Provinces, mostly in the northern regions, have compiled Fish Maps, and in most cases have been published by the Provinces and available. The main constraint at the present moment for the utilization of this source if information is the fact that no centralized work of co-ordination and synthesis is done for any fish species. Eel presence has been ascertained in most of the catchments were investigations have been carried out, but no data on density or biomass are available.

Other samplings in Italy concern environmental monitoring, that involves a network of Agencies at different levels. The APAT (Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici) is the technical organ of the Ministry of the Environment, whose function is to co-ordinate actions as well as to maintain the connection with the European network EIOnet, while the ARPA are Regional Agencies involved in environmental protection. An important section of the work of these Agencies involves water environments. Data from environmental monitoring are collected, elaborated and divulgated on a framework basis through the SINAnet, the National Environmental Informative System. In this way a great amount of information regarding different environmental aspects is made available. These agencies are not involved in fish monitoring, but some pilot actions are beginning, in relation to the standardization of methods, in view of the Water Framework Directive actuation.

IT.K. Stock assessment

In Italy no routine assessment of eel stock is under any scheme nor at the central nor regional level. There is no formal advice on ell fishery management.

IT.L. Sampling intensity and precision

Having stated beforehand that no samplings nor investigations on catch composition and/or age and growth are carried out within official recordings, it is not possible to analyse variation in samplings, within and among sites, seasons, gears. Anyway, a discussion on this topic seems important for eel in Italian waters (and probably in other Mediterranean countries) in relation to the heterogeneity in eel habitats and fisheries organization, to the seasonal variation of eel catch and catch composition most pronounced in lagoons etc.

IT.M. Standardisation and harmonisation of methodology

Having stated beforehand that only incidental samplings within specific researches have been performed, it is impossible to give an overview of methods with regards to the different items. In most research studies, sampling collection and sampling treatment (size measurements, age reading, sex determination, stage identification) as well as any other biological observation (parasites) or determination (contaminants) has been done by following the latest protocols as inferred from literature, available at the moment the research was carried out.

The setting up of a standardised sampling methodology and of protocols for biological investigations on eel is therefore a priority, and will take great advantage of the discussion within the DCR actions.

IT.N. Overview, conclusions and recommendations.

In the present report an overview of the European eel stock and fisheries is presented for Italy. From the presented information, it is possible to summarise the following points:

- Eel landings in Italy, in coastal waters as well as in inland water bodies, show a continued decrease, while glass eel monitoring confirms the current low trend in recruitment.
- Scientific surveys on a continuative basis have been carried out only for recruitment, along 15 years (1999–2005) within the Three-years Plans of Ministry of Agriculture and Forestry Politics, law 41/82, and contributed up to now to the understanding of the eel stock situation in Italy with respect to the rest of Europe. At the present moment, anyway, the continuation of the monitoring is in doubt, because no prosecution has been foreseen nor financed. Changes in the research financing system are under way at the, that involve also research for monitoring and resource assessment. Recently, the Scientific Committee of the Ministry of Agriculture and Forestry Politics has suggested the setting up of a specific research programme for eel data collection, in view of its inclusion among the species concerned by the EC regulation 1543/2000.
- No specific actions have been undertaken up to now by the Administration in relation to the DCR nor to the establishing of a National Management Plan as provided by the Proposal for a Council Regulation establishing measures for the recovery of the eel stock. Notwithstanding this, debate on the course of action to be undertaken to comply with the European Commission dispositions is currently being held at different levels, administrative as well as scientific, in relation to the awareness of the necessity of urgent actions for the eel stock recovery, in order to bring about some pilot actions.
- The establishing of the Data Collection national plan for eel shall represent a major opportunity to collect data on the eel stock in Italy and to evaluate its

present state in the setting of a coordinated framework. This shall require undoubtedly some costs and efforts, but notwithstanding the gaps and inconsistencies of existing initiatives at a decentralised level, an effort in supporting, co-ordinating and implementing the existing schemes shall prove to be more cost-effective and realistic than the setting up of a centralised Data Collection Programme for eel.

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Annex 4: Technical minutes from the ACFM Review Group on Eel 2006

Chair: Martin Pastoors

Reviewers: Wim Demare and Maris Plikshs

Presenter: Willem Dekker

24 March 2006

General comments

The WG has produced a very informative report on European Eel. The report is clearly a result of an ongoing process that started years ago. All the TOR's have been addressed.

The main message is that the eel stock is in a very poor state and that this has been for many years now. The WG has documented causes for the decline and lists management tools to ameliorate the situation. The executive summary gives a good overview of the results obtained in the report. The summaries after each section facilitate the reading of the report.

The report is often characterized by a strong mixing of science (state of the stock), advice and setting management objectives. The review group agrees with the WG that the future focus of the WG should be on further developing the scientific basis (including data compilation) that can underpin the advice.

Section 2 – Trends in recruitment, stock and yield

Under trends in recruitment, the influence of NAO-index on recruitment is mentioned. It is not clear how these could could be correlated on a longer time-scale. This needs more explanation.

There are trends in SSB available in section 4 (apparent from the SSB-R plot). It would have been useful to present these trends section 2, even though the analysis have not been carried out by this WG. The time trends in SSB were based on the assumption that SSB is proportional to landings, i.e. that F was more or less constant over 50 years. Although there could be some justification this remains speculative.

Several reasons for the stock decline are described. These reasons can be different in the different River Basin Districts (RBD). It would be useful to consider some kind of classification of RBD's where the main reason is fishing, pollution or others impacts. The review group acknowledges that this is not an easy task.

Layout

- there is no reference to table 2.4.1
- the logarithmic scale on a proportion (recruitment) is confusing. Either a proportion or a logarithmic scale on abundance would be easier to interpret.

Section 3 – Spawner quality

This section considers all possible parameters that could influence the spawners quality. The background information is very wide and comprehensive. It is not clear how these parameters have contributed to the reduction of spawning stock and what actions should be included in the national management plans (need for prioritization?)

The main conclusion from this Section is that the required data base is lacking, e.g. there is not an adequate spatial coverage of PCB concentrations in the population). So it is highly relevant, but not feasible in the short term.

Section 4 – Objectives, targets and time frames for restoration

Section 4.3. Stock–recruitment relationship.

- Is it appropriate to use the landings as a proxy for stock size in the S-R relationship (Figure 4.1. SSB proportional to the landings from continental stock…)?. This would need some more explanation (e.g. derived from Dekker 2004). E.g. is SSB expected to be proportional to landings of yellow or silver eel or both together? From freshwaters or from the Sea?.
- Usually CPUE is used as indicator of stock size. Would that be appropriate here?
- If the stock consists of several sub-stocks (by RBDs), would it be useful to consider the SSB-R relationships for several RDBs where the data are sufficient to carry out a full assessment. This is relevant under the assumption that homing is an important feature fore eel. However, this is not apparent from the data. It has been shown that R series from almost all over Europe correlate well and that all recruits are genetically almost identical (in comparison to oher fish, or any other organism). Homing is highly unlikely.
- Could the shift in the mid 1980s be interpreted as a regime shift that corresponds to the observed regime shifts in the Baltic and North Sea (see: WKIAS, REGNS).

Section 4.4. The terminology on precautionary approach is confusing. Section 4.4 is called "long term targets" but it is actually looking at the PA reference points. The standard ICES terminology is that a limit reference point is set to prevent stock collapse . A precautionary reference point is proposed to take account of the uncertainty in the assessment process and thus as a safety margin on the limit reference point. In addition, managers can agree on target reference points that aim to achieve e.g. maximum sustainable yield. ICES often explicitly states that PA points (limit and precautionary reference points) should not be used as targets!

Section 4.6 – Recovery time depends on the reduction in fishing mortality. Does that include all "anthropogenic" mortality? See also Annex 2.

Section 4.7. According to the WG, reduction of fishing mortality and the improvement of upstream and downstream migration should be the priorities for short term measures. If these are the two main areas, would it be possible to advice on a prioritization of the list of actions in that section?

Section 5 – Spatial resolution in targets, controls and post-evaluation

This is a confusing section because it is unclear what the topic is of the section. It seems to oscillate between assessment techniques, monitoring aspects and linkages between areas. The section would have benefitted from a more tight editing.

Section 5.2.2. The harvest rate model assumed that fishing effort is directly related to fishing mortality. Is there any evidence for this from the eel fisheries?

A conclusion is missing from the section on the Eel assessment toolbox. What is the recommended line of development? What is "nice to know" and what is "going to be undertaken"?

It is not clear what problem the "dashboard method" is attempting to resolve.

Section 6 – Spatial distribution of eel fisheries

From the report it is difficult to find out the landing information. It is reflected in the national reports (Annex 3) but not summarized. The WG already recognized that it is important to compile landings data by RBD. This is important for future establishment of eel monitoring under the DCR.

Eel is considered as a one stock, but there are substantial landings from non-EU countries (e.g. Egypt). Is there any view on how these landings can be included into the data collection process?

Are unreported landings (angling, black landings etc) an issue?

Is there information available on the glass eel export to Asia for aquaculture?

Are there indicators for trends in the fishery available (e.g. number of fishermen, fishing effort)?

Section 7 – Re-stocking of glass eel as a means to aid stock recovery

Section 7.5.3.5. What could be the consequences if the sex ratio is altered?

Section 7.8.2.1. The suggestions to use eel-surveys to calibrate multi-species surveys: has this been tried in the past? If so, a dissemination of those results would be useful.

Layout :

- Figure 7.2: x-axis has label 1056 instead of 1956
- The last sentences of section 7.5.2 are very difficult to understand?
- section 7.8.2.1 – reference to table 2 (should be 7.3?)

Annex 2

Equation 1

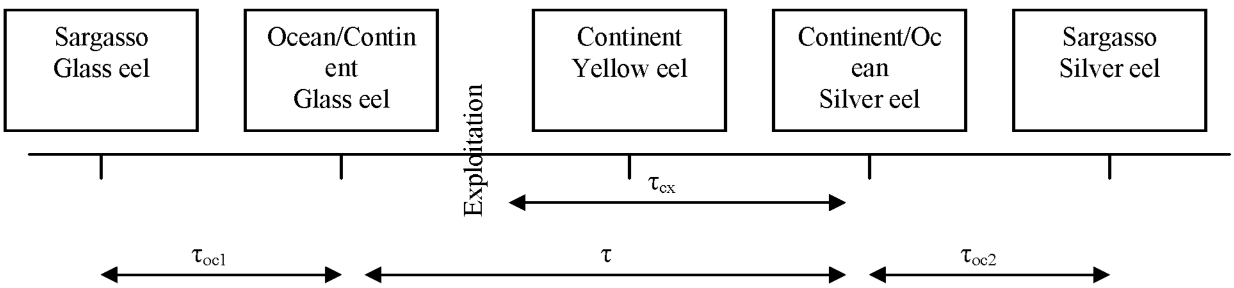
- why only M during continental phase (τ)?
- is there only exploitation during the continental phase (τ_{ex}) and not during the oceanic?

t_{full} = time it takes to grow from the youngest exploited stage to spawner escapement

τ_{ex} = time span of the exploited stages which is a part of the continental phase

What is the difference between t_{full} and τ_{ex}?

It would be helpful to have a time bar with the different stages on it. Something like below:



Layout:

- Equation 3: is there a "-1" missing in the denominator?

Discussion:

- Maris. Section 7. Restocking practices. No real conclusion. Northern Europe approach restocking is good. Southern Europe different view.
- Wim:
  - Restocking the same river not problematic. But amount of glasseels is going down.

    - Restocking in other river is more difficult.
- ACFM summary of 2005: add management action plan. New proposal by EC (not published yet); requests National Management Plans. Habitats directive. Water Framework directive.
    - Management consideration; evaluation of EC proposal in relation to annex 2. Restocking.
    - Factors affecting fisheries and stock.
    - Uncertainties in assessment and forecasts.
- Sex ratio