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Marine fish diseases: an overview of 10 years' investigations by MAFF (UK)

D Bucke and S W Feist

Ministry of Agriculture, Fisheries and Food,
Directorate of Fisheries Research, Fish Diseases Laboratory
Weymouth, Dorset DT4 8UB (UK)

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Abstract

MAFF's investigations on the status of fish diseases and their possible relationship with adverse environmental conditions, in the North Sea and Irish Sea over the past 10 years, are reviewed. Early studies were broad-based involving several fish species and a wide range of diseases and parasites. For the purposes of monitoring pollution effects, such results were found to be too subjective. Subsequently, through consultation and international collaboration, standardised sampling and recording procedures were adopted. Although recent studies have revealed fluctuations in disease prevalence rates between some areas, no upward trend in overall disease levels has been identified, nor has any unequivocal evidence been obtained of a link between pollution and higher prevalence rates. Throughout these studies, special attention has been given to elucidating the underlying pathogenesis of the main disease conditions observed. This has led to research into changes in the liver in flatfish species, including neoplasia, and laboratory studies to investigate the health status of fish after long-term exposure to contaminated marine sediments.

1. Introduction

Disease studies in marine fish by MAFF (UK) have, until recently, had the singular objective of checking to identify if reports of diseased fish occurring in coastal waters were valid, rather than monitoring for spatial and temporal trends in disease prevalence levels (Shelton and Wilson, 1973). Since 1980, within MAFF's Directorate of Fisheries Research (DFR), a programme of *ad hoc* studies has developed into an in-depth field and laboratory investigation into the epidemiology and pathogenesis of marine fish diseases (Bucke et al., 1983a, 1983b; Bucke and Nicholson, 1987; Bucke and Stokes, 1988; Bucke et al., 1989). Most of the results from these studies have been reported to ICES either through the Annual Reports of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO), or through presented papers (Bucke, 1989). This paper is an overview of studies and discusses plans for future work in this area.

2. Rationale and methodologies used for disease investigation

Over the past decade, MAFF has carried out over 20 sea-going surveys for fish diseases. Table 1 lists the areas investigated in the North Sea and the Irish Sea and the research vessels employed. Some cruises were solely dedicated to work on fish diseases, but others included fish disease

investigations, amongst other studies. Almost all cruises were attended by at least one experienced "fish disease specialist". The earlier surveys, in 1980 and 1982, were planned to find out whether disease problems occurred in fish on waste disposal sites, as had been reported elsewhere (Mahoney et al., 1973; Mearns and Sherwood, 1974; Sindermann, 1979; Dethlefsen, 1980). Following these earlier investigations, MAFF scientists participated in International Fish Disease cruises and sea-going Workshops on Standardisation of Methodologies for Fish Disease Surveys (ICES, 1986a). In addition, within the DFR, a multi-disciplinary team of scientists was established to discuss the approach to further pollution-related marine fish diseases surveys. Subsequently, cruises took place in 1985 and 1986 to look at the feasibility of integrating fish disease surveys into existing groundfish studies. This line was pursued because of the high costs of dedicated fish disease cruises and the existence of other priorities of research vessels.

The programmes for the later sea-going surveys have taken into account the experience gained on surveys on standardisation of methodologies for fish diseases and, where possible, have presented data to ICES as requested (ICES 1989a). However, although the monitoring of the prevalence of external diseases has become the accepted way of obtaining data related to pollution, we have always had doubts that there is a significant relationship (Bucke, 1985). For that reason, we have tried to understand more about the pathogenesis of the diseases (Bucke et al., 1984; Bucke, 1989). Consequently, research projects have been initiated into liver pathologies in dab (*Limanda limanda*) and flounder (*Platichthys flesus*), as well as into laboratory-based experiments to investigate the immunocompetence of fish exposed to contaminated sediments for long periods (Bucke et al., 1989). These research projects have involved collaboration with other research groups and regular workshops on marine fish diseases have been held over the past 4 years at the Fish Diseases Laboratory, Weymouth, England. These have involved most UK scientists working in the field of fish diseases in relationship with pollution.

3. A critical synopsis of MAFF (UK) fish disease surveys

A bibliography of published literature relating to MAFF fish disease studies is given at Appendix I. With hindsight, it is easy to be critical of sampling methods and procedures for presenting fish disease data. Experience was gained from the earlier surveys and, in the more recent studies, effort

has been made to standardise techniques. Some of the highlights and the problems are discussed.

(a) Thames Estuary

The 1980 Thames Estuary study was initiated to investigate whether fin-rot, and other epidermal anomalies, were more prevalent in Dover sole, other flatfish species and gadoids, caught on stations on, or near, a waste disposal site in the outer Thames Estuary, than on reference stations. Of the 7,345 fish examined, 398 (5.5%) had some obvious abnormality; 110 of those fish (1.5% of the total) showed some degree of fin rot (which mostly was classified as "slight"). The prevalence of fin rot in those samples was generally lower than that reported by other workers in the New York Bight and off the California sludge outfalls (Mahoney et al., 1973; Mearns and Sherwood, 1974). There was no significant evidence for spatial trends of fin-rot, and the other diseases recorded on stations in the outer Thames Estuary, apart from a slight increase on one station furthest away and upstream from the waste disposal site. The prevalence of lymphocystis in flounder was higher at the reference station than at the disposal site.

This was probably the first European marine fish disease survey which included a histopathological examination of normal and abnormal tissues. Of note, nodules and tumours occurring in flatfish species were all diagnosed as non-neoplastic, and generally represented inflammatory changes as might be found in response to infectious diseases. The conclusion from the study was that there was no evidence that the dumping of sewage sludge significantly influenced the prevalence of fish diseases in the outer Thames Estuary. Experience has shown that the choice of Dover sole for monitoring fish diseases was not good, because of its migratory life-style and localised habitats. A later study, in the outer Thames Estuary in 1988, revealed that even the recommended target species (dab or flounder) were extremely scarce and to reach suitable sample sizes for meaningful statistical analysis in this area, as recommended by ICES, would be time-consuming and costly. Other problems included the fact that the outer Thames Estuary is not an easy area to work, with its awkward currents, tides, fluctuating depths and heavy shipping activity. It was also apparent that the fish population in this area is fairly mobile. The outer Thames Estuary was not a particularly suitable area for fish disease monitoring.

(b) Irish Sea

Fish disease surveys in the Irish Sea relate to a waste disposal site in Liverpool Bay. The first of the studies was rather significant because it

was the first survey for fish disease prevalence in this area since the pioneering work of Shelton and Wilson (1973). It was interesting to note that the results indicated that the overall prevalences of epidermal diseases in flatfish (dab and plaice) were lower than those found a decade earlier. Furthermore, there was no evidence that diseases were more prevalent from fish sampled on the disposal site stations than on reference stations. A selection of organs was sampled for histological examination, and results revealed that some pathological changes had occurred in the livers of dab. The presence of putative neoplastic changes was extremely rare, even compared with the prevalences of such changes identified in livers from North Sea dab (Bucke et al., 1984). Subsequent investigations in the Irish Sea included feasibility studies (where we applied various methodologies for sampling and included other commercial fish species); these again provided evidence that there was no obvious time trend in disease prevalence in fish in the Irish Sea. Of note, there has been no evidence of "X-cell" gill disease in the Irish sea dabs, yet it is not uncommon in North Sea dabs (McVicar et al., 1987; Diament & McVicar, 1987).

(c) North Sea

Surveys for fish disease prevalence in the North Sea fall into 3 categories.

(i) Monitoring on waste disposal sites (north-east English coast, including the Humber area) (Figure 1).

This is the sampling area from which we have elected to submit fish disease data to ICES. The monitoring programme is currently in its third year: to date, there has been no evidence of significant spatial trends in disease prevalence. It is too early to consider temporal trends. The main problems encountered are the difficulty in trawling on these disposal site stations in the North Sea because of the uneven bottom topography, which adds costs to this type of study due to the time factor involved.

(ii) Integrated studies with annual groundfish surveys (whole North Sea).

This is the fourth year this type of extensive survey has been made. It is possible to collect a large amount of disease data on many fish species, including dab, from fixed stations over all of the North Sea (including the Dogger Bank), which can be integrated and plotted against vast amounts of other data collected for the groundfish survey. Therefore, over an extended period, it is possible to obtain a very good background picture of spatial and temporal trends of fish diseases. The selected diseases can be subjected to good statistical analysis (Bucke and Stokes, 1988) and, additionally, the

significance of emerging diseases can be assessed. The main disadvantage of this type of programme is that it has to be combined with the full programme arranged for groundfish surveys. Fish disease studies have relatively low priority when it comes to sampling because there is usually only time for stations to be trawled once. This means that sample sizes may be inadequate and that "inter-haul" variability cannot be compared. Having said that, from our experience we would recommend that anyone contemplating marine fish disease programmes should first participate in a groundfish survey. It offers the best opportunity to learn standardised methods for sampling, sub-sampling, and handling catches of fish because the methodologies have been uniformly accepted by most ICES countries for many years.

(iii) Pathogenesis and diagnosis of diseases in commercial fish stocks.

MAFF's responsibilities also include investigation of reported outbreaks of disease in commercial fish and shellfish stocks in order to advise if these are significant and whether affected fish are marketable. Examples of such problems in recent years include concern expressed by the industry of certain diseases in cod (*Gadus morhua*). Our investigations have included field studies using local knowledge for pin-pointing areas of disease occurrence, market surveys and laboratory tests. From these investigations, we have provided information on the significance of the problems and have been able to give re-assurance that the fish are safe for consumption (Bucke, 1989).

4. Laboratory experiments

Laboratory experiments were introduced to assess the effects on fish health of them being subjected to long-term exposure (up to 6 months) to highly-contaminated harbour sludge and less-contaminated reference sediments. Dab (*Limanda limanda*) have been used for most experiments, although the effects on a variety of other fish species were also investigated. These studies focussed on the detection of subtle changes in the immunocompetence of exposed fish rather than the pathogenesis of recognised disease conditions. The demonstration of a link between impaired immune response and the increased incidence of macroscopic diseases was also sought. During the course of these experiments, ulceration and epidermal hyperplasia occurred in fish exposed to contaminated and to reference sediments. These diseases were associated with heavy infestations of *Trichodina* ciliates. A correlation with impaired immunocompetence was not confirmed in these cases. Overall, results have shown a large, natural variation in immune response between

individuals and also between species, which may mask sediment-related effects (Bucke et al., 1989). This work is continuing at FDL Weymouth and, by collaboration with other institutes, a variety of other biological indicators of stress is being investigated.

5. Future plans

MAFF plans to continue monitoring fish and shellfish diseases in UK waters in accordance with national and international requirements and to advise as required on the risks to public health. It is expected that laboratory experiments will provide simpler and cheaper methods for assessing the effects of anthropogenic contaminants on the health of fish, than the laborious and costly methods presently used in fish epidemiological studies.

6. Conclusions

From the past 10 years of fish disease investigations, a number of conclusions have been reached. General statements on spatial and temporal trends in disease prevalence are extremely difficult to make for the whole of the period covered, and accurate data is really only available for certain diseases such as lymphocystis and ulceration. Along with other investigators, we have progressed from broad initial studies, in which a wide variety of conditions were recorded, to more refined standardised data recording which has become accepted as the norm. Most diseases used for pollution monitoring purposes have infectious aetiologies, and pollution-related effects, if present, may be minimal. The most likely exception to this is hepatic neoplasia which is possibly the only truly pollution-related disease routinely recorded. This condition is widespread, but of low prevalence in North Sea dab. Detailed light- and electron-microscope investigations have shown that the neoplasia does not proceed to form aggressive tumours and that smaller lesions may easily be confused with parasitic cysts or other hepatic anomalies. Consequently, the recording of "hepatic neoplasia" should be approached with caution and wherever possible confirmed by the use of histology.

The epidemiology of several diseases in dab populations is still unclear. Prevalence of each disease in dab depends on the density, length and possibly age of the population sampled; a disease regarded as important in one area may not be significant in another because the optimum density

required for disease transmission and similar fish length and age distribution may not apply to that area.

Laboratory studies have provided interesting parallels with field observations. Epidermal diseases, including epidermal hyperplasia, were found to occur in dab held in seawater aquaria containing reference as well as contaminated sediments. These diseases were associated with the presence of large numbers of ectoparasites, notably Trichodinid ciliates.

During the past 10 years, much progress has been made and a basic appreciation of marine fish diseases has been achieved. Further advances with regard to disease/pollution relationships will depend on a multi-disciplinary approach using a suite of analytical and biomedical techniques.

7. References

- Bucke, D. (1985) Are epidermal anomalies the best criteria for assessing the health status of fish? ICES CM 1985/E:42, 6pp. (Mimeo)
- Bucke, D. (1989) Observations on visceral granulomatosis and dermal necrosis in populations of North Sea cod, *Gadus morhua* (L). ICES CM 1989/E:17, 13 pp. (Mimeo)
- Bucke, D. and Feist, S.W. (1984) Histological changes in livers of dab, *Limanda limanda* (L). ICES CM 1984/F:9, 8 pp. (Mimeo)
- Bucke, D. and Nicholson, M.D. (1987) Fish disease investigations in the Irish Sea. ICES CM 1987/E:19, 12 pp. (Mimeo)
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- Bucke, D., Feist, S.W., Norton, M.G. and Rolfe, M.S. (1983b) A histopathological report of some epidermal anomalies of Dover sole, *Solea solea* (L) and other flatfish species in coastal waters off south-east England. J. Fish Biol., 23, 565-578.
- Bucke, D., Feist, S.W. and Rolfe, M.S. (1983c) Fish disease studies in Liverpool Bay and the north-east Irish Sea. ICES CM 1983/E:5, 9 pp. (Mimeo)
- Bucke, D., Watermann, B. and Feist, S.W. (1984) Histological variation of hepato-splenic organs from the North Sea dab, *Limanda limanda* (L). J. Fish Dis., 7, 255-268.

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- ICES (1986a) Methodology of Fish Disease Surveys. Report of the 1984 Workshop. Co-op. Res. Rep., int. Coun. Explor. Sea (140), 33 pp.
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- ICES (1987) Working Group on Diseases and Pathology of Marine Organisms. ICES CM 1987/F:34, 51 pp. (Mimeo)
- ICES (1988) Working Group on Diseases and Pathology of Marine Organisms. ICES CM 1988/F:37, 96 pp. (Mimeo)
- ICES Co-operative Research Report No.166. (1989) Methodology of Fish Disease Surveys. 43 pp.
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- Shelton, R.G.J. and Wilson, K.W. (1973) On the occurrence of lymphocystis, with notes on other pathological conditions, in the flatfish stocks of the north-east Irish Sea. Aquaculture, **2**, 395-410.

Sindermann, C.J. (1979) Pollution-associated diseases and abnormalities of fish and shellfish: a review. Fish. Bull., Nat. Mar. Fish. Surv. U.S., **76**, 717-749.

Table 1.

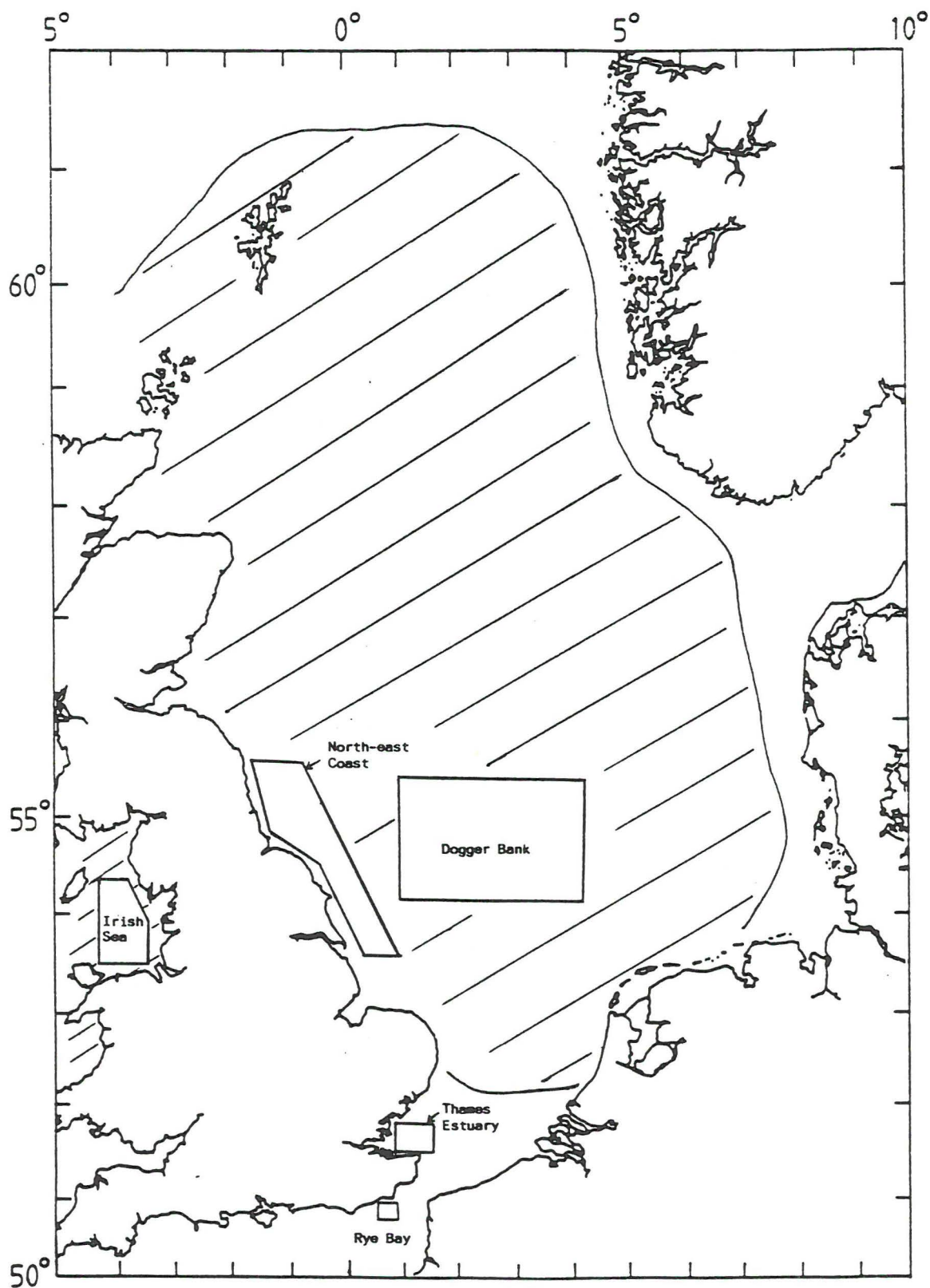
MAFF FISH DISEASE EPIDEMIOLOGICAL INVESTIGATIONS 1980-1990

DATE	SHIP	AREA SAMPLED	TARGET SPECIES	REASON FOR STUDY	REFERENCES
April 1980	RV <i>Corella</i>	Outer Thames Estuary and Rye Bay (English Channel)	Dover sole, other flatfish and gadoids	Sludge disposal site fish disease information	Bucke <i>et al.</i> , 1983a
May 1980	MV <i>Maagen</i>	"	"	"	" " " " 1983b
April 1982	RV <i>Clione</i>	Liverpool Bay and N.E. Irish Sea	Dab, plaice	Sludge disposal site fish disease information	" " " " 1983c
September 1985	RV <i>Clione</i>	Irish Sea	Plaice, whiting	Investigatory cruise to test the use of ground-fish cruises and personnel for fish disease monitoring	Bucke and Feist, 1984 ICES (1986b)
November 1985	RV <i>Cirolana</i>	Irish Sea	Dab, plaice, whiting	Further investigation to standardise sampling techniques	" "
April 1986	RV <i>Cirolana</i>	Irish Sea	Dab, plaice	Final cruise on standardisation techniques	ICES (1987)
June 1986	MV <i>Independence</i>	North Sea (N.E. coast)	Cod	Epidemiological study on cod skin necrosis	Bucke, 1989; ICES (1987)
November 1986	RV <i>Cirolana</i>	Irish Sea, Liverpool Bay and reference stations	Dab, plaice	Sludge disposal site, disease investigations	Bucke and Nicholson, 1987; ICES (1987)
January 1987	MV <i>St Leger</i>	North Sea, Humber - Dogger Transect	Dab	Transect information	ICES (1988)

Table 1. (Cont'd)

DATE	SHIP	AREA SAMPLED	TARGET SPECIES	REASON FOR STUDY	REFERENCES
August/ September 1988	RV <i>Cirolana</i>	North Sea	Dab, other commercial species	Annual groundfish survey, background data	Bucke and Stokes, 1988; ICES (1988)
February 1988	MV <i>Jodalee</i>	Outer Thames Estuary	Dab, flounder	Sludge disposal site, disease investigations	
August/ September 1988	RV <i>Cirolana</i>	North Sea	Dab, cod	Annual groundfish survey, background data	ICES (1989b)
September 1988	MV <i>Prince Madog</i>	Irish Sea, Liverpool Bay	Dab	Sludge disposal site, disease investigations	" "
October/ November	RV <i>Corystes</i>	North Sea: Dogger Bank Southern North Sea	Dab, cod	a) Dogger Bank disease survey b) Cod - visceral granuloma study	" " Bucke, 1989
April 1989	RV <i>Corystes</i>	North Sea (N.E. coast)	Dab, cod	Sludge disposal site, disease investigations	ICES (1990)
August/ September 1989	RV <i>Cirolana</i>	North Sea	Dab, other commercial species	Annual groundfish survey, background data	" "
September 1989	MV <i>Prince Madog</i>	Irish Sea, Liverpool Bay	Dab	Sludge disposal site, disease investigations	" "
May 1990	RV <i>Corystes</i>	North Sea (N.E. coast and NSTF stations	Dab, other commercial species	NSTF stations and sludge disposal site, disease investigations	
August/ September 1990	RV <i>Cirolana</i>	North Sea	Dab, other commercial species	Annual groundfish survey, background data	

Figure 1. MAFF fish disease investigations 1980-1990.
Boxed areas - regions of special interest; shading
denotes area covered during routine disease surveys.



APPENDIX I

Annotated bibliography of MAFF (UK) published papers and reports on marine fish diseases

- Bucke, D. (1985) Are epidermal anomalies the best criteria for assessing the health status of fish? ICES CM 1985/E:42, 6 pp. (Mimeo)
A critical appraisal of diseases used for pollution monitoring purposes, favouring hepatic changes to epidermal diseases.
- Bucke, D. (1986) A short note on a rare occurrence of lymphocystis in Dover sole, *Solea solea* (L). Bull. Eur. Ass. Fish Pathol., 6, 1.
An authenticated (illustrated) report of this rare occurrence.
- Bucke, D. (1988) Fish diseases in perspective. Fisheries Spotlight, MAFF Direct. Fish. Res., Lowestoft 1987-88, 45-49.
Information for the lay-person about diseases in commercial fishing species.
- Bucke, D. (1988) Pathology of fish diseases in the North Sea. pp.286-301. In "Environmental Protection of the North Sea" (eds. P.J. Newman and A.R. Agg). Heinemann Professional Publishing Ltd., Oxford, London.
A pathological description of diseases in North Sea fish with references to historical material, which showed that essentially all currently-known diseases have occurred, at least for the past 60 years.
- Bucke, D. (1988) A proposal for round-table discussions on tumour diagnosis. Bull. Eur. Ass. Fish Pathol., 8, 49.
The question of terminology for "tumour" and cancer in fish is discussed.
- Bucke, D. (1989) Observation on visceral granulomatosis and dermal necrosis in populations of North Sea cod, *Gadus morhua* (L). ICES CM 1989/E:17, 13 pp. (Mimeo)
Case histories of two diseases currently affecting large cod in the North Sea reveal that these two conditions of unknown aetiology are causing concern to the fishing industry.
- Bucke, D. and Feist, S.W. (1984) Histological changes in livers of dab, *Limanda limanda* (L). ICES CM 1984/F:9, 8 pp. Mimeo.

A histological description of liver pathologies in dab sampled from the North Sea and Irish Sea, including first report of hepatic adenoma in this species.

Bucke, D. and Feist, S.W. (1985) Examples of neoplasia or neoplastic-like conditions in marine fish. pp.197-201. In "Pathology in Marine Aquaculture" (eds. C.P. Vivares, J.-R. Bonami and E. Jaspers). European Aquaculture Society, Spec. Publ. No.9. Bredene, Belgium.

Detailed histological classification of marine fish neoplasias updating records for inter-laboratory Pathology Registers.

Bucke, D. and Feist, S.W. (1985) Histopathology of some fish tumours from British waters, including an olfactory glioma in coalfish, *Pollachius virens* (L). J. Fish Biol., 27, 293-305.

Both freshwater fish and marine fish neoplasias are described with special interest in one of the rarest fish tumours reported.

Bucke, D. and Nicholson, M.D. (1987) Fish disease investigations in the Irish Sea. ICES CM 1987/E:19, 12 pp. (Mimeo)

A review of all fish disease studies in the Irish Sea, with statistical analysis applied to define spatial and temporal trends.

Bucke, D. and Stokes, K. (1988) Fish disease monitoring on the 1987 North Sea Groundfish Survey. ICES CM 1988/E:7, 10 pp. (Mimeo)

A report of the first time that fish disease monitoring was integrated into the annual groundfish survey. Fish disease data was integrated with groundfish data in order to identify biological parameters that may relate to disease prevalence.

Bucke, D. and Watermann, B. (1988) Pollution in the North Sea: an assessment. pp.612-623. In "Effects of pollution on fish". (eds. W. Salamons, B.L. Payne, E.K. Duursma and U. Förstner). Springer-Verlag, Berlin.

This paper reviews the gross pathological changes of all important fish diseases occurring in the North Sea and assesses their possible relationship with pollution.

Bucke, D, Feist, S.W., Norton, M.G. and Rolfe, M.S. (1983) A histopathological report of some epidermal anomalies of Dover sole, *Solea solea*

(L) and other flatfish species in coastal waters off south-east England.

J. Fish Biol., **23**, 565-578.

A detailed histological description of pathological conditions in fish sampled from the outer Thames Estuary and reference stations.

Bucke, D., Feist, S.W. and Rolfe, M.S. (1983) Fish disease studies in Liverpool Bay and the north-east Irish Sea. ICES CM 1983/E:5, 9 pp. (Mimeo)

A report of a survey of a fish disease study in Liverpool Bay (sludge disposal site) and reference station, which revealed that no spatial trends were occurring.

Bucke, D., Norton, M.G. and Rolfe, M.S. (1983) The field assessment of effects of dumping wastes at sea. II. Epidermal lesions and abnormalities of fish in the outer Thames Estuary. Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft (72). 16 pp.

A report of an epidemiological and pathological survey of diseases in fish sampled from a sludge disposal site in the outer Thames Estuary, which revealed no spatial trends for disease prevalence rates.

Bucke, D., Watermann, B. and Feist, S.W. (1984) Histological variations of hepato-splenic organs from the North Sea dab, *Limanda limanda* (L). J. Fish Dis., **7**, 255-268.

The first published reference to hepatic changes, including putative neoplasia in North Sea dab, and the first reference demonstrating spleen melanomacrophage centres quantitatively assessed using image analyses technique, as a tool for biological effects monitoring.

Brander, K.M., Colebrook, J.M., Rees, I.S., Parker, M.M. and Bucke, D. (1988) Section C. General biology and fisheries of the Irish Sea. In: "The Status and Current Knowledge on Anthropogenic Influences in the Irish Sea" (eds. R.R. Dickson and R.G.U. Boelens). Co-op. Res. Rep., int. Coun. Explor. Sea, (155), 25-60.

A brief reference of knowledge of fish diseases is included in a larger chapter on the conditions in other animals in the Irish Sea.

Heron, F., Bucke, D., Chubb, J. and Wallace, I.D. (1988) Re-appraisal of the James Johnstone Collection of examples of diseased fish materials. ICES CM 1988/E:9, 9 pp. (Mimeo)

The James Johnstone Collection of pathological specimens, microscope slides and his published works are being re-appraised. This is a summarised version of the full report, which is in preparation.

Shelton, R.G.J. and Wilson, K.W. (1973) On the occurrence of lymphocystis, with notes on other pathological conditions, in the flatfish stocks of the north-east Irish Sea. *Aquaculture*, 2, 395-410.

Shelton, R.G.J. and Wilson, K.W. (1973) Epidermal lesions in Irish Sea flatfish. *Nature, London.*, 241, 140-141.

The first major works on fish disease surveys in European waters, which are much referred to in the literature because of the very good survey design used in the studies.