

C. I. P. S.

MATHEMATICAL MODEL OF MARINE  
POLLUTION IN THE NORTH SEA

TECHNICAL REPORT

1974/Biol. -Synthese RZ 02

This paper not to be cited without prior reference to the author.

FURTHER INVESTIGATIONS ON THE DUMPING OF ORGANIC INDUSTRIAL  
WASTE DERIVED FROM THE PRODUCTION OF PROTEOLYTIC ENZYMES  
ALONG THE BELGIAN COAST.

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by R. DE CLERCK

Ministry of Agriculture, Fisheries Research Station, Ostend, Belgium  
Working group "Biology" (Com. T.W.O.Z. - I.R.S.I.A.)

### INTRODUCTION.

In earlier studies the dumping as well as the effects of organic waste derived from the production of proteolytic enzymes on fish and shrimp stocks along the Belgian coast was described (De Clerck et al 1972, 1973, De Clerck and Vandeveld 1973). Higher densities of plaice, shrimps and whiting were found in the dumping area compared with those in the reference area. Some obstacle to commercial fishing occurred during a few days after dumping owing to the waste lumps present and for that reason a new dumping ground was chosen along the Belgian coast.

The aim of this study is to illustrate the distribution and density of the marine organisms in this new dumping area as well as in the surrounding area.

### MATERIAL AND METHODS.

On September 3th 1973 a meeting was held with the representatives of the Ministry of Agriculture, the Ministry of Communications, the fishermen and the factory. The obstacles ascertained

during fishing activities of the shrimp fleet of Zeebrugge lead to the approval of a new dumping area along the Belgian coast within the following coordinates : 51°27'N/2°54'E, 51°26'N/2°52'E, 51°27'N/2°56'E, 51°26'N/2°54'E (figure 1). The area was chosen as the nature of this area does not allow commercial fishing due to the roughness of the sea-bottom. The new regulation came into force in September 1973.

In this new area several series of hauls by the R. V. "Hinders" were carried out in April, May, July and September 1974. The catch resulting from a 15 minutes haul was sampled in the dumping area and in a reference area (figure 1). Fishing took place during day-time with the otter trawl (mesh size 18 mm) and with a groundrope equipped with bobbins.

The catch of commercial fish was grouped in undersized and sized species following the same procedure as in the earlier studies (De Clerck et al 1972).

Fish plankton was sampled in May 1974.

The catch of non-commercial fishes and other marine organisms was examined on a quantitative basis during May 1974 and on a qualitative basis during the other samplings.

## RESULTS.

### Commercial fishes.

The following commercial fishes were present on the dumping ground as well as on the reference area : plaice (*Pleuronectes platessa* L.), dab (*Limanda limanda* L.), flounder (*Pleuronectes flesus* L.), cod (*Gadus morhua* L.), whiting (*Gadus merlangus* L.), tub gurnard (*Trigla lucerna* L.), sole (*Solea solea* L.), sprat (*Sprattus sprattus* L.) pout (*Gadus luscus* L.), horse mackerel (*Trachurus trachurus* L.), lemon sole (*Pleuronectes microcephalus* Donovan.) dory (*Zeus faber* L.) and thornback (*Raja clavata* L.).

On a qualitative basis no difference could be made between the dumping area and the reference area.

The quantitative analysis of the most abundant commercial fishes is listed in table 1. Although the investigation is in an early stage no significant difference can be ascertained between the fish stock in both areas with the exception however of whiting which has a pronounced higher density in the dumping ground. The same phenomenon was already been found in the previous dumping area. The presence of mature plaice and dab is also characteristic for the area.

#### Non-commercial fishes.

In both areas the following non-commercial fishes have been reported : dragonet (*Callionymus lyra* L.) armed bullhead (*Agonus cataphractus* L.), sea snail (*Liparus liparis* L.), spotted goby (*Gobius minutus* L.), transparent goby (*Aphia minuta* L.), weever (*Trachinus vipera* Cuv.) and sand eel (*Ammodytes tobianus* L.).

No differences appeared between the dumping area and the reference area.

#### Fish plankton.

During the May survey plankton samples were taken on the five stations. The densities are given in table 2.

The results show the occurrence of eggs and larvae of sole and sprat. The densities of sprat plankton are similar to those ascertained in the vicinity (Smagge, unpublished results). The spawning area of sole is situated near the Belgian-French border (Smagge and Van de Velde, 1974). The low densities of sole eggs in the area studied are in agreement with those findings.

Other marine organisms.

During May 1974 a quantitative analysis per station has been carried out on the by-catch (table 3). The most abundant species in both areas were brittle-star (*Ophiura texturata* L.), common starfish (*Asterias rubens* L.) and common crab (*Macropipus holsatus* Fabr.). The common starfish and mainly the brittle-star had a significant higher density on the dumping ground compared with the surrounding area.

The shrimp stock in the area is rather unimportant in relation to other areas of the Belgian coast (De Clerck et al, 1974).

DISCUSSION.

The aim of this study was to draw a first overall picture of the marine life in the new dumping area and in the surrounding area. The commercial fishes, the non-commercial fishes, the fish plankton and the other marine organisms have been sampled partly on a quantitative basis and partly on a qualitative basis.

The most striking phenomenon ascertained during the period under review consisted in a fairly higher density of whiting and brittle-star in the dumping area.

At this early stage of the research no definite conclusions can as yet be drawn on the effects of the dumping on the marine environment. Monitoring in the area will be continued.

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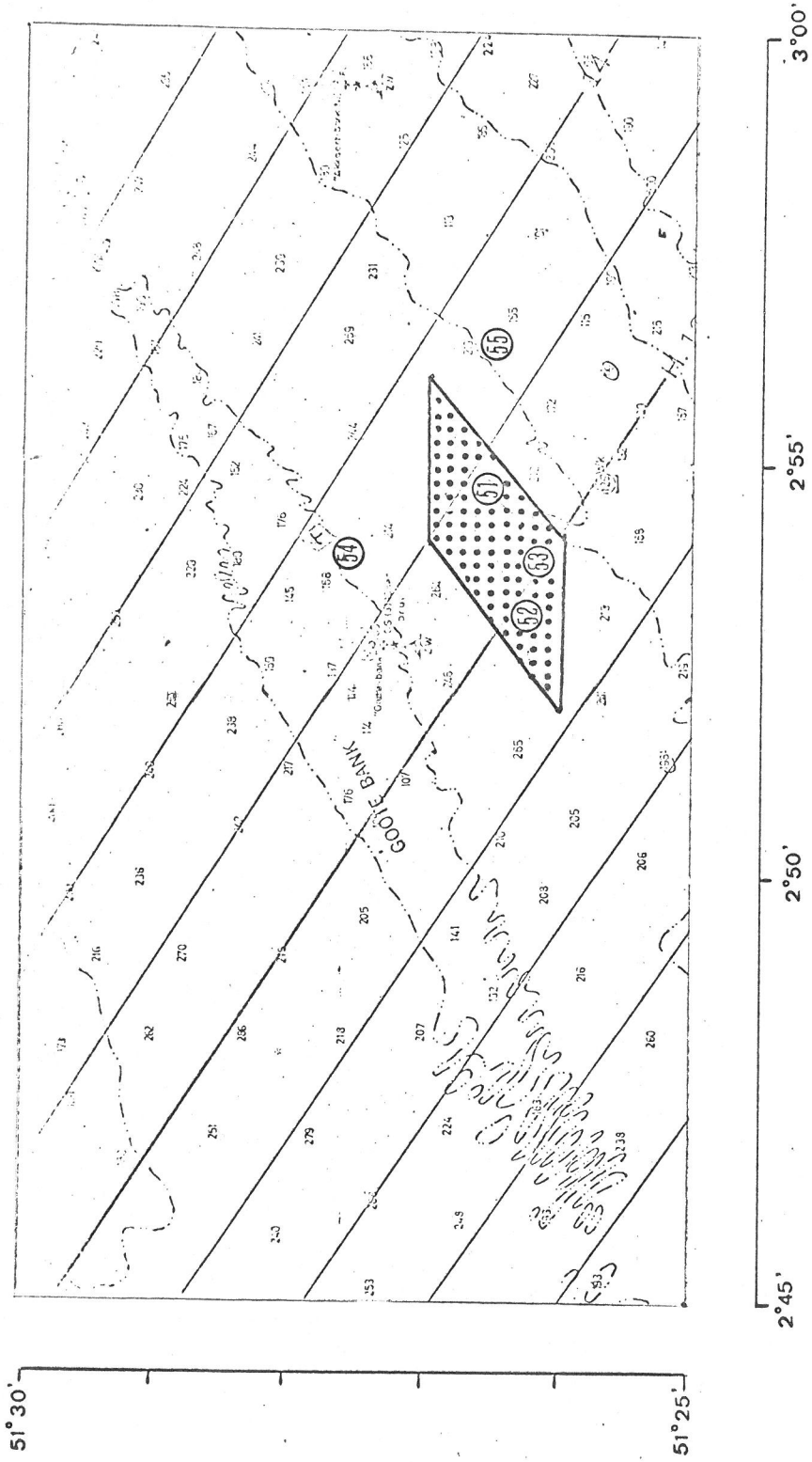


Figure 1; Position of the dumping ground and of the sampling stations.

Table 1 - The densities (number per hour fishing) of commercial fishes in the dumping area and in the reference area.

	Dumping area				Reference area			
	APR	MAY	JUL	SEP	APR	MAY	JUL	SEP
<u>Plaice</u>								
< 24 cm	0	2	20	13	2	83	28	2
> 24 cm	49	5	24	13	43	16	20	0
<u>Dab</u>								
< 19 cm	8	135	50	68	7	151	4	10
> 19 cm	2	35	40	20	0	8	12	52
<u>Flounder</u>								
< 20 cm	0	0	0	0	0	0	0	0
> 20 cm	5	0	0	0	0	0	0	0
<u>Cod</u>								
< 35 cm	0	0	0	0	0	0	0	2
> 35 cm	0	0	0	1	5	0	0	0
<u>Whiting</u>								
< 30 cm	15	144	16	208	27	73	0	4
> 30 cm	5	15	4	36	8	6	0	72
<u>Tub gurnard</u>								
< 25 cm	0	3	10	0	0	4	8	0
> 25 cm	0	2	4	0	0	0	4	2
<u>Sole</u>								
< 24 cm	2	0	0	0	0	6	0	0
> 24 cm	0	3	4	2	0	0	0	0
<u>Sprat</u>								
< 10 cm	132	13	0	0	56	0	0	0
> 10 cm	11	9	0	0	15	0	0	0
<u>Pout</u>								
	124	233	29	1674	117	21	0	6376
<u>Horse Mackerel</u>								
	0	79	0	158	0	32	0	344

Table 2. - The density (numbers/m<sup>2</sup>) of fish plankton during May 1974.

	51	52	Stations		55
			53	54	
<u>Eggs.</u>					
Sprattus sprattus L.	0.5653	0.0566	0.3893	0.3507	0.6225
Solea solea L.	0.0217		0.0200	0.0117	0.0201
Onos spec.	0.0109		0.0100		0.0201
Callionymus lyra			0.0100		
<u>Larvae.</u>					
Sprattus sprattus L.			0.1298	0.0535	0.0201
Solea solea L.			0.0200	0.0234	0.0201
Gobius minutus L.			0.0200	0.0117	



Table 3 - The densities of the by-catch, expressed in numbers per 1,000 m<sup>2</sup> during May 1974 (\*).

Species	Dumping area			Reference area	
	51	52	53	54	55
Phylum <u>PORIFERA</u>	x	x			
Phylum <u>COELENTERATA</u>					
Classis HYDROZOA					
Tubularia species	x	x	x		x
Laomedea species		x			
Hydrallmania falcata (L.)	x				
Sertularia species			x		
Classis ANTHOZOA					
Actinia equina (L.)	0.17	0.67			
Metridium senile (L.)	0.06	0.20		0.07	0.17
Phylum <u>ANNELIDA</u>					
Aphrodite aculeata (L.)	0.06				0.42
Lanice conchilega (Pallas)	0.12		0.81		
Pectinaria koreni (Malmgren)			0.81		
Phylum <u>MOLLUSCA</u>					
Classis LAMELLIBRANCHIA					
Spisula solida (L.)	0.06				
Classis GASTROPODA					
Buccinum undatum (L.)		0.20			
Natica catena (Da Costa)					0.08
Other Gastropoda	0.06				
Classis CEPHALOPODA					
Sepia atlantica d'Orbigny	0.12			0.13	
Allotheutis subulata (L.)		0.20	0.24	0.07	
Phylum <u>BRYOZOA</u>	0.06		0.24	0.07	
Phylum <u>ARTHROPODA</u>					
Classis CRUSTACEA					
Ordo Decapoda					
Crangon crangon (L.) < 54 mm	6.57	6.05	12.10	0.74	20.03
Crangon crangon (L.) > 54 mm	6.91	1.34	0.81	5.51	45.16
Crangon allmanni Kinahan				0.07	
Macropipus holsatus (Fabricius)	6.16	16.73	35.40	2.55	56.96
Portunus puber (L.)	0.17				
Pagurus bernhardus (L.)	0.23			0.07	0.34
Phylum <u>ECHINODERMATA</u>					
Classis ASTEROIDEA					
Asterias rubens (L.)	5.99	21.71	32.26	1.08	1.61

Classis OPHIUROIDEA					
Ophiura texturata Lamarck	50.23	830.31	1148.71	3.16	38.88
Classis ECHINOIDEA					
Psammechinus miliaris (Gmelin)	0.17	27.76	2.50	0.20	

(\*) Partly according to original data from F. REDANT.