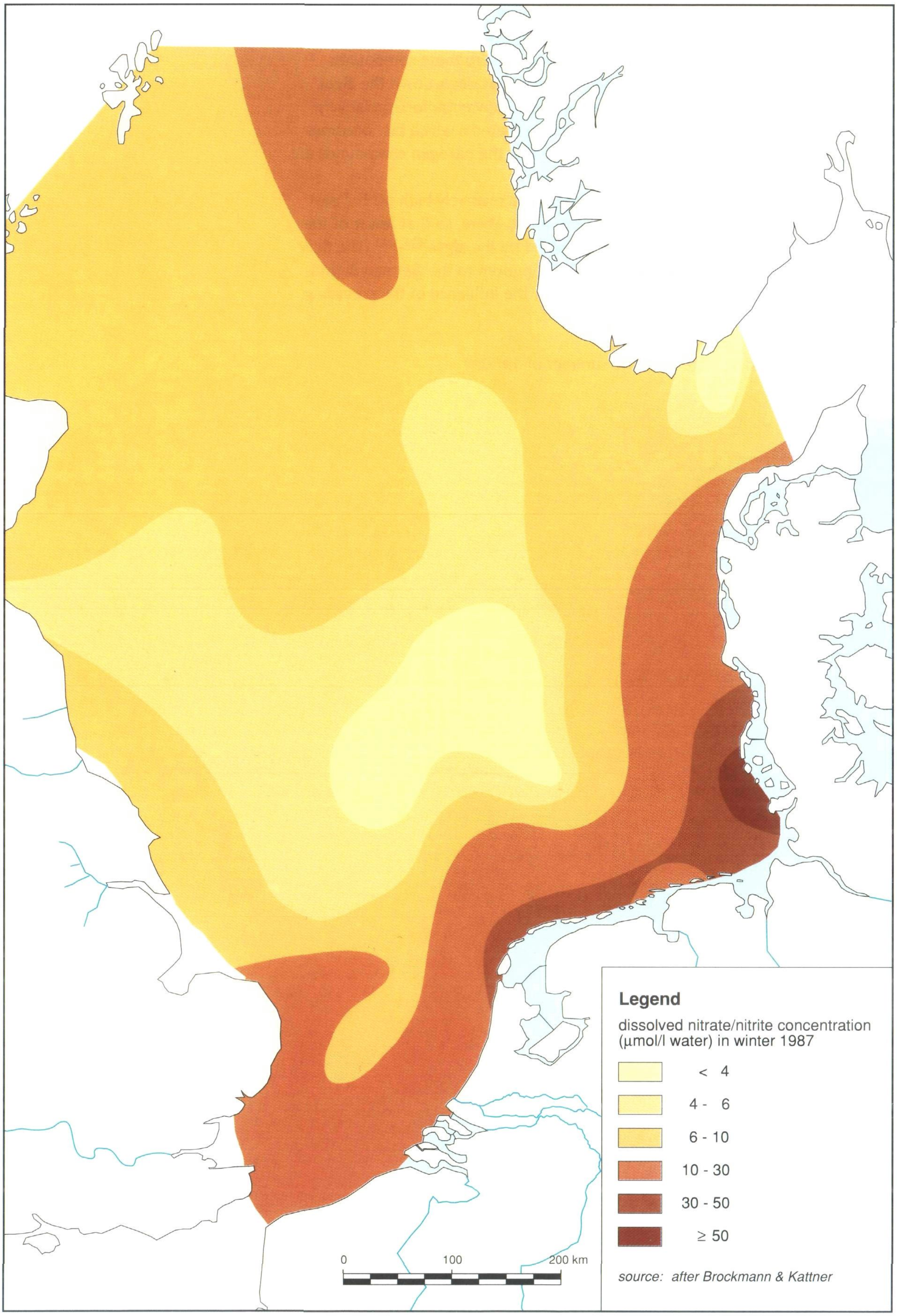
Nitrate and nitrite concentration in winter



Nitrate and nitrite concentration in summer

In summer the nitrate and nitrite concentrations of the seawater are much lower than in winter (21). This is because more sunlight penetrates into the water, so that algae are more numerous and they absorb these compounds much more actively. A scarcity of nitrogen compounds slows down the algal growth. In the German Bight the nitrate and nitrite concentration is relatively high. It is assumed that phosphate is the building material which first becomes limited during algal growth in that area (24), so that the nitrogen compounds are no longer fully absorbed.

The concentration of nitrogen compounds is also relatively high off the east coast of the United Kingdom. The sea is very turbid there, so that fewer of the nutrients brought in by the Thames are absorbed by the algae (27, 28). The flow of nutrients from the east coast of the United Kingdom to the German Bight is caused by the eastward water movement under the influence of the prevailing southwest winds.

The map is based on data from the summer of 1986.

Source:

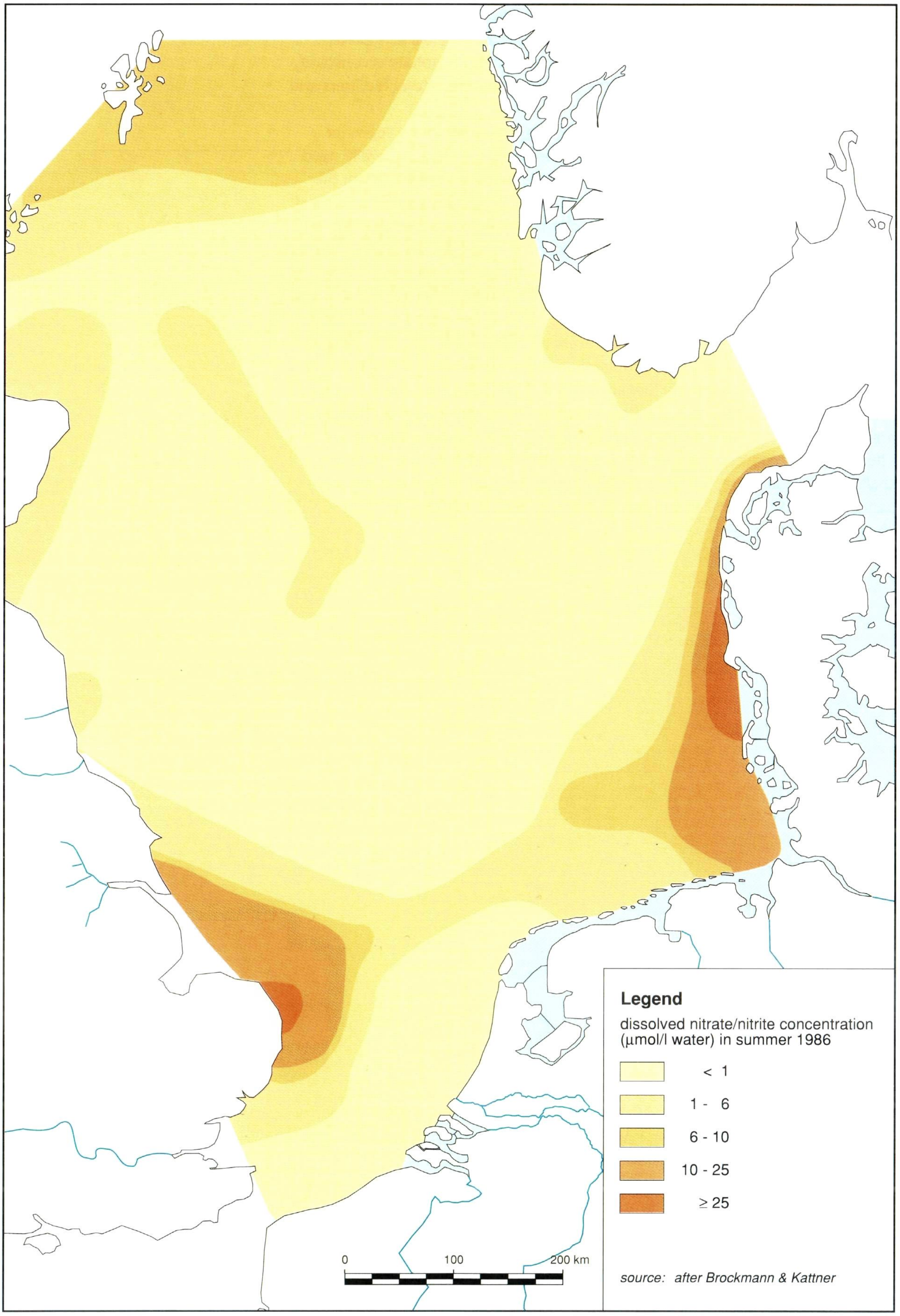
Brockmann, U.H., Laane, R.W.P.M., Postma, H. (1990). Cycling of nutrient elements in the North Sea. Neth. J. of Sea Res., 26 (2-4), p. 239-264.

Brockmann & Kattner (in press). In: Estuarine Coastal Shelf Science.

Laane, R.W.P.M., Leewis, R.J., Colijn, F., van Berge Henegouwen, A., Hisgen, R., (1990). De zee, de zee de Noordzee. SDU, The Hague.

Peeters, J.C.H. (V&W/RWS/DGW) (1991): oral information.

Nitrate and nitrite concentration in summer



Phosphate concentration in winter

Phosphorus (P) occurs most commonly as a chemical compound with oxygen (O) in the form of phosphate. Like the nitrogen compounds, it is a "macro-nutrient", an indispensable foodstuff for phytoplankton. Phosphate is constantly added to seawater, mainly via the rivers. It comes from agricultural fertilisers and sewage discharge.

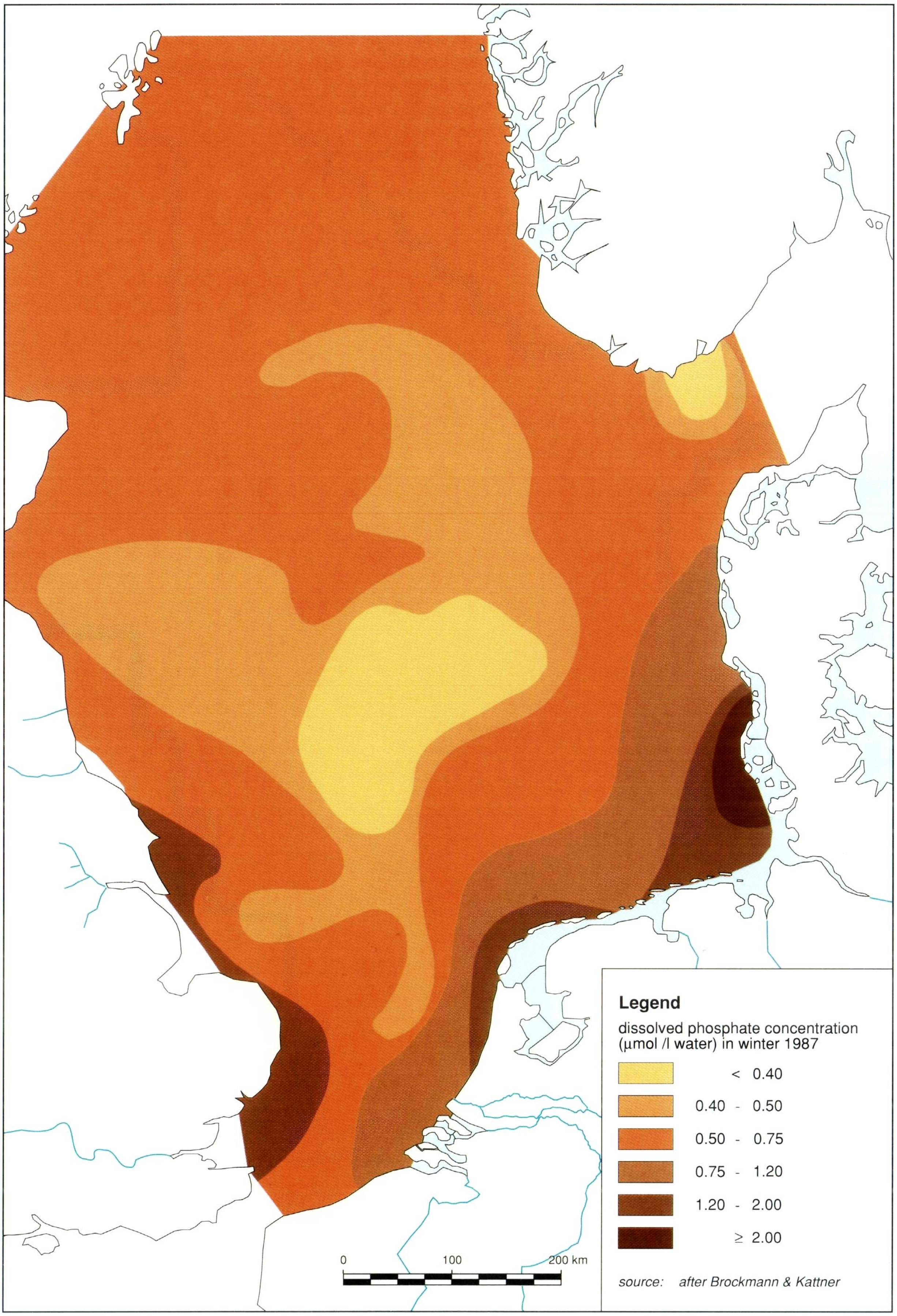
The supply of too many nutrients results in overmanuring of the seawater, which disrupts the North Sea ecosystem (eutrophication). Algae generally need sixteen times more nitrogen molecules than phosphates molecules. When the supply of nutrients departs widely from this ratio, the possibility exists that algal species will predominate which causes a nuisance or are poisonous to man.

In order to combat eutrophication, the North Sea states decided at the Second North Sea Ministers Conference to aim at a reduction of the discharge of nutrients into the sea by 50% before 1995, on the basis of the situation in 1985.

The map shows the phosphate concentrations in the winter of 1987. The phosphate concentrations of the seawater are higher in winter than in summer. This is because of the relatively low absorption of phosphate by algae, so that more phosphate remains in the water in winter. The higher values on the coasts are the result of the slow mixing of phosphate-rich river water with seawater. The phosphate concentration on the Dogger Bank is relatively low. The sea is shallow and clear there, so that a relatively large amount of light can deeply penetrate to the bottom. This means that algae, even in winter (21,27), can absorb phosphate.

Source:
Brockmann, U.H., Laane, R W P M , Postma, H (1990). Cycling of nutrient elements in the North Sea. Neth. J. of Sea Res , 26 (2-4), p. 239-264.
Brockmann & Kattner (in press) In· Estuarine Coastal Shelf Science
Laane, R.W.P.M , Leewis, R.J., Colijn, F , van Berge Henegouwen, A., Hisgen, R., (1990). De zee, de zee de Noordzee. SDU, The Hague.
Peeters, J.C.H. (V&W/RWS/DGW) (1991)· oral information.

Phosphate concentration in winter



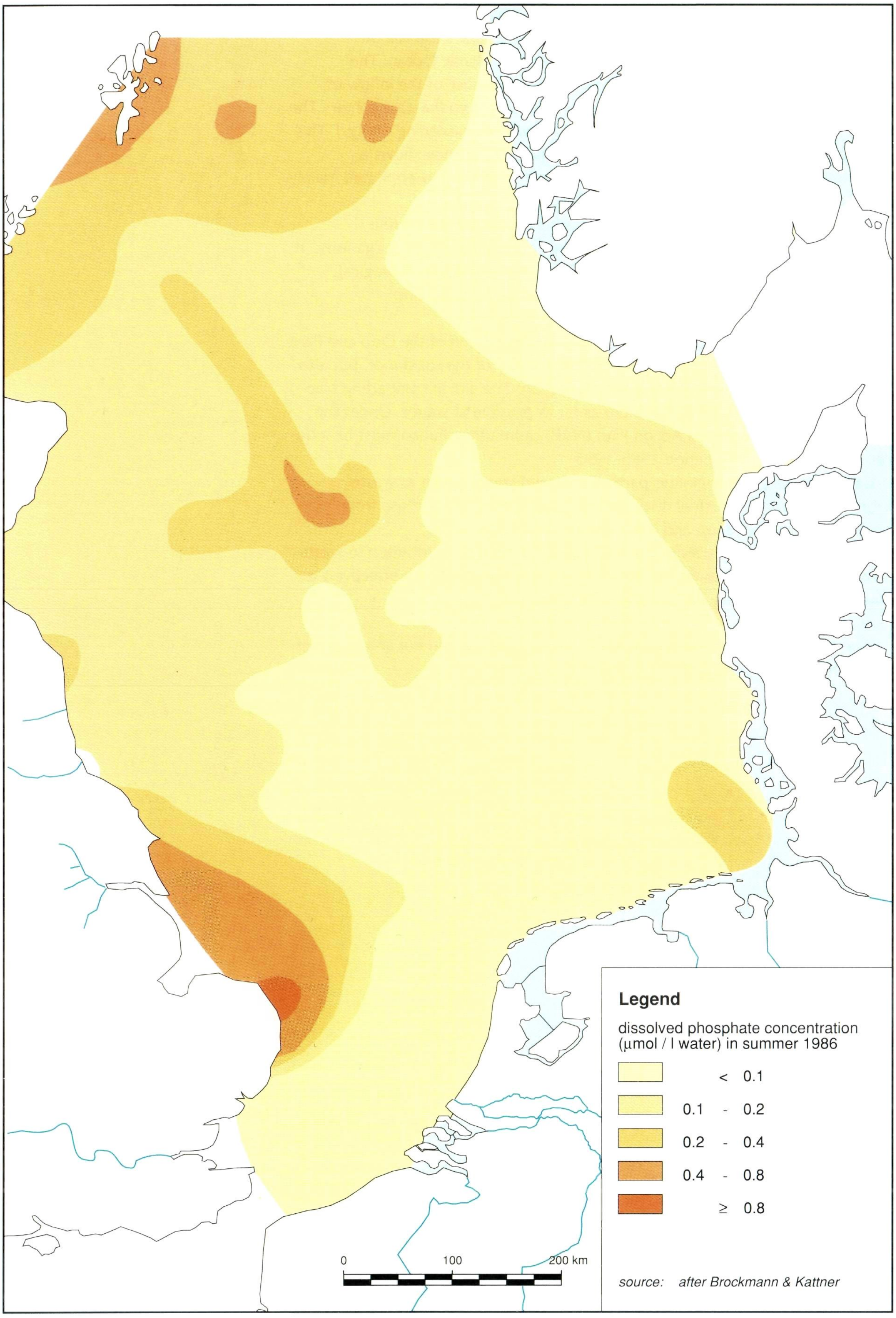
Phosphate concentration in summer

The phosphate concentrations in the North Sea are lower in summer than in winter [23]. This is related to the increase in the quantity of sunlight which penetrates into the water. More light and higher temperatures stimulate algal growth and thus the absorption of phosphate. The higher phosphate concentration in the Elbe and Thames estuaries is probably partly the result of the low algal activity caused by the turbidity of the water. The increase in phosphate northwards is related to the presence of phosphate-rich Atlantic water.

The map is based on data for the summer of 1986.

Source:
Brockmann, U.H., Laane, R.W.P.M., Postma, H. (1990). Cycling of nutrient elements in the North Sea. Neth. J. of Sea Res., 26 (2-4), p. 239-264.
Brockmann & Kattner (in press). In: Estuarine Coastal Shelf Science.
Laane, R.W.P.M., Leewis, R.J., Colijn, F., van Berge Henegouwen, A., Hisgen, R., (1990). De zee, de zee de Noordzee. SDU, The Hague.
Peeters, J.C.H. (V&W/RWS/DGW) (1991): oral information.

Phosphate concentration in summer



Cadmium concentration

Cadmium (Cd) occurs naturally in seawater in concentrations of under 10 nanogrammes per litre (ng/l). In the North Sea these values can still be measured only in the water which flows in from the Atlantic Ocean. The concentration has increased in the remaining areas because of the inflow of polluted river water and the precipitation of cadmium from the atmosphere. The concentration is highest in the coastal areas, sometimes exceeding 40 ng/l. This is because river water mixes poorly with seawater. The seabed shows a comparable pattern, with cadmium-polluted river mud being precipitated mainly in the catchment area of the river water (32).

Little is known about the specific effects of cadmium on the marine environment, although the element is certainly poisonous to living organisms. It has a chemical structure which is very similar to that of calcium. Biological processes in which calcium plays a part are disrupted by cadmium.

Cadmium has been placed on the blacklist of the EC and of the Oslo and Paris Commissions. This is not only because of the toxicity of the substance, but also because of its tendency towards bioaccumulation. The aim in combatting blacklisted substances is to deal with them as far as possible at source. Under the guidelines of the North Sea Action Plan (NAP) cadmium pollution must be reduced by 90% during the period 1985-1995.

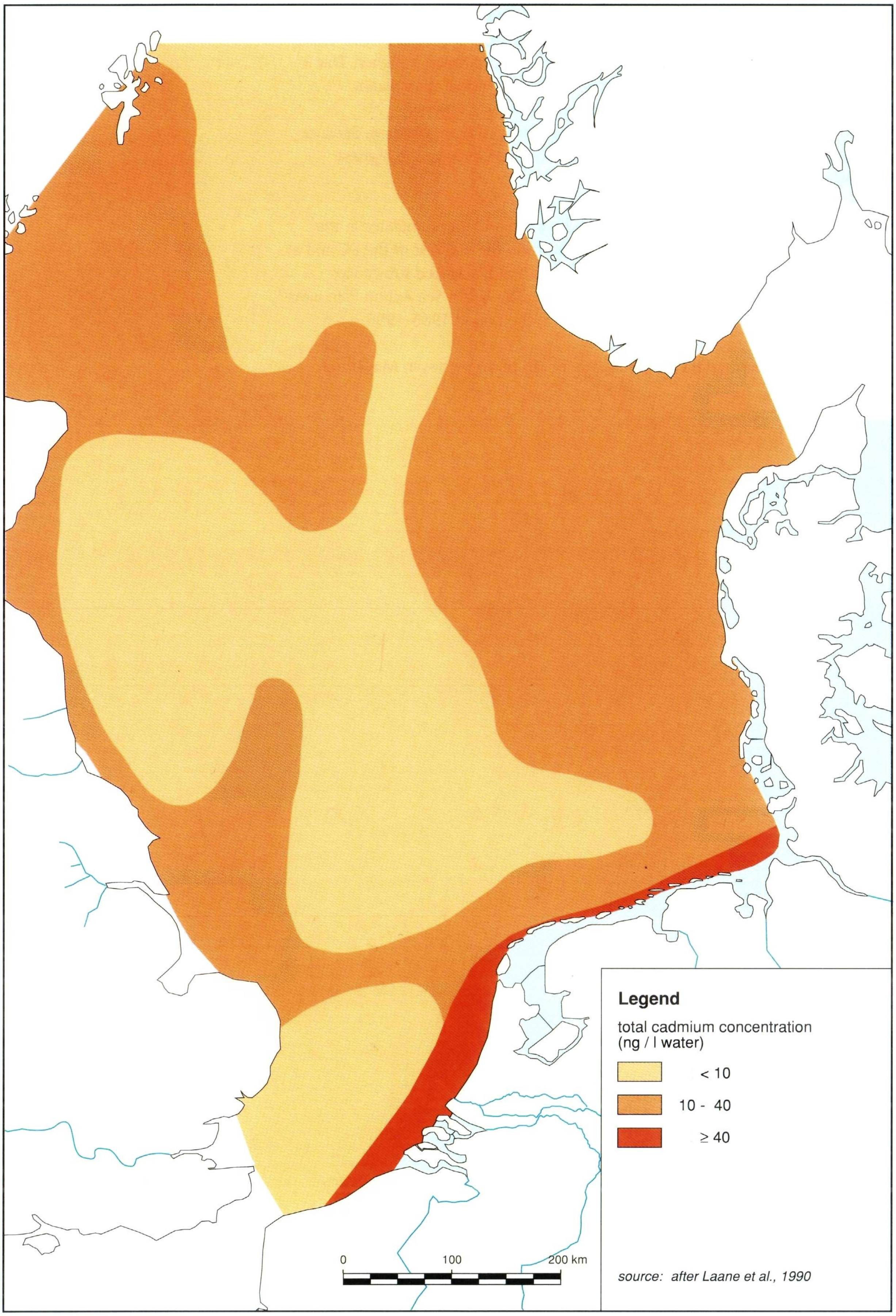
Cadmium pollution originates partly from point sources such as waste incineration plants, industrial discharges, including particularly those from artificial fertiliser factories, and industrial emissions into the air.

Because of the many uses of the metal and the related contribution to waste flows, it also gives rise to diffuse pollution. This can be dealt with effectively at source only by reducing the emission of the substance.

The measurements on which the map is based were carried out at a depth of 10 metres in May/June 1986.

Source:
Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische waterkwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.
Laane, R.W.P.M., Leewis, R.J., Colijn, F., van Berge Henegouwen, A., Hisgen, R., (1990). De zee, de zee de Noordzee. SDU, The Hague.

Cadmium concentration



Lead concentration

Seawater naturally contains a certain quantity of lead (Pb, less than 0.5 ng/l water). In the North Sea this value can still be measured only in the water which flows in from the Atlantic Ocean. Elsewhere the concentration is higher. This is because of the release of lead in industrial processes, incineration plants, combustion products of leaded petrol and various waste flows.

Lead is carried into the sea by river water and from the atmosphere. Because river water mixes poorly with seawater, the coastal areas have the highest concentrations of lead (up to 5 ng/l water).

Lead is highly poisonous; it does not break down and it accumulates in the food chain. For these reasons it has been placed on the blacklist of the EC and of the Oslo and Paris Commissions.The proposal is that blacklisted substances should be dealt with as far as possible at source. The North Sea Action Plan aims to reduce lead pollution bij at least 70% during the period 1985-1995.

The map is based on data measured at a depth of 10 metres in May/June 1986.

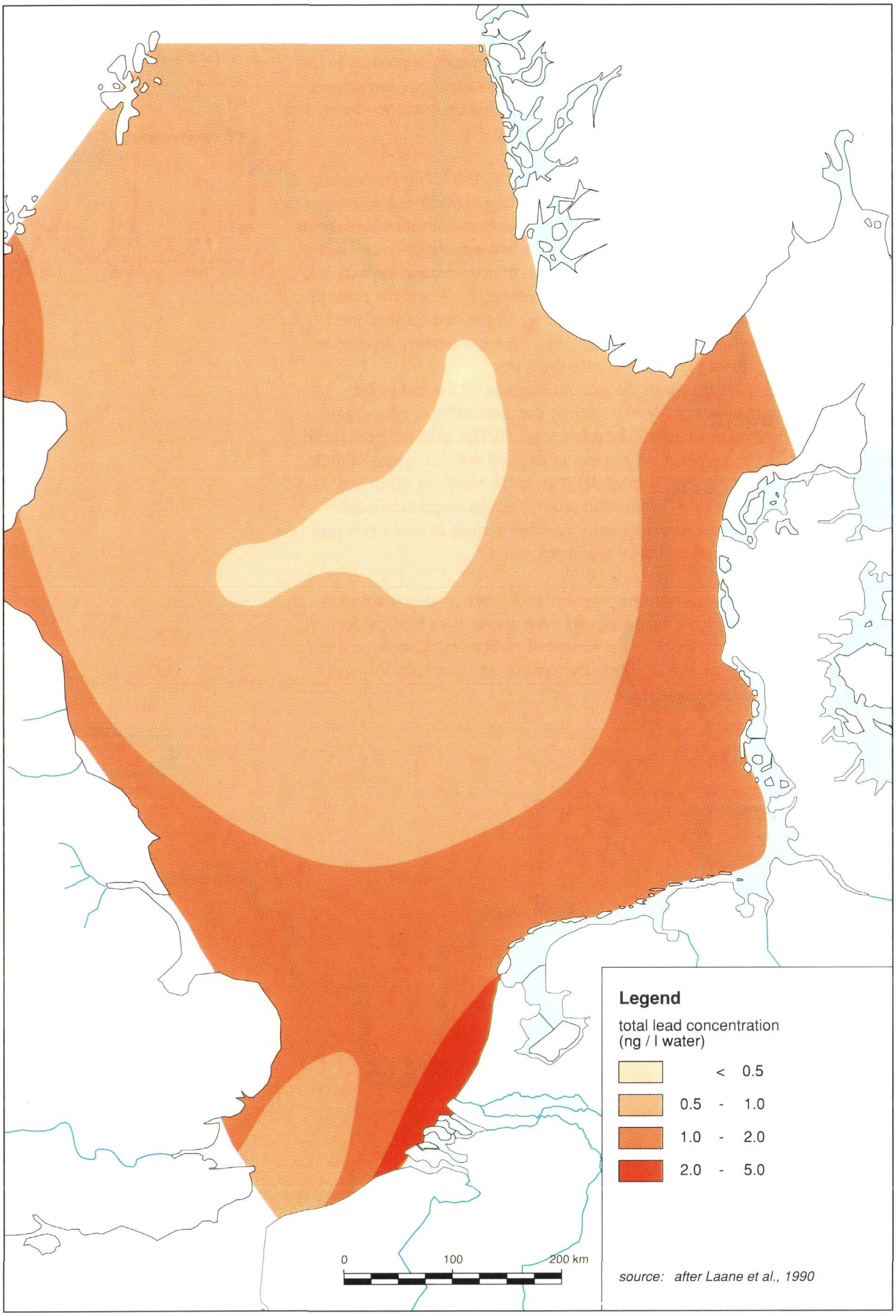
Source:

Laane, R.W.P.M., Leewis, R.J., Colijn, F., van Berge Henegouwen, A., Hisgen, R., (1990). De zee, de zee de Noordzee. SDU, The Hague.

Ministerial Declaration of the Third International Conference on the protection of the North Sea, The Hague, 8 March 1990.

Ministry of Transport, Public Works and Water Management (1990). North Sea Action Plan 1990, national implementation document of the Third International North Sea Conference. Second Chamber, 1990-1991, 21 884, nos. 1-2. SDU, The Hague.

Lead concentration



Primary production in winter

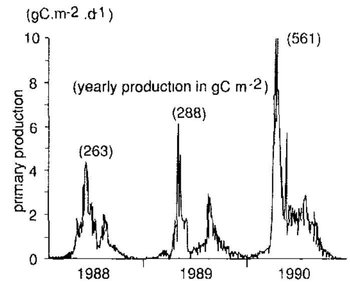
All the life in the sea forms a chain of eating and being eaten. The beginning of the food web in the sea, primary production, is the process of carbon dioxide-uptake by the phytoplankton (algae) by which nutrients such as phosphate and nitrate are absorbed with the help of sunlight and converted into new organic (algal) material and oxygen. Thus algae form the beginning of the food web and are therefore called the primary producers of the sea.

The map shows primary production in the winter of 1987. Primary production is not everywhere uniform in the North Sea. It is often higher in the southern North Sea and in the coastal areas where the nutrient concentration is relatively high [21, 23]. In places where the light can penetrate deep into the water and there is a good supply of nutrients, an increase in primary production may also be observed. Examples are the Dogger Bank in winter [21, 23] and the coast of Holland. Large quantities of mud in the water, as off the east coast of the United Kingdom and in the German Bight, result in a low primary production because the light cannot penetrate far into the water.

Primary production varies with the seasons. Because of the low water temperature and the low light-level in winter, the production of new organic material is lower than in summer. The primary production gradient from south to north is related to the declining amount of daylight with increasing latitude. In the north the days are shorter in winter than in the southern North Sea. The understanding of the primary production process and its magnitude is still limited, however, because measurements have been made at only a few sites *and annual cycles have seldom been measured.*

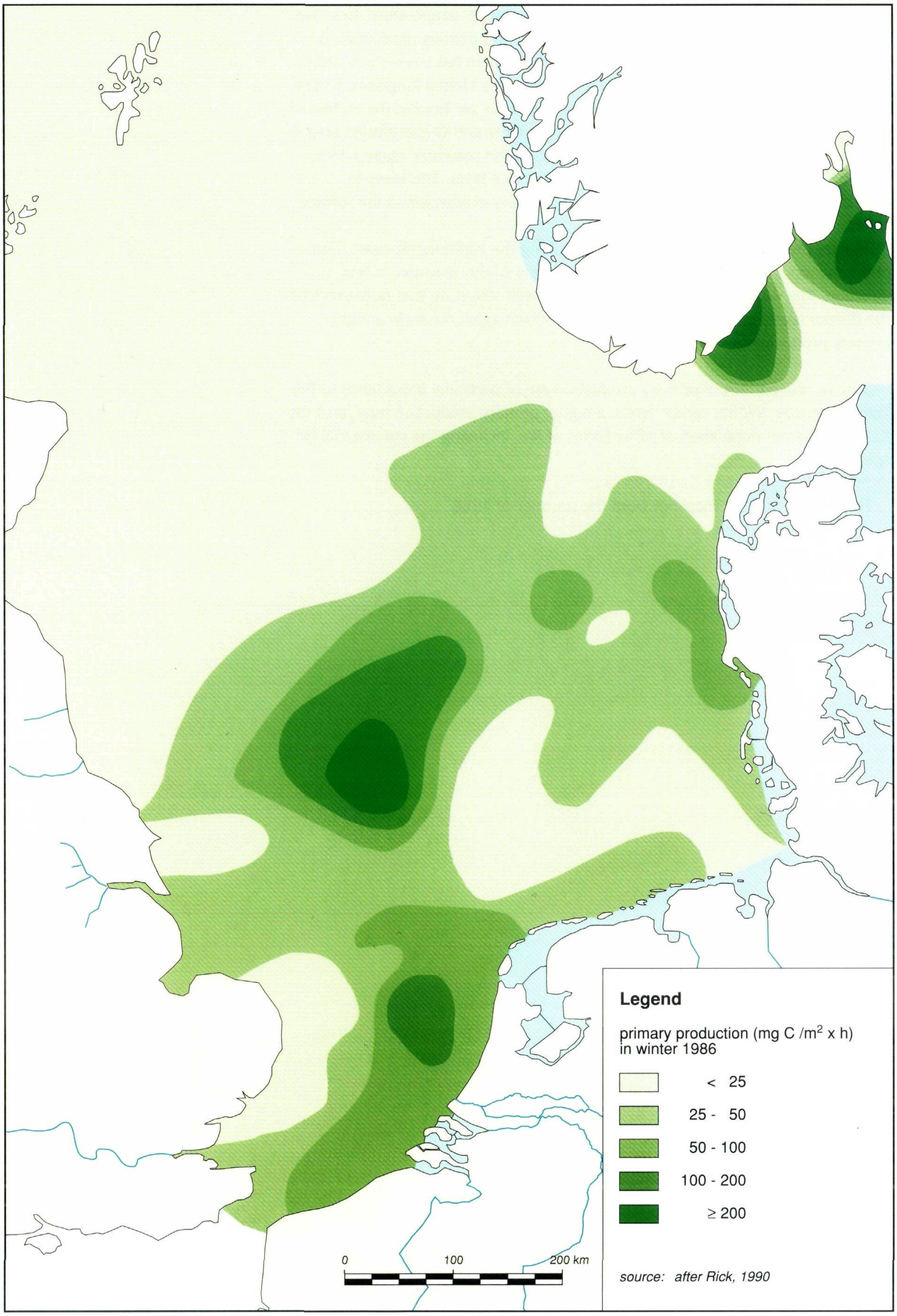
The map provides a snapshot from the winter of 1987. Wide variations in annual production can occur over the years even in one place (see the figure). Primary production is expressed in the weight of carbon (mg C) produced per square metre (m^2) per hour (h) in the water column at a particular location.

Daily production in the water colom at sampling station Noordwijk 20 (±20 km off the coast)



Source:
Peeters, J C H (V&W/RWS/DGW) (1991): oral information.
*Peeters, J C H , Haas, H.A., Peperzak, L. (1991) Eutrofiering, primaire produktie en zuurstofhuishouding in de Noordzee. Final report Euzout*2. V&W/RWS/DGW nota GWAO-91 083.*
Rick, H.J. (1990) Ein Beitrag zur Abschatzung der Wechselbeziehung zwischen den planktischen Primarproduzenten des Nordseegebietes und den Schwermetallen Kupfer, Zink, Cadmium und Blei auf Grundlage von Untersuchungen an naturlichen Planktongemeinschaften. Dissertation Aachen

Primary production in winter



Primary production in summer

As the sunlight grows stronger in spring and the water temperature rises, the activity of the phytoplankton greatly increases, so that primary production is higher in summer than in winter. A very high production has been measured in summer in the area of the Frisian Front and east of the United Kingdom, where the increase in biomass can exceed 1000 mg C per m^2 per hour in the middle of the day. Stratification occurs around the Dogger Bank and Oysterground area in the course of time. Because of this stratification of the seawater, algae which have sunk to the bottom do not return to the surface layer. This leads to adepletion of nutrients and a rapid decline in primary production in the surface layer.

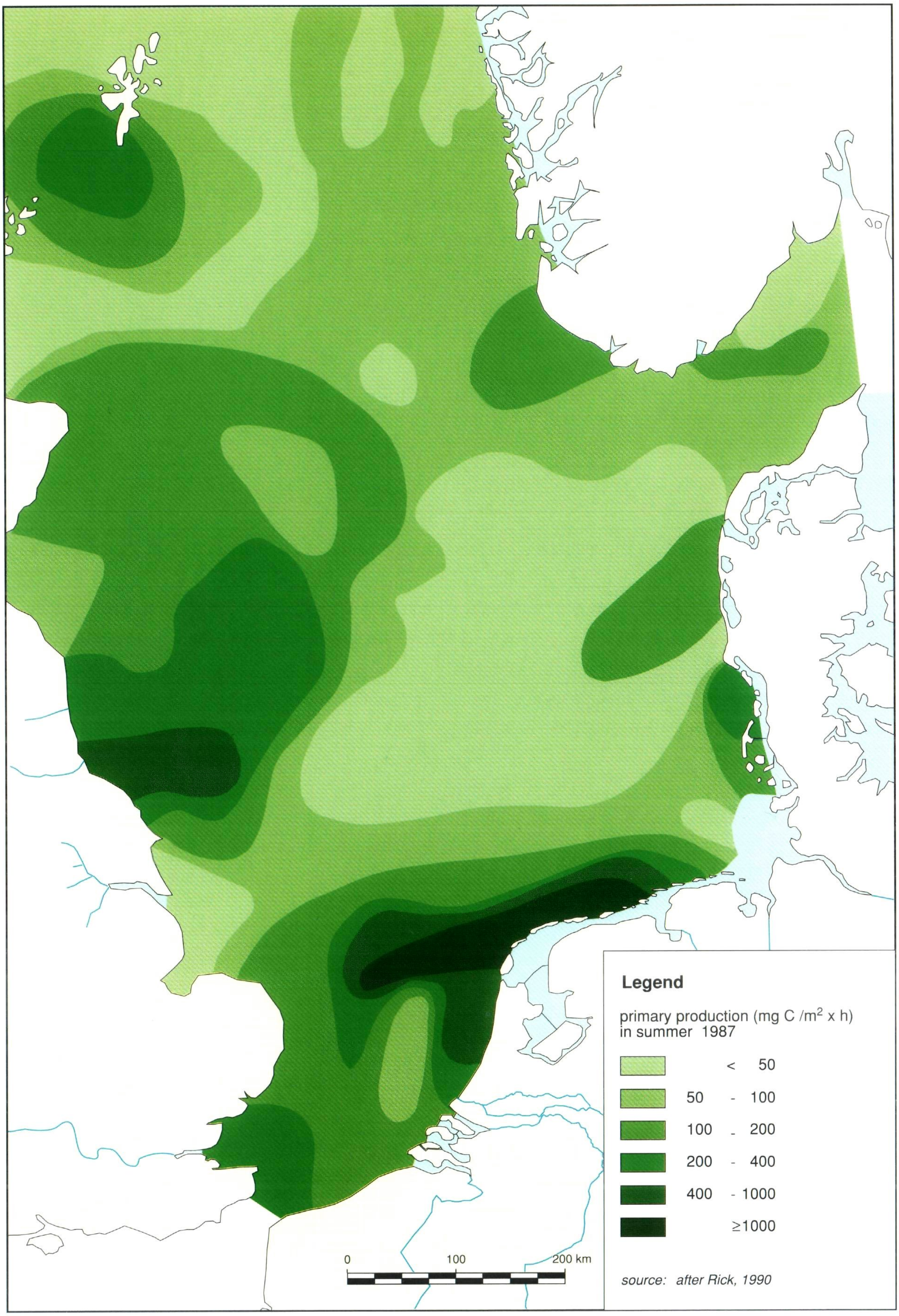
Primary production increases northwards along the Netherlands coast. This phenomenon is related to the decreasing turbidity of the seawater in that direction. The waters off the Shetland Isles are well mixed, so that nutrients from the deeper layers are brought to the surface, which again results in a higher primary production.

Data on the pattern of primary production are of particular importance to the fishing industry. Within certain limits, a higher primary production may form the basis for a larger population of other forms of life, including the commercial fish species.

The map provides a snapshot from the summer of 1986.

Source:
Peeters, J. C. H. (V&W/RWS/DGW) (1991) oral information
Rick, H. J. (1990) Ein Beitrag zur Abschatzung der Wechselbeziehung zwischen den planktischen Primarproduzenten des Nordseegebietes und den Schwermetallen Kupfer, Zink, Cadmium und Blei auf Grundlage von Untersuchungen an naturlichen Planktongemeinschaften. Dissertation Aachen

Primary production in summer



Seabed

Physical features (map 29 to 31)
Chemical features (map 32 to 36)

Composition of the surface of the seabed

The upper 50 centimetres of the seabed of the Netherlands sector of the Continental Shelf (NCS) consist of gravel, sand, clay and glacial till. The pattern in which these deposits occur has been partly determined by current velocity, wave action and water depth. Thus the sediment in areas with a low current velocity and/or little wave action on the seabed is more fine-grained than in areas with a stronger water movement. This is because more current and wave energy is needed for the transport of coarser material than for that of fine material.

The surface of the seabed in the relatively shallow southern part of the NCS is exposed to strong current and wave action and consequently consists mainly of coarse sands. There is a gradual northwards transition to a bottom consisting predominantly of fine sand and mud.

There are a few exceptions to this general picture. In the northern half of the Continental Shelf formations occur which were deposited in the ice age by land ice or meltwater. Examples are the gravelly deposits of the Cleaver Bank (around 54° N and 3° E) and the glacial till and boulders northwest of Texel. Marine currents and wave action have not been able to shift this material.

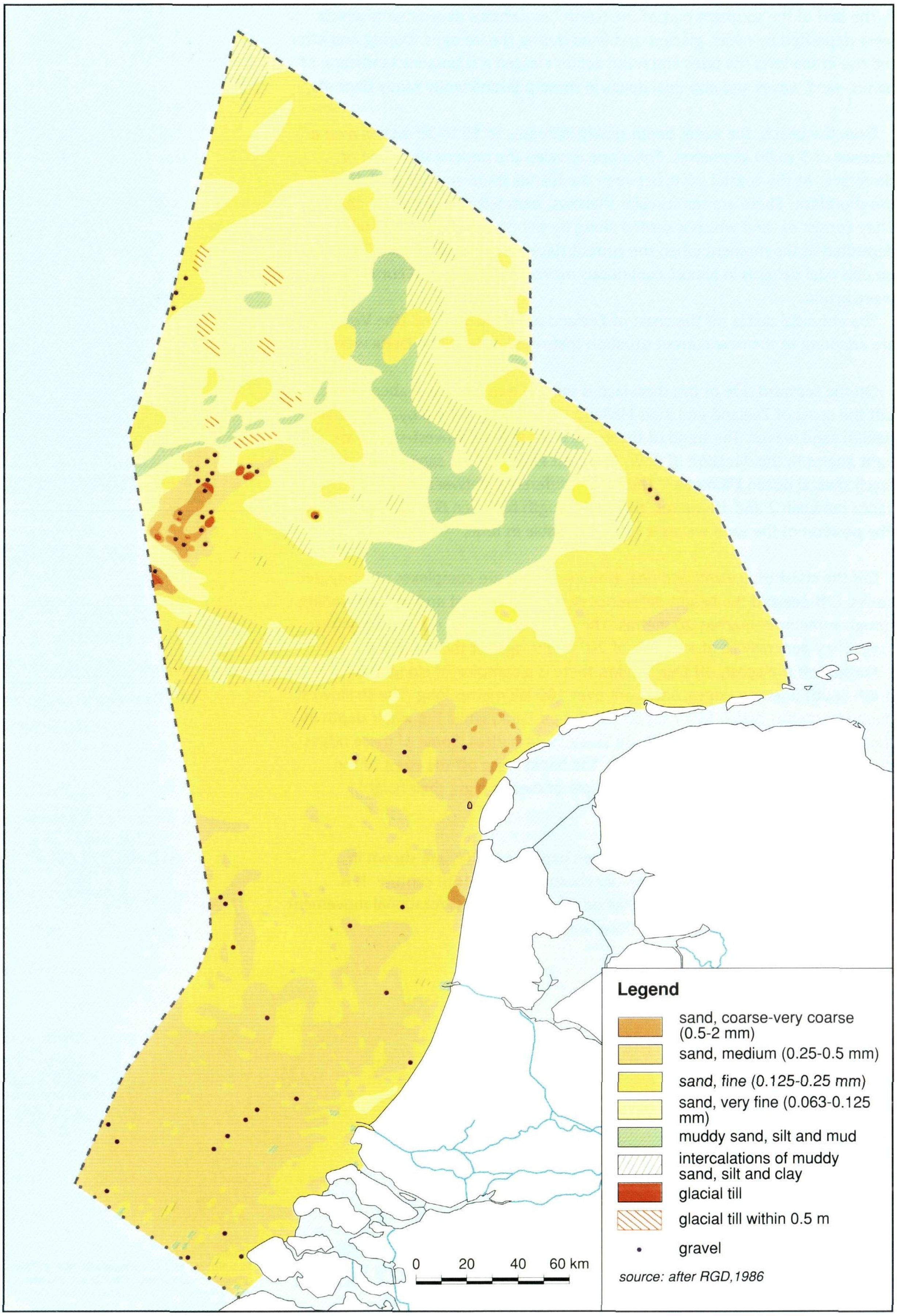
The Dogger Bank, in the most northerly part of the NCS, consists of coarser sands because of the shallow water depth, and consequently more intense wave action.

The differences in the composition of the seabed help to determine the opportunities for the seabed organisms to establish themselves. Thus the Cleaver Bank and the mud-rich Oystergrounds possess a species-rich benthic fauna. The sandy and dynamic bed of the southern North Sea, by contrast, is poorer in seabed life (42, 53).

Because of the decreasing number of sites for sand and gravel extraction on land, the demand for marine sand and gravel has been increasing in recent years. The gravel of the Cleaver Bank and Texel are of interest to the building industry. The sandy deposits along the coast are favoured for use as fill sand because of the short distance they need to be shipped (73).

Source:
Geological Survey of the Netherlands (RGD) (1986). Geologie van Nederland, deel 2. Delfstoffen en samenleving. RGD, Haarlem & the Physical Geographical and Pedological Laboratory of the University of Amsterdam.
Schüttenhelm, R.T.E. (1980). The superficial geology of the Dutch sector of the North Sea. Marine Geology 34, M.27-M.37.

Composition of the surface of the seabed



Seabed morphology

The bed of the southern part of the North Sea consists of sediments which were deposited by rivers, glaciers and wind during the ice ages. During and after the rise in sea level the tides and wave action created a submarine landscape of banks, sand waves and ebb tidal deltas in these predominantly sandy deposits.

From the beach, the water depth slowly increases to 15 to 20 metres over a distance of 5 to 10 kilometres. This slope is called the underwater slope or shoreface. At the coastal inlets between the islands there are ebb tidal deltas on the shoreface. These are semicircular shallows, bisected by a deep ebb channel. They consist of sand which is carried along by the powerful ebb tide and is deposited at the moment when the current slackens in the open sea. The sand on ebb tidal deltas is in almost continuous movement because of current and wave action.

The ebb tidal deltas off the coast of Zeeland and Zuid-Holland (the Voordelta) are adapting to the new current situation that resulted from the Delta works.

On the seaward side of the shoreface is the more or less flat seabed or shelf. Off the coast of Zeeland and Zuid-Holland the latter is covered by an extensive field of sand waves. The trend of the crests is roughly northwest-southeast, at right angles to the direction of flow. The crest length of the sand waves may reach several dozen kilometres. The height difference between crest and trough varies between 2 and 10 metres, the wave length between 60 and 600 metres. The position of the sand waves is relatively stable in time.

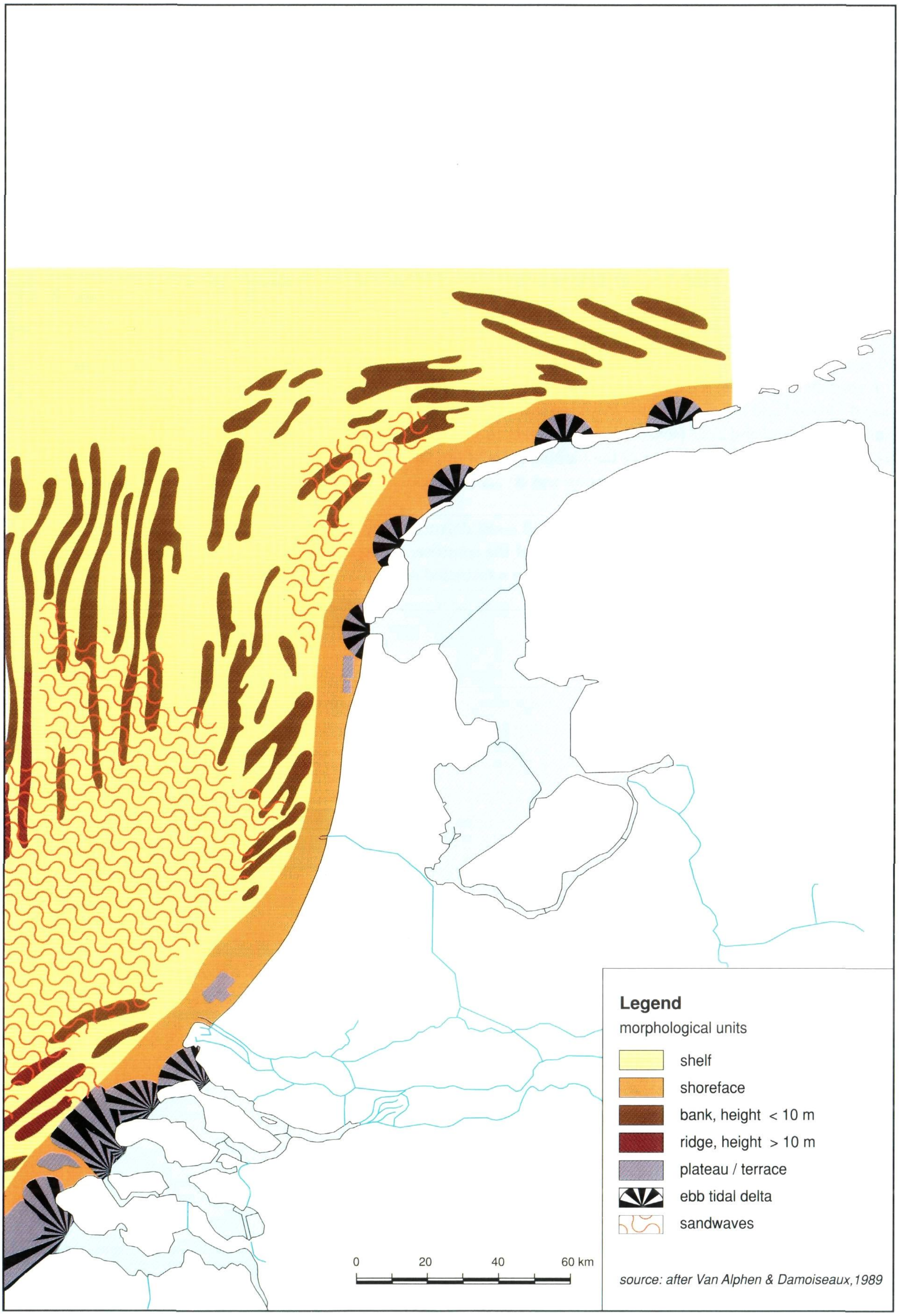
Off the coast of Zeeland and near IJmuiden there are complexes of elongated banks. Off Zeeland the height difference between the crest and the intervening trough sometimes reaches 20 metres. The banks are several dozen kilometres long. They generally lie at an angle of 20° to 35° against the shoreface.

Further off the coast, off Den Helder, there is a complex of elongated north-south oriented ridges. Some are over 100 kilometres long. The shallowest point (19 metres below MSL) lies on the Brown Bank, while the water depth in the neighbouring trough, 1 kilometre away, is 44 metres. Some of these ridges may have been pushed up by land ice. The banks lying off the coast of the Wadden Islands are generally only a couple of metres high; their height increases eastwards.

The origin of the banks has not yet been explained. They are shown in approximately the same position on old charts from the 16th century. It is assumed that their shapes are maintained by a more or less rotational movement of sand created by the alternating flood and ebb currents.

Source:
Van Alphen, J.S.L.J., Damoiseaux, M.A. (1989). A geomorphological map of the Dutch shoreface and adjacent part of the continental shelf. Geol. & Mijnb. 68, p. 433-443.

Seabed morphology



Coastline behaviour

The Netherlands coast largely consists of sand. Current and wave action constantly move the sand from the beach and the dunes to the breaker zone and the shoreface and vice versa. Sand is also moved along the coast. When at a particular section of coast the sand supply equals the sand loss, the coastline remains in its position. If the supply of sand is greater than the removal of sand, this results in coastal accretion; the reverse situation leads to coastal erosion.

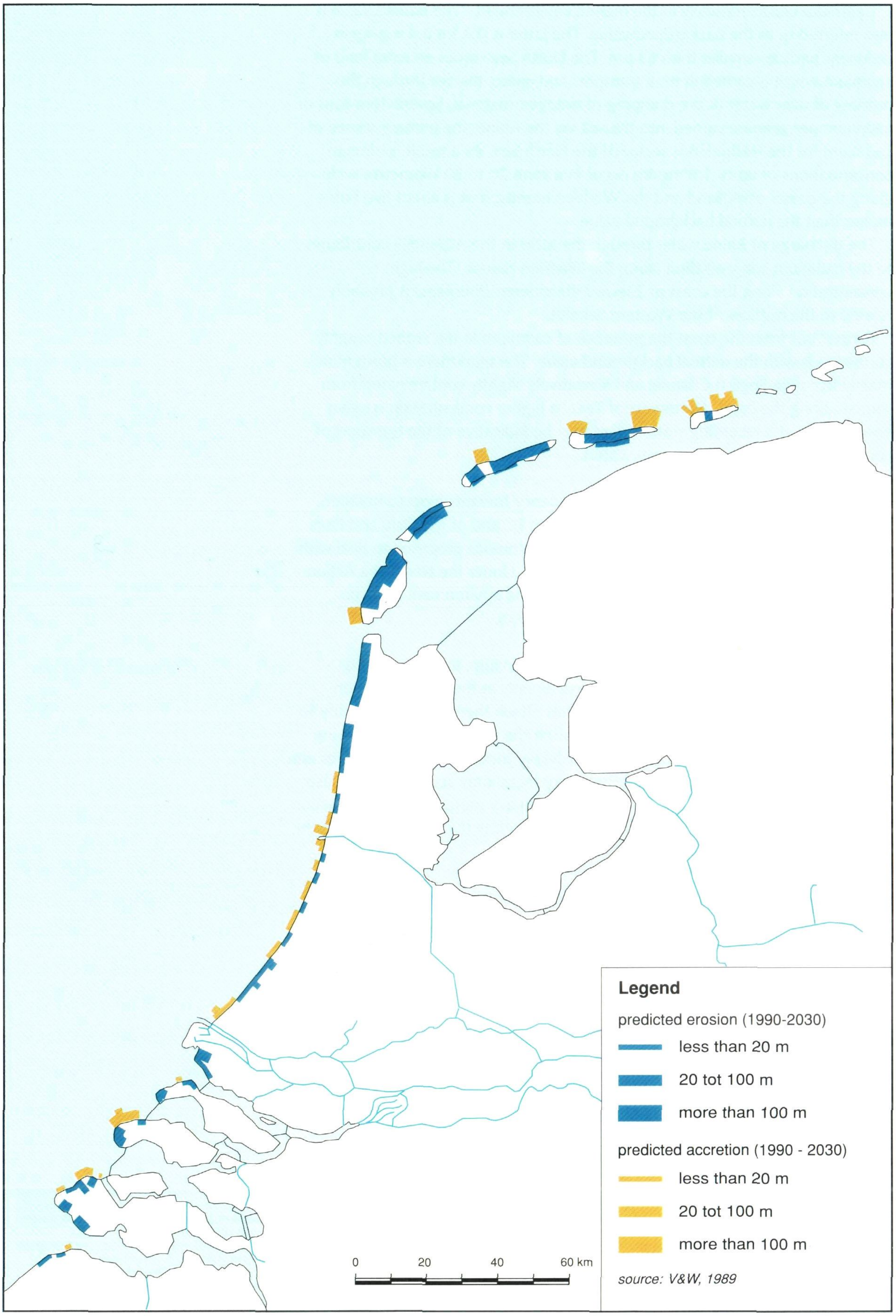
Coastal erosion and coastal accretion alternate along the coast. At a particulare location such an alternation also occurs in time: material removed from the beach in winter is naturally restored in summer. Structural coastal erosion, which occurs at the same place over a number of years in succession gives greater cause for concern. Such erosion may damage the dunes and, with them, the coastal defences. Where the latter happens, artificial sand must be brought in to restore the beach and dunes and thus keep the defences intact against flooding. The map shows how the coastline would change over the next 40 years in the absence of human intervention.

A considerable retreat is expected at a number of places along the coast of Noord-Holland and the coasts of the Wadden Islands. The promonteries of the islands of Zeeland and Zuid-Holland are also subject to structural erosion. Natural accretion occurs in the lee of the harbour piers of IJmuiden and on the east sides of Ameland and Schiermonnikoog and on Schouwen.

In 1990 the government laid down as part of its coast defence policy that central government would maintain the position of the coastline, giving the natural dynamics of the dune coast free play within a restricted margin.

Source:
Ministry of Transport, Public Works and Water Management (V&W) (1989). Kustverdediging na 1990 en bijbehorende technische achtergrondsrapporten. Second Chamber, 1989-1990, 21 136, no. 5-6. SDU, The Hague.

Coastline behaviour



Cadmium content of the seabed

Cadmium occurs naturally in the marine environment. The natural value is also referred to as the background value. The latter is 0.2 tot 0.4 mg/kg in sediment particles smaller than 63 µm. The North Sea carries an extra load of cadmium which is carried in mud transport and enters the sea through the outflow of river water or the dumping of dredged material. Several tens tons of cadmium per year are carried into the sea via the Rhine, the primary source of cadmium for the Netherlands sector of the North Sea. As a result, cadmium concentrations of up to 1.5 mg/kg occur in a zone 20 to 30 kilometres wide along the coasts of Holland and the Wadden Islands; that is about five times higher than the natural background value.

The discharge of Rhine water through the locks in the Afsluitdijk contributes to the cadmium concentration along the Wadden Islands. The high concentration along the coast of Zeeuws Vlaanderen (Breskens) is probably related to the outflow of the Western Scheldt.

Further out from the coast the presence of cadmium in the seabed roughly corresponds with the natural background value. The mud there is brought in mainly from the English Channel and is relatively slightly contaminated from sources along the coast. Northwest of Texel a higher concentration is again encountered at a recording station. This may be indicative of the transport of contaminants from English coastal waters.

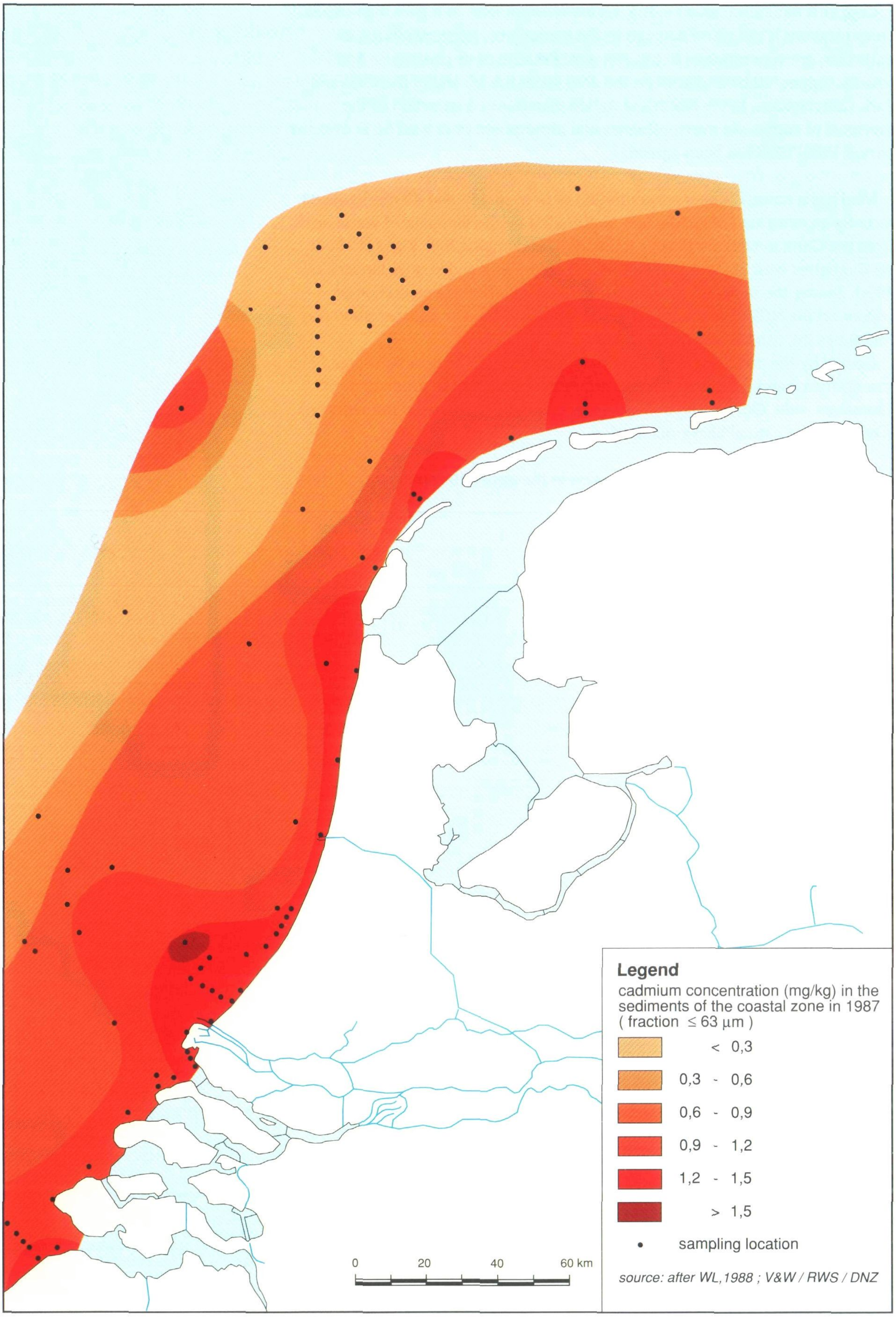
Because of its toxicity, persistence and tendency towards bioaccumulation, cadmium has been placed on the blacklist of the EC and of the Oslo and Paris Commissions. The Third North Sea Ministers Conference proposed to deal with blacklisted substances as far as possible at source. Under the North Sea Action Plan (NAP) the transport of cadmium to the marine environment must be reduced by at least 90% over the period 1985-1995.

The concentration of a heavy metal, such as cadmium, in the seabed is generally determined by carrying out measurements in the seabed fraction smaller than 63 µm (mud), since heavy metals attach themselves particularly to these mud particles, which move freely through the water. Thus by following the mud movements one can also trace the heavy metals. The mud particles are also absorbed by organisms, so that the heavy metal may accumulate in these organisms. Another reason for determining the heavy metals in this fine fraction is that the measurable quantity of metal may fall below the detection limit if the seabed sample is too large.

The values relate to the mud fraction in the upper 10 centimetres of the seabed. The samples were taken in 1986.

Source:
Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische waterkwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.
Ministry of V&W, RWS, North Sea Directorate (V&W/RWS/DNZ) unpublished data
Delft Hydraulics (WL) (1988). Microverontreinigingen in sedimenten van de Noordzee, verslag bemonstering 1986

Cadmium content of the seabed



Copper content of the seabed

Copper is naturally present in the marine environment. In higher than natural concentrations it can cause damage to the marine ecosystem. Molluscs, in particular, are very sensitive to this element. Because of its persistence and toxicity copper has been placed on the grey list of the EC and of the Oslo and Paris Commissions. In the North Sea Action Plan (NAP) a reduction of the transport of copper via rivers, estuaries and atmosphere of at least 50% over the period 1985-1995 has been agreed.

Mud has a natural copper concentration of between 15 and 40 mg/kg. Until recently an extra load of copper was contributed by the dumping of waste acids from the German titanium dioxide industry. This dumping took place at about 50 kilometres west of Hoek van Holland. The dumping ended on 1 January 1990. During the sampling campaign in 1986 the highest concentration of copper on the NCS were measured at the dumping site. The concentration was four times the natural background value.

Carried by the prevailing water and mud movements, the pollution spread out in a northeast and southwest direction from the dumping site over a zone 50 kilometres wide. Outside this zone the concentration of copper in the sediment is equal to the natural background value.

The values relate to the < 63 µm fraction in the upper 10 centimetres of the seabed. The samples were taken in 1986.

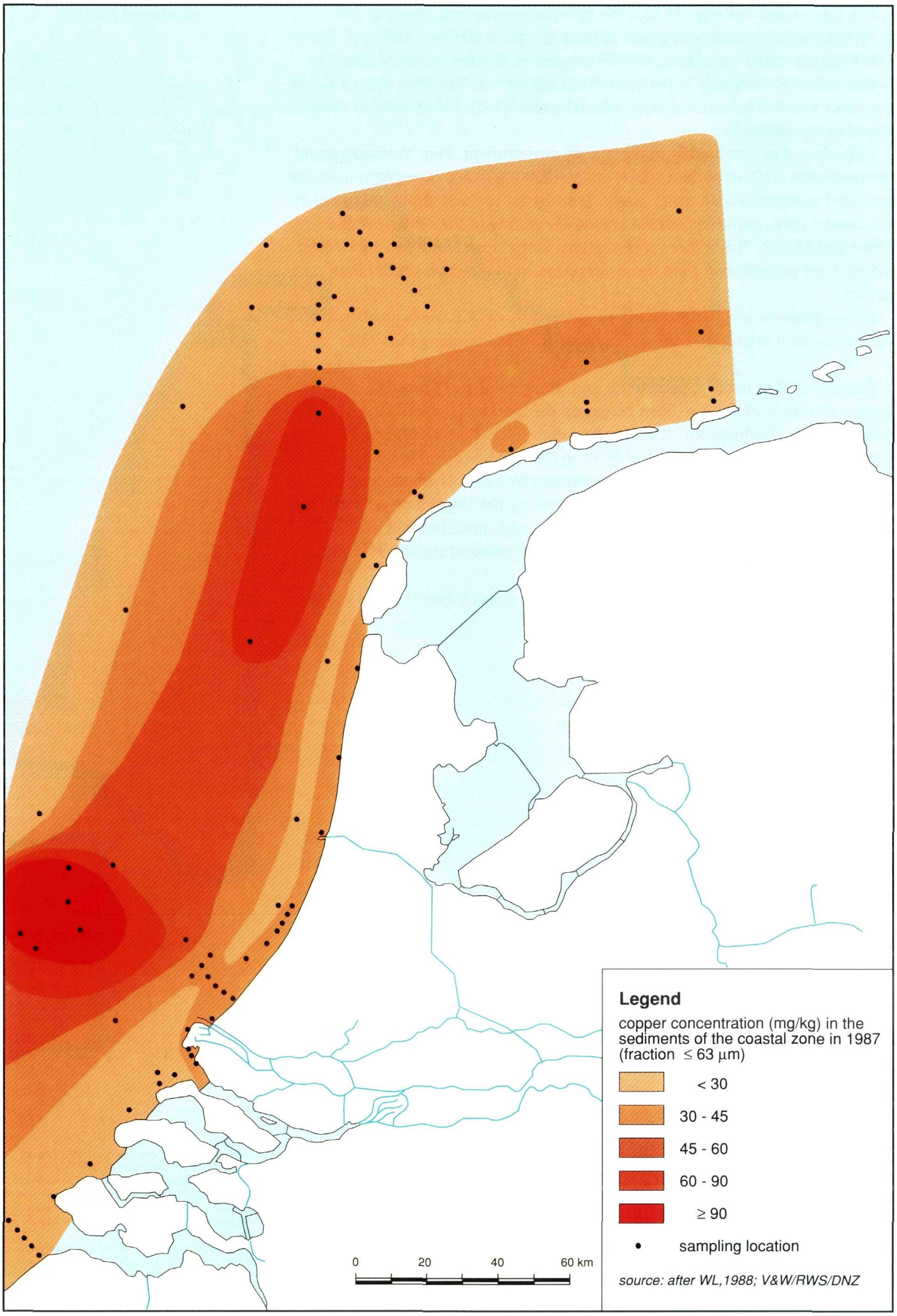
Source:

Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische waterkwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.

Ministry of V&W, RWS, North Sea Directorate (V&W/RWS/DNZ): unpublished data.

Delft Hydraulics (WL) (1988). Microverontreinigingen in sedimenten van de Noordzee, verslag bemonstering 1986.

Copper content of the seabed



PCB 138 content of the seabed

Polychlorinated biphenyl (PCB) is the collective name for a group of 209 different chemical substances which all have the same skeleton: biphenyl. The 209 PCBs are called congeners. All PCB congeners dissolve relatively poorly in water, but dissolve readily in the body fat of organisms. This gives them a strong tendency towards bioaccumulation, which increases with the number of chlorine atoms in the molecule.

PCBs do not occur naturally in the marine environment. Thus the background concentration is nil. Important supply sources are the rivers, dumping of harbour mud and transport via the atmosphere. The highest concentrations are found in the coastal zone, particularly in the immediate vicinity of the outflow of the Rhine and Meuse. The higher concentrations in the open North Sea are derived mainly from precipitation from the atmosphere, in the fraction smaller than 63 μm.

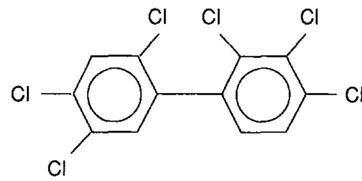
For purposes of analysis, standard measurements of PCB contamination are performed with reference to a small number of PCBs, including PCB 138.

Because of their toxicity, persistence and strong tendency towards bioaccumulation, PCBs have been placed on the blacklist of the EC and of the Oslo and Paris Commissions. It was agreed during the Third North Sea Ministers Conference to stop the transport of PCBs to the North Sea and to take measures to have these substances banned and destroyed by 1995. The final deadline for countries which are unable to complete the task by the target date is 1999.

The effects of PCBs on living organisms are already perceptible at low concentrations, e.g. on the reproduction of seals, birds and starfish [88].

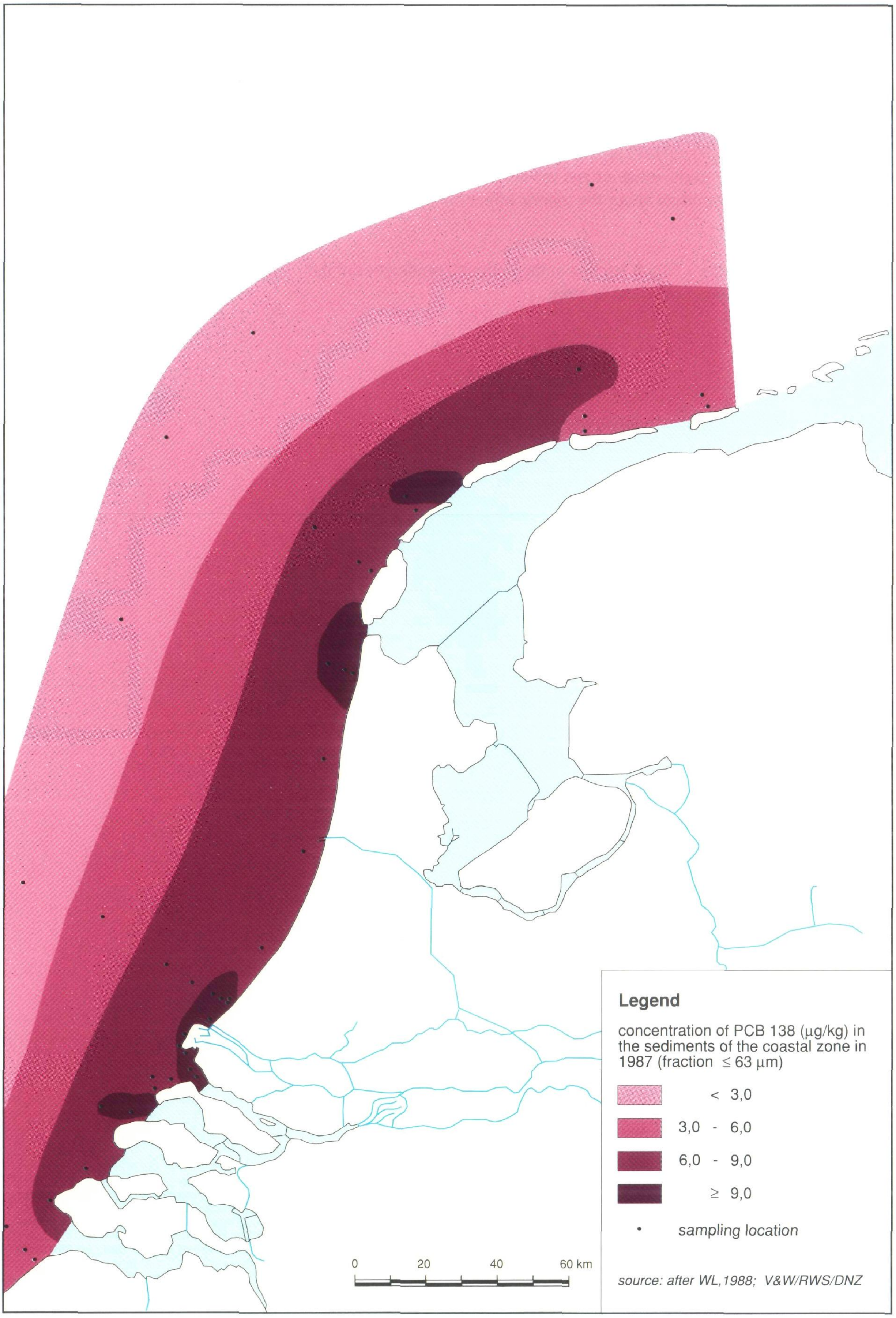
The values relate to the < 63 μm fraction in the upper 10 centimetres of the seabed. The sampling was carried out in 1986.

structure of PCB 138



Source:
Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische waterkwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.
Reijnders, P.J.H. (1987). Reproductive failure in common seals feeding on fish from polluted coastal waters. Nature 324, 456-457.
Ministry of V&W, RWS, North Sea Directorate (V&W/RWS/DNZ): unpublished data.
Delft Hydraulics (WL) (1988). Microverontreinigingen in sedimenten van de Noordzee, verslag bemonstering 1986.

PCB 138 content of the seabed



HCB content of the seabed

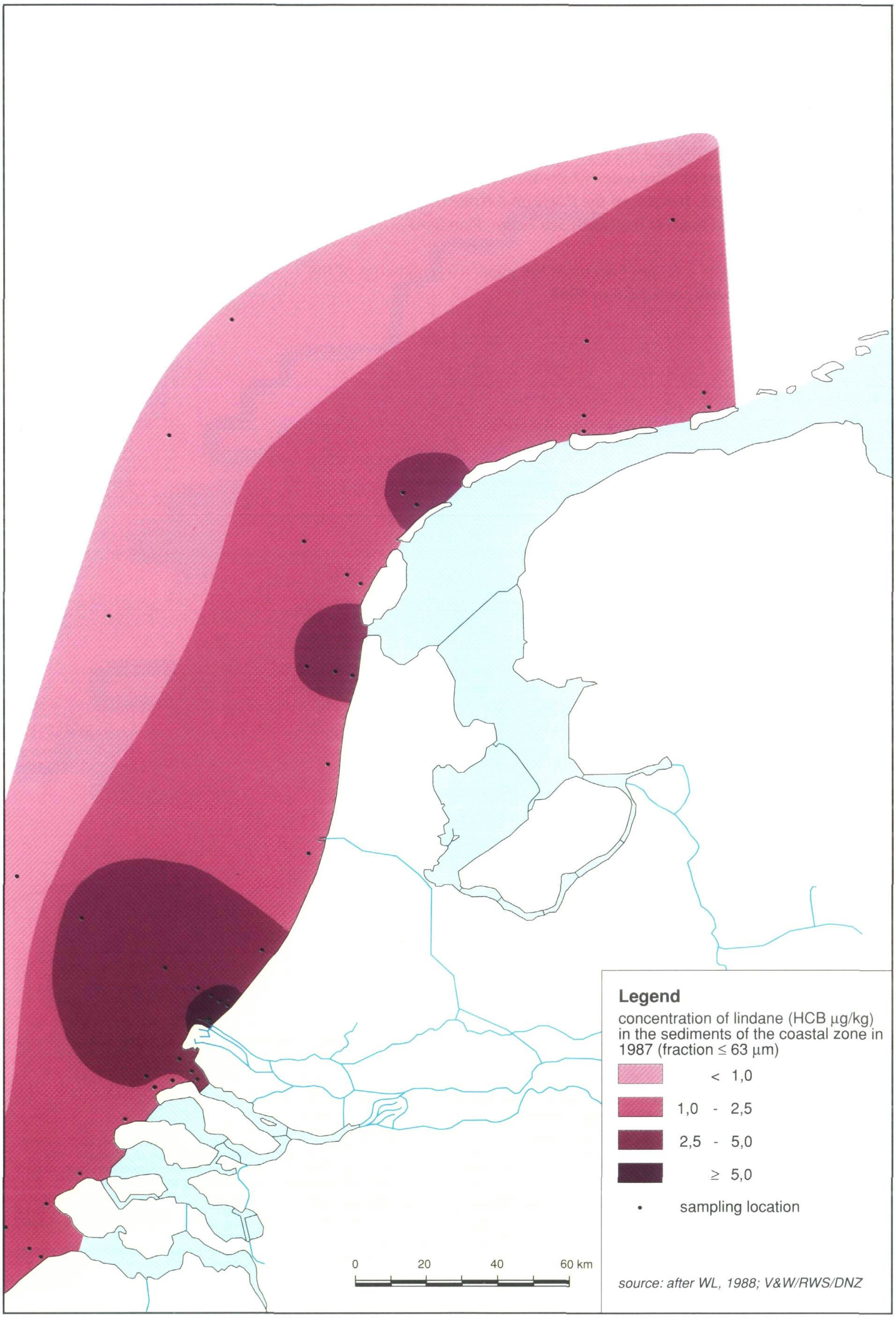
Hexachlorobenzene (HCB) is a substance which appears on the blacklist of the EC and of the Oslo and Paris Commissions. The natural background value of HCB is nil; the substance derives wholly from organic chemistry. This explains the relatively high values found in the coastal zone, particularly where water from the rivers Rhine and Meuse flow into the sea via the New Waterway and the Lake IJssel.

The North Sea Action Plan (NAP) provides for a reduction of at least 50% in the supply of HCB from rivers, estuaries and the atmosphere between 1985 and 1995. Little is known at present about the specific effects of HCB on the marine ecosystem.

The values relate to the < 63 µm fraction in the upper 10 centimetres of the seabed. The sampling was carried out in 1986.

Source:
Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische water-kwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.
Ministry of V&W, RWS, North Sea Directorate (V&W/RWS/DNZ): unpublished data.
Delft Hydraulics (WL) (1988). Microverontreinigingen in sedimenten van de Noordzee, verslag bemonstering 1986.

HCB content of the seabed



PAH content of the seabed

Polycyclic Aromatic Hydrocarbons (PAHs) occur naturally in very low quantities in marine mud. The higher concentration in the coastal zone is a result of transport via the rivers and the dumping of dredged material. The high concentration found north of the Wadden Islands are probably the result of transport by the atmosphere.

A relationship has been been demonstrated between the occurence of liver tumours among flounder [90] and the presence of certain PAHs. PAHs are currently included in a list of substances which are eligible for placing on the blacklists. The Netherlands has placed the PAHs on a national list of priority substances and included them in the North Sea Action Plan (NAP).

The values relate to the < 63 μm fraction in the upper 10 centimetres of the seabed. The sampling was carried out in 1986.

Source:

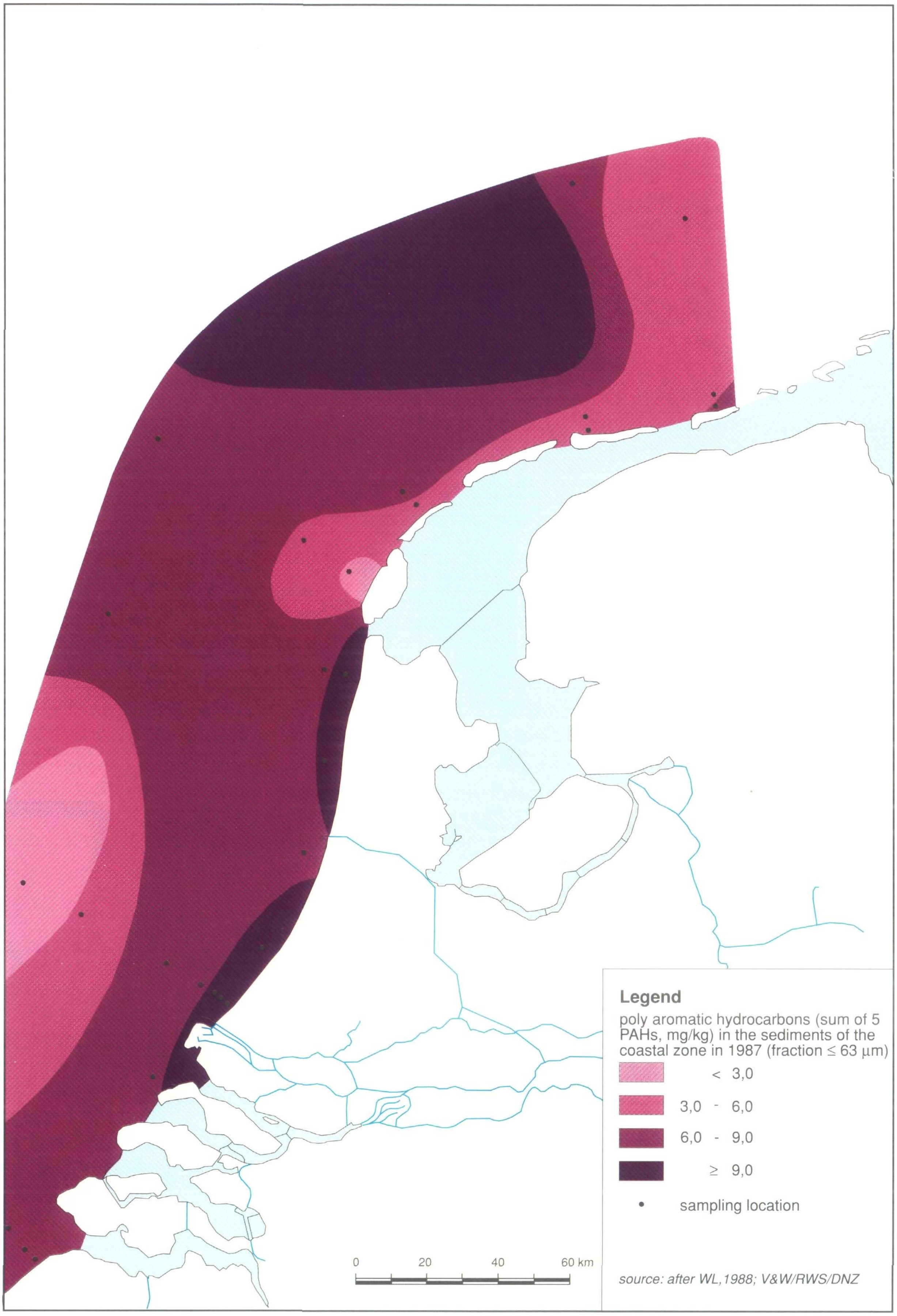
Van Eck, Turkstra, van 't Sant (1985). Voorstel referentiewaarden fysisch-chemische waterkwaliteitsparameters Nederlandse zoute wateren. V&W/RWS and Ministry of VROM.

Marquenie, J., Vethaak, A.D. (1988). Effecten van verontreinigingen op zoutwater ecosystemen. Verslag studiedag Vereniging voor Milieuwetenschappen, Ede, 1988.

Ministry of V&W, RWS, North Sea Directorate (V&W/RWS/DNZ): unpublished data.

Delft Hydraulics (WL) (1988). Microverontreinigingen in sedimenten van de Noordzee, verslag bemonstering 1986.

PAH content of the seabed



Air

Physical features (map 37 to 39)

Precipitation from October to March

The map gives a picture of precipitation in the "wet" season; i.e. the period from October to March. The months of November, December and January are the wettest.

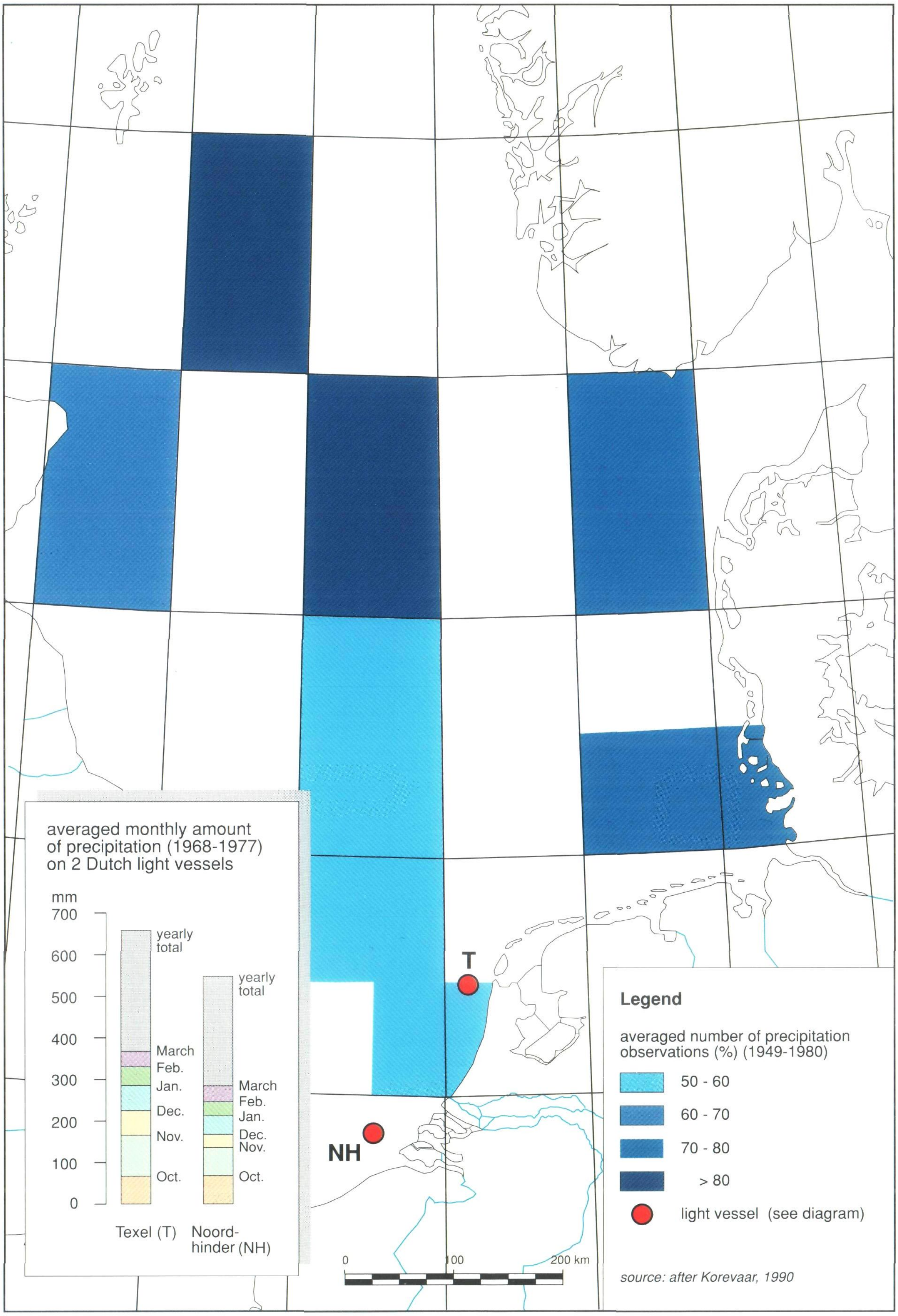
Precipitation is recorded with reference to the "averaged number of precipitation observations" expressed as percentages. In other words, this gives the percentage of the total number of observations in which precipitation, in the form of rain, snow, hail etc., has been reported for the area concerned. The number of observations is greatest in the northern part of the North Sea.

In January and February a large part of the precipitation consists of snow. The rainfall observations on board lightships have been averaged over the period 1949-1980. The observations originating from voluntarily observing ships have been averaged over the period 1961-1980.

The map also shows the amount of precipitation measured each month. These measurements cannot be made on moving ships. The figures concerned came from the Texel and Noordhinder lightships and were averaged over the period 1968-1977.

Source:
Korevaar, C.G. (1990). North Sea Climate: based on observations from ships and lightvessels.

Precipitation from October to March



Precipitation from April to September

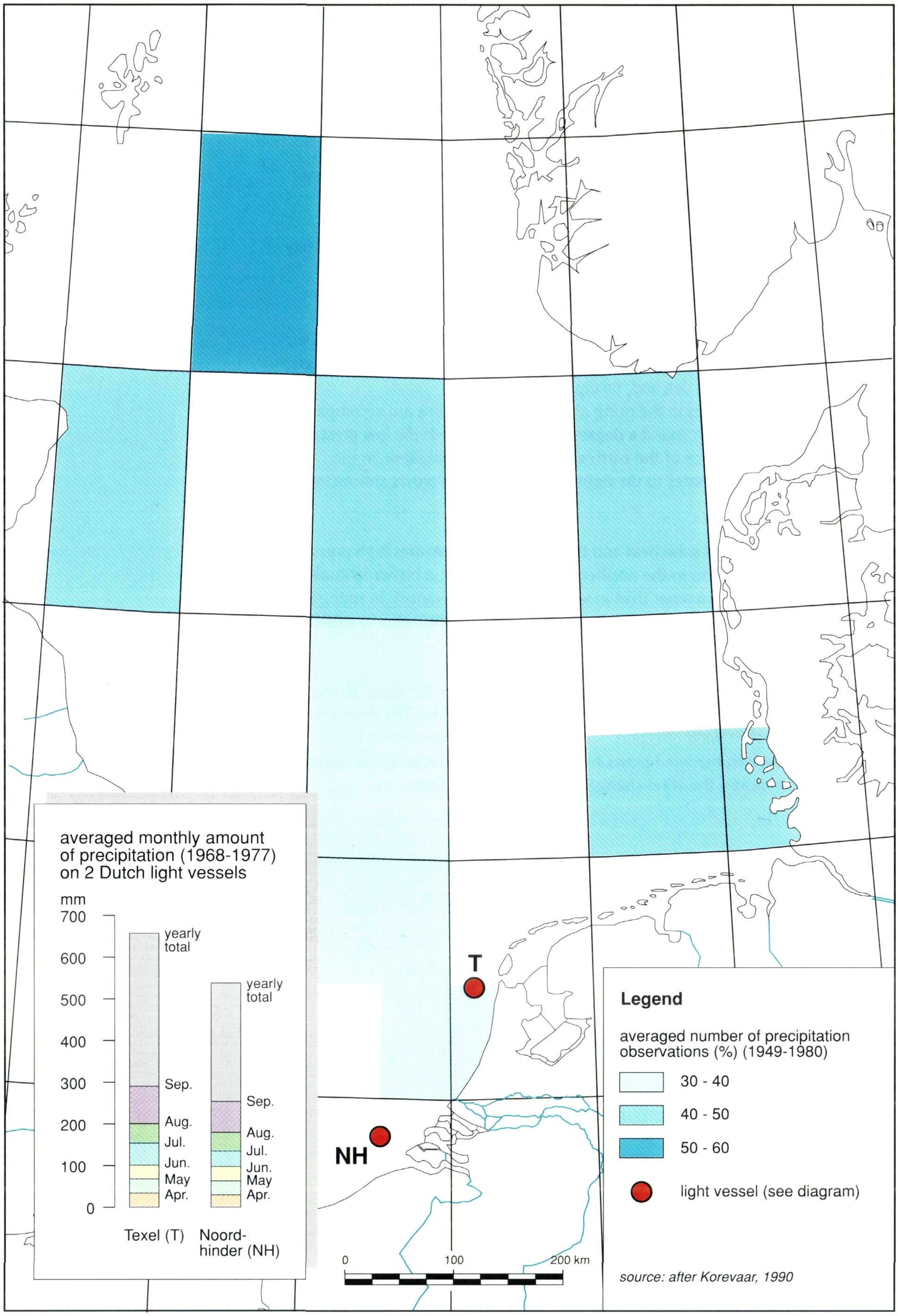
The map gives the averaged number of precipitation observations (in percentages) for a number of areas in the "dry" season; that is the period from April to September. The driest months are May, June and July. Most precipitation falls in the form of drizzle. The precipitation observations on board lightships have been averaged over the period 1949-1980. The observations from voluntarily observing ships have been averaged over the period 1961-1980.

The map also indicates the average amount of precipitation per month, measured over the period 1968-1977. These measurements were carried out on the Texel and Noordhinder lightships. The amount of precipitation is greatest in autumn and reaches a maximum in September. Precipitation is least in spring.

The lightships and voluntarily observing ships form part of a worldwide network of the World Meteorological Organization (WMO). Other climatic data collected by these ships include air temperature, air humidity, surface temperature of the seawater, air pressure, cloud cover, precipitation, visibility, wind and wave height.

Source:
Korevaar, C.G. (1990). North Sea Climate: based on observations from ships and lightvessels.

Precipitation from April to September



Wind velocity and direction in November

The wind regime of the North Sea is largely determined by the average air pressure differences above the North Atlantic Ocean and the European continent. A large high pressure area is centred permanently near the Azores and a low pressure area between Iceland and Greenland. An airflow is maintained between these systems which is predominantly southwesterly over the southern North Sea and turns off southerly over the northern North Sea. This airflow is strongest in winter, when the air pressure difference is greatest under the influence of the icy polar air. The highest wind velocities are recorded in the winter months.

Depressions occur on a smaller scale within the large-scale air circulation. They are characteristic of the changeable weather picture over the North Sea. Depressions arise along the separation plane of cold polar air, originating from high latitudes, and warm subtropical air from the south. Along the separation plane the warm air is forced to rise up over the cooler air in the bottom air layer.

The large-scale air circulation carries the depressions with it from west to east: over the ocean, the North Sea and, finally, the continent.

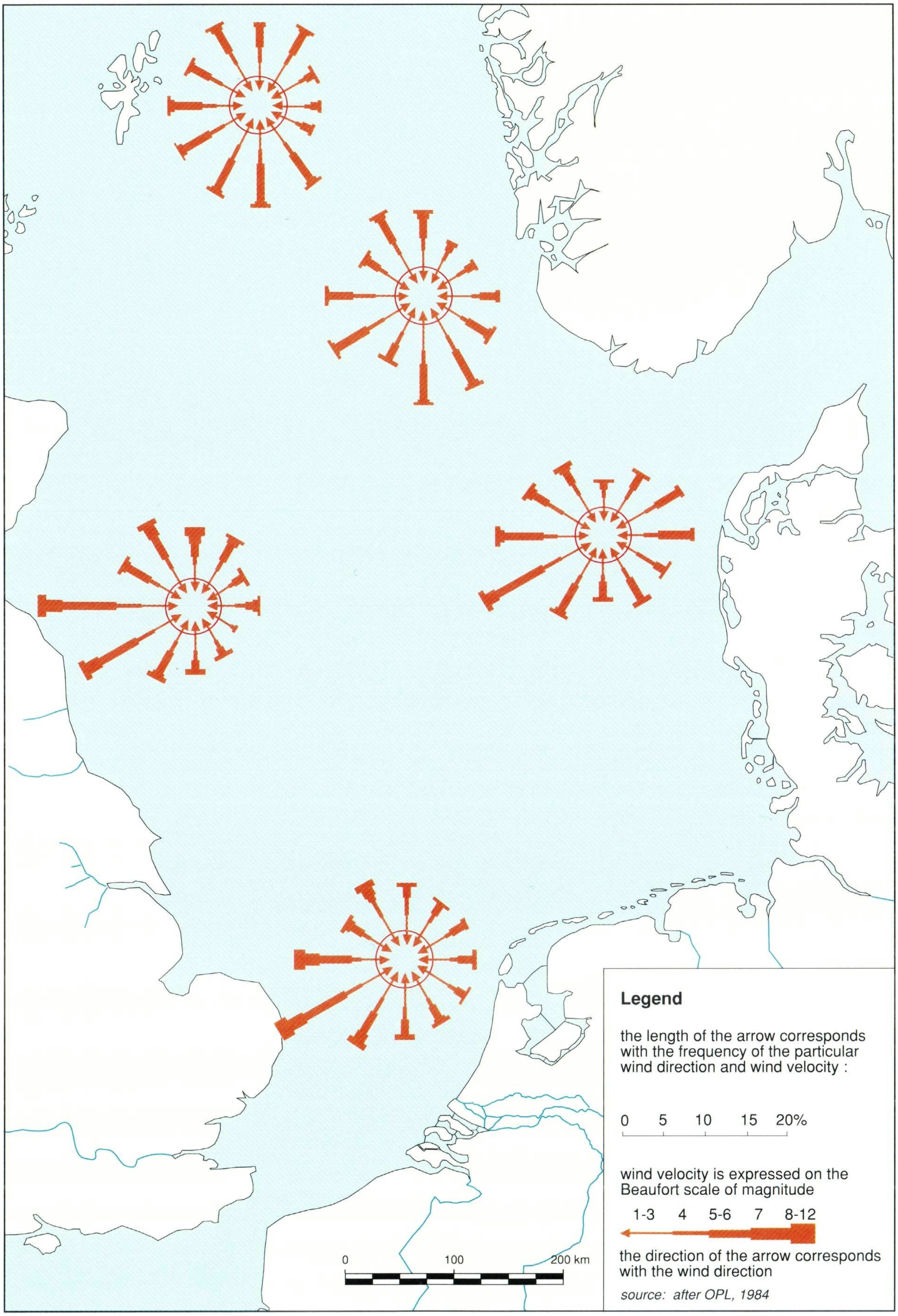
Water vapour condenses in the rising air, so that depressions are accompanied by clouds and rain. The air round a depression moves towards the low pressure centre. Under the influence of the earth's rotation the air circulation in the northern hemisphere deviates to the right. The wind always blows anticlockwise round a depression.

Under the influence of solar heat and the position of the Azores high pressure area, the depression tracks in the northern hemisphere lie at a higher latitude (latitude of Norway) in summer than in winter (latitude of France). In spring and autumn the depression belts shift across the Netherlands. This helps to explain the phenomenon of spring and autumn storms.

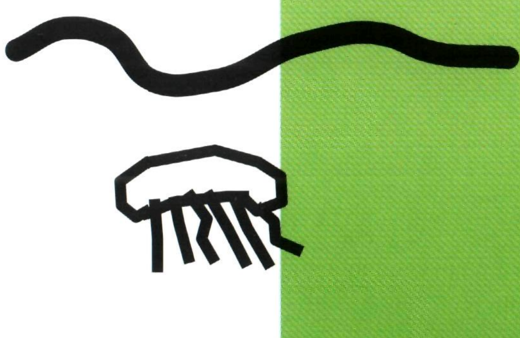
Wind roses have been drawn on the map which show the direction, strength and frequency of the wind for different parts of the North Sea. The direction of the arrows shows the wind direction. The length of the arrows shows the frequency with which the wind blows from the indicated direction. The thickness of the arrows indicates the wind strengths on the Beaufort Scale.

Source:
Børresen, J.A. (1987). Wind atlas for the North Sea and the Norwegian Sea. Norwegian University Press/ The Norwegian Meteorological Institute, Oslo.
Oilfield Publications Limited (OPL) (1984?). The North Sea Environmental Guide.
Wieringa, J., Rijkoort, P.J. (1983). Windklimaat van Nederland. SDU, The Hague.

Wind velocity and direction in November



Flora and fauna



Large benthic fauna: number of species on the NCS

The benthic fauna is divided into the classes large and small. Large benthic or macrobenthic fauna (macrozoobenthos) consists of animals living in and on the seabed which remain behind in a sieve with a 1 mm mesh. Small benthic fauna (meiozoobenthos) is smaller than 1 mm.

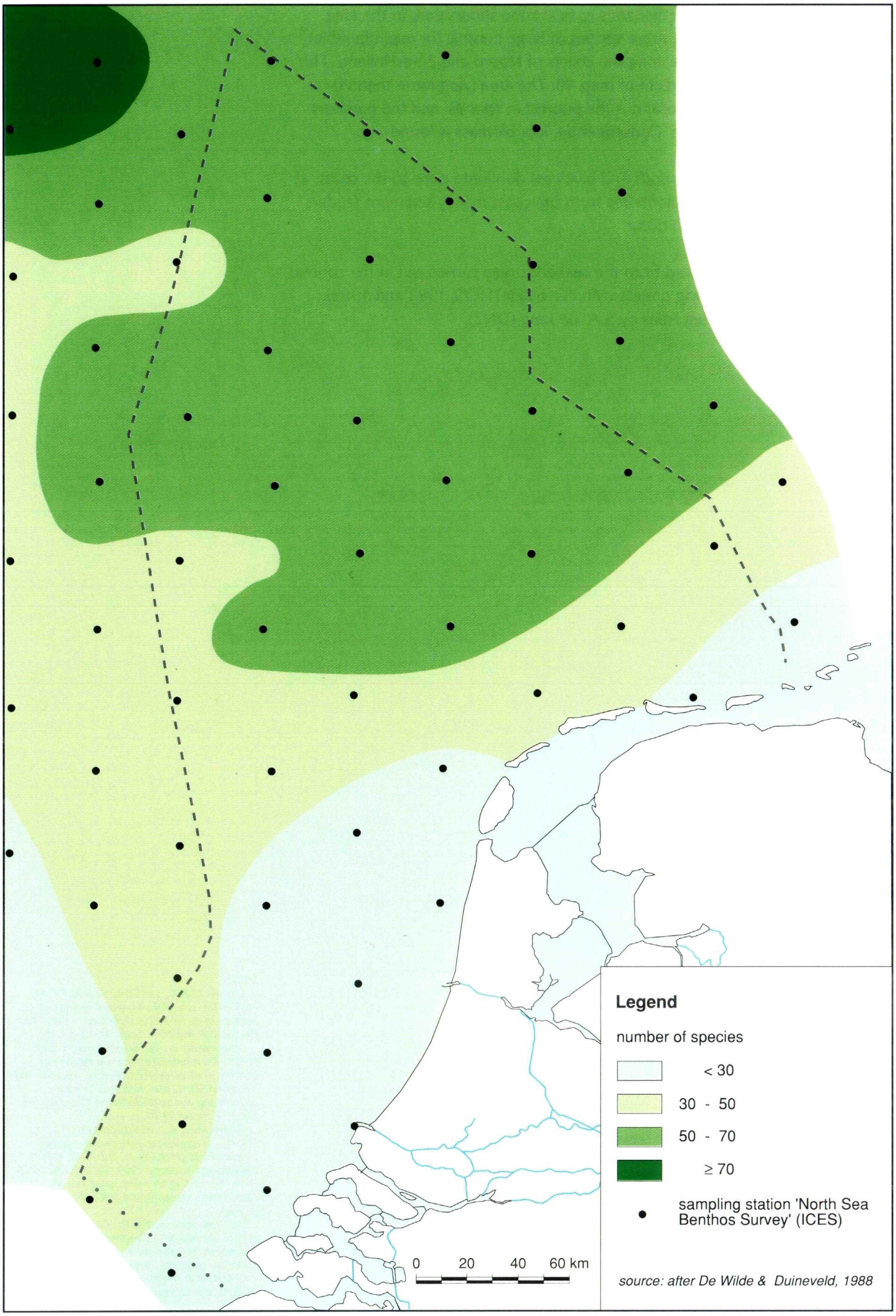
The distribution of the macrozoobenthos in the North Sea is determined by temperature, depth, the composition of the sediment, food supply and grazing. Temperature plays a secondary role on the relatively shallow NCS. The macrobenthic fauna can be further divided according to the manner in which they take up their food. The suspension feeders filter food particles from the water; the sediment feeders take it up from or out of the sediment.

The most important animal groups among the macrozoobenthos are the polychaetes *(Polychaeta)*, molluscs *(Mollusca)*, echinoderms *(Echinodermata)* and crustaceans *(Crustacea)*. The number of macrozoobenthos species on the NCS ranges between 25 and 68 per sampling station. The number of species and the total biomass are lowest in the southern North Sea. The most species-rich areas are the Oystergrounds and the north side of the Dogger Bank (46-63 species per sampling station). Within the coastal zone the number of species ranges from 5 or less to 38 species per sampling station. The numbers of the sea urchin *(Echinocardium cordatum)* have increased in the Dogger Bank area during the past 6 years.

The map data are derived from the ICES Benthic Mapping programme of 1986. Five seabed samples were taken at each sampling station, and the macrofauna of the samples was identified. The data are reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:
Creutzberg, F., Wagenaar, P., Duineveld, G., Lopez-Lopez, N. (1984). Distribution and density of the benthic fauna in the southern North Sea in relation to bottom characteristics and hydrographic conditions. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 183. 101-110
Duineveld, G.C.A., de Wilde, P.A.J.W., Kok, A. (1990). A synopsis of the macrobenthic assemblages and benthic ETS-activity in the Dutch sector of the North Sea. Neth. J. Sea Res. 26: 125-138.
Heyman, R. (1990). Benthic front systems of the Dogger Bank. In: Beukema J.J. (ed.). Annual Report NIOZ 1989, p. 50.
ICES (1986). Macrozoobenthic Mapping Programme 1986. Sixth report of the ICES Benthos Ecology Working Group.
De Wilde, P.A.W.J., Duineveld, G.C.A. (1988). Macrobenthos van het Nederlands Continentale Plat, verzameld tijdens de ICES 'North Sea Benthos Survey', April 1986. NIOZ, p. 1-3.

Large benthic fauna: number of species on the NCS



Large benthic fauna: number of species in the coastal zone

The detailed map of the Netherlands coastal zone shows that, in the area north of the Wadden Islands, more species of large benthic (or macrobenthic) fauna occur at each site than along the coasts of Noord and Zuid-Holland. This accords very well with the picture of map 40. The area lying more than 20 kilometres off the coast of Holland is the poorest in species, and the numbers per species are also low there. Consequently, low biomass is found.

Suspension feeders (chaetopods and bivalves) dominate close to the coast; at a distance of more than 20 kilometres from the coast mainly sediment feeders (chaetopods and sea urchins) occur.

The data have been derived from the seabed survey carried out in the context of the Environmental Zoning project (MILZON-BENTHOS, 1988 and 1989), reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:

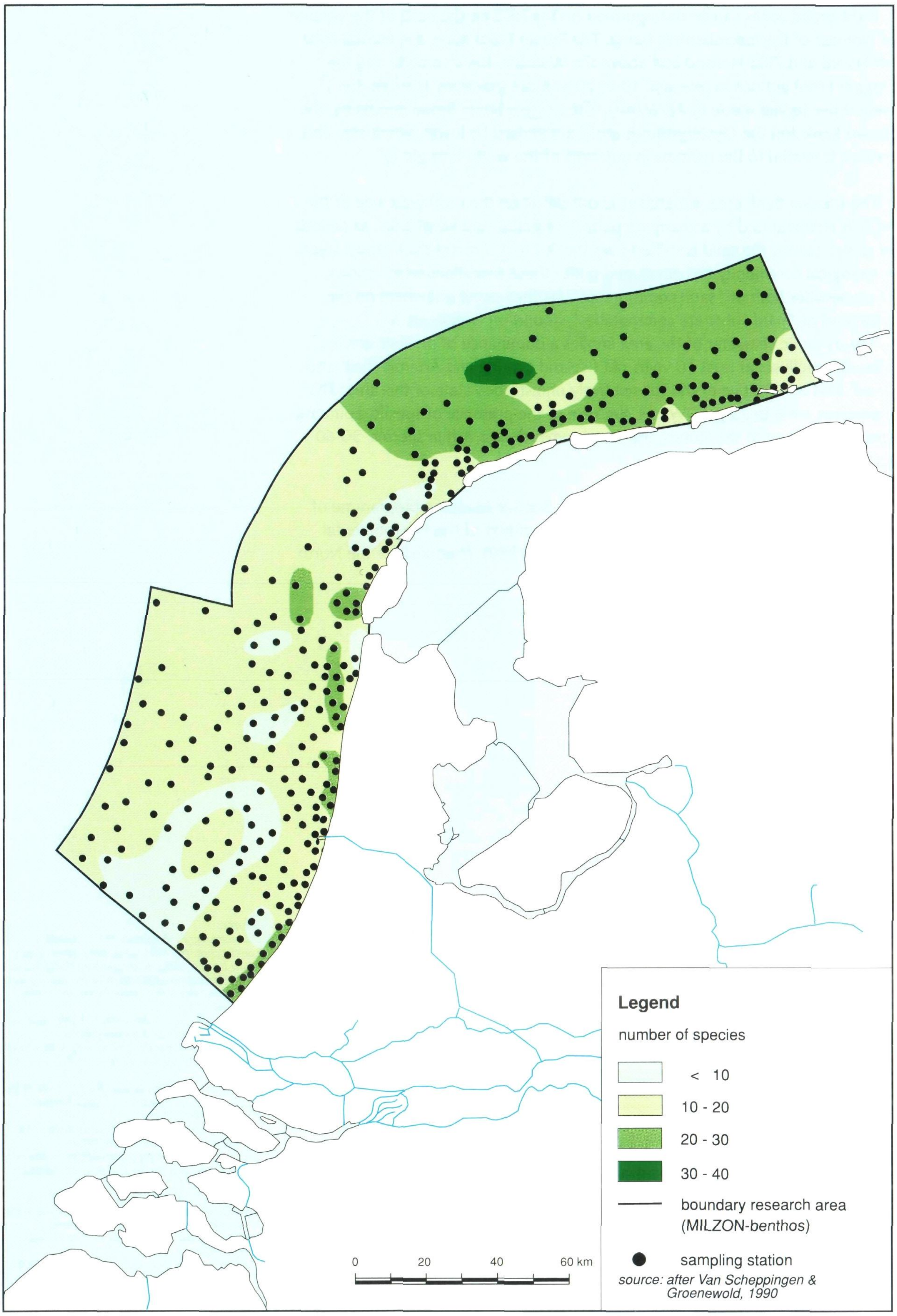
Groenewold, A., van Scheppingen, Y.C M. (1987). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee. V&W/RWS/DNZ&DGW MILZON report 87-12, p. 1-14.

Groenewold, A., van Scheppingen, Y.C.M. (1989). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, voorjaar 1988. V&W/RWS/DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 89-01, p. 1-27.

Groenewold, A., van Scheppingen, Y C.M. (1990). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Noord-Nederlandse kustzone 1989. V&W/RWS/DNZ& DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-01, p. 1-24.

Van Scheppingen, Y.C.M., Groenewold, A. (1990). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Nederlandse kustzone: overzicht 1988-1989. V&W/RWS/DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-03, p. 1-27.

Large benthic fauna: number of species in the coastal zone



Large benthic fauna: biomass on the NCS

Eight broad zones can be distinguished on the NCS on the basis of the volume of biomass of the macrobenthic fauna. The Frisian Front zone, the coastal zone off Noord and Zuid-Holland and above the Wadden, the Voordelta and the Dogger Front are rich in biomass: 10 to 20 or more grammes ash-free dry weight per square metre (g ADW/m^2). The Dogger Bank, Broad Fourteens, the Brown Bank and the Oystergrounds are characterised by lower biomasses. This pattern is related to the richness in nutrients of the water brought in.

The Cleaver Bank area, situated at about 54° N on the northwest side of the NCS, is characterised by a changing pattern of gravel and sandbanks. In periods of severe storms the sand is shifted over the 0.5 to 1.3 metre thick gravel layer. A biological community has developed under these conditions which shows characteristics both of "sand communities" (as they occur elsewhere on the NCS) and of "hard substrate communities" (found on wrecks etc.).

The dynamic character of the area implies a dominance of pioneer species, although molluscs at least 10 years old (Iceland cyprine and Artemis shell) also occur. This is indicative of the still relatively undisturbed state of this area. The biomasses are 6 to 23 g ADW/m^2. Because of the presence of specific epifauna species, attached to the stones, the area is nevertheless rich in species, 30-60 species per sampling station.

The data have been derived from the ICES Benthic Mapping programme of 1986 and the seabed survey carried out in the context of the Environmental Zoning project (MILZON-Klaverbank, 1988 and 1989), reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:

Creutzberg, F., Wagenaar, P., Duineveld, G., Lopez-Lopez, N. (1984). Distribution and density of the benthic fauna in the southern North Sea in relation to bottom characteristics and hydrographic conditions. Report P.-v. Réun. Cons int. Explor. Mer. 183: 101-110.

Duineveld, G.C.A., de Wilde, P.A.J.W., Kok, A. (1990) A synopsis of the macrobenthic assemblages and benthic ETS-activity in the Dutch sector of the North Sea. Neth. J. Sea Res. 26.125-138.

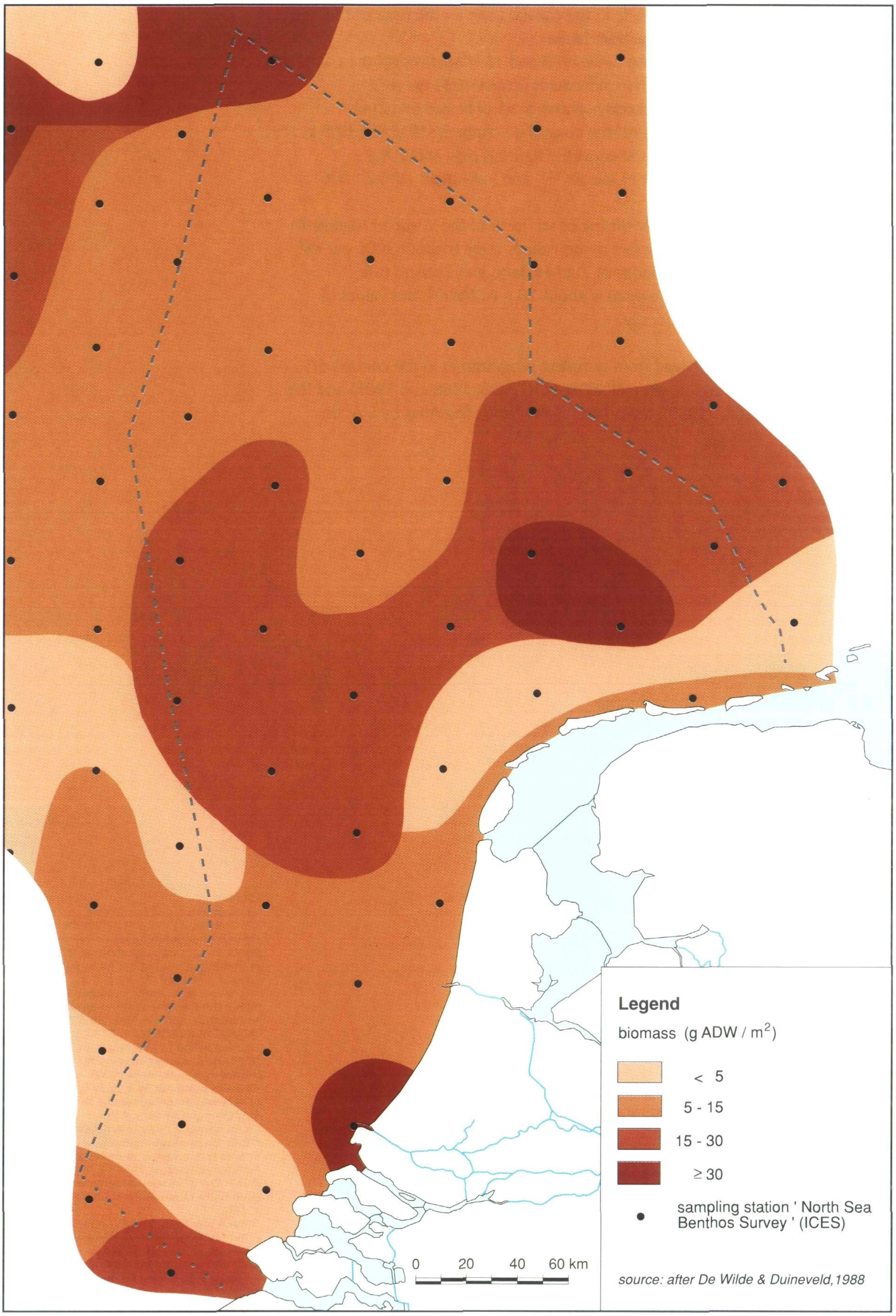
Heyman, R. (1990). Benthic front systems of the Dogger Bank. In: Beukema, J.J. (ed.). Annual Report NIOZ 1989, p. 50

Van Moorsel, G.W.N.M., Waardenburg, H.W (1990). Impact of gravel extraction on geomorphology and the macrobenthic community of the Klaverbank (North Sea) in 1988. Bureau Waardenburg, p 1-53.

Sips, H.J.J., Waardenburg, H.W. (1989). The macrobenthic community of gravel deposits in the Dutch part of the North Sea (Klaverbank): ecological impact of gravel extraction. Bureau Waardenburg, p. 1-34.

De Wilde, P.A.W.J., Duineveld, G.C A. (1988). Macrobenthos van het Nederlands Continentale Plat, verzameld tijdens de ICES 'North Sea Benthos Survey', April 1986. NIOZ, p. 1-3.

Large benthic fauna: biomass on the NCS



Large benthic fauna: biomass in the coastal zone

The following division can be made in the coastal zone on the basis of the biomass of large benthic (macrobenthic) fauna :

- the biomass is highest in the zone between 5 and 12 kilometres off the coast, at about 50 g ADW/m^2 and rich in individuals (about 4000 per m^2);
- the biomass declines relatively quickly off the coast of Noord and Zuid-Holland. At 12 to 25 kilometres off the coast the volume is still about 12.5 g ADW/m^2; at 65 kilometres off the coast the figure is only about 7 g ADW/m^2. This area is also poor in species [41] and individuals (about 1000 individuals per m^2);
- the biomass declines less sharply off the coast north of the Wadden Islands (to about 18 g ADW/m^2). The number of individuals there is about 3000 per m^2;
- the average biomass off the islands of Zuid-Holland and Zeeland (the Voordelta is not shown on the map) is about 20 g ADW/m^2, but values of 60 g ADW/m^2 are possible locally.

The results have been derived from sampling programmes in the context of the Environmental Zoning project (MILZON-BENTHOS, 1988 and 1989) and the Voordelta project (1987-1989), reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:

Craeymeersch, J.A., Hamerlynck, O., Hostens, K., Vanreusel, A., Vincx, M. (1990) De ekologische ontwikkeling van de Voordelta Deelrapport 1 De huidige ekologische situatie van de Voordelta Delta Institute for Hydrological Research/University of Gent, p. 1-92

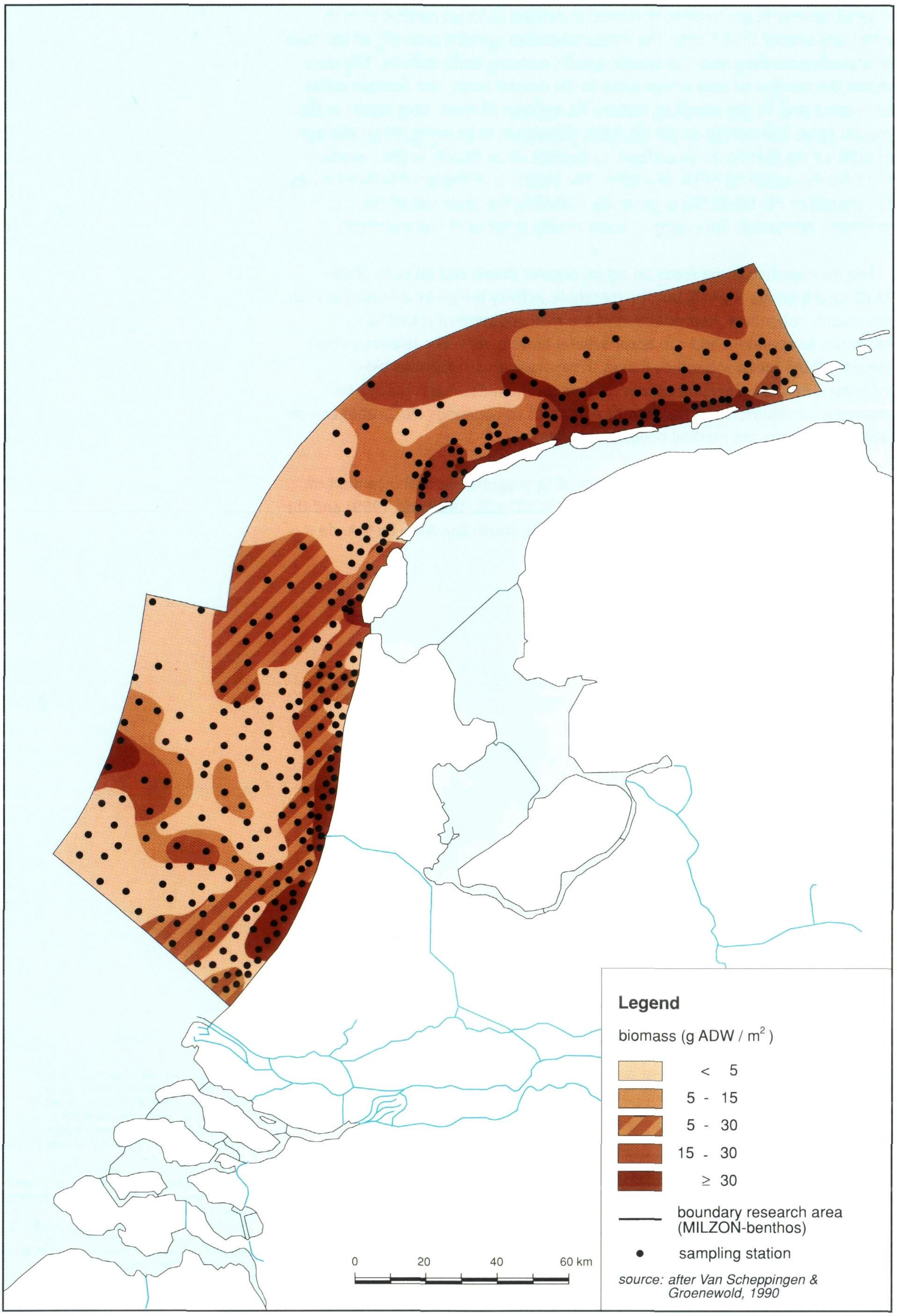
Groenewold, A., van Scheppingen, Y C M (1987) De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee V&W/RWS/-DNZ&DGW MILZON report 87-12, p 1-14

Groenewold, A., van Scheppingen, Y C M (1989). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee voorjaar 1988 V&W/RWS/DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 89-01, p. 1-27.

Groenewold, A., Van Scheppingen, Y C M (1990) De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee de Noord-Nederlandse kustzone 1989. V&W/RWS/DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-01, p 1-24

Van Scheppingen, Y C.M., Groenewold, A (1990) De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee de Nederlandse kustzone overzicht 1988-1989 V&W/RWS/DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-03, p 1-27

Large benthic fauna: biomass in the coastal zone



Small benthic fauna: number of taxa in the coastal zone

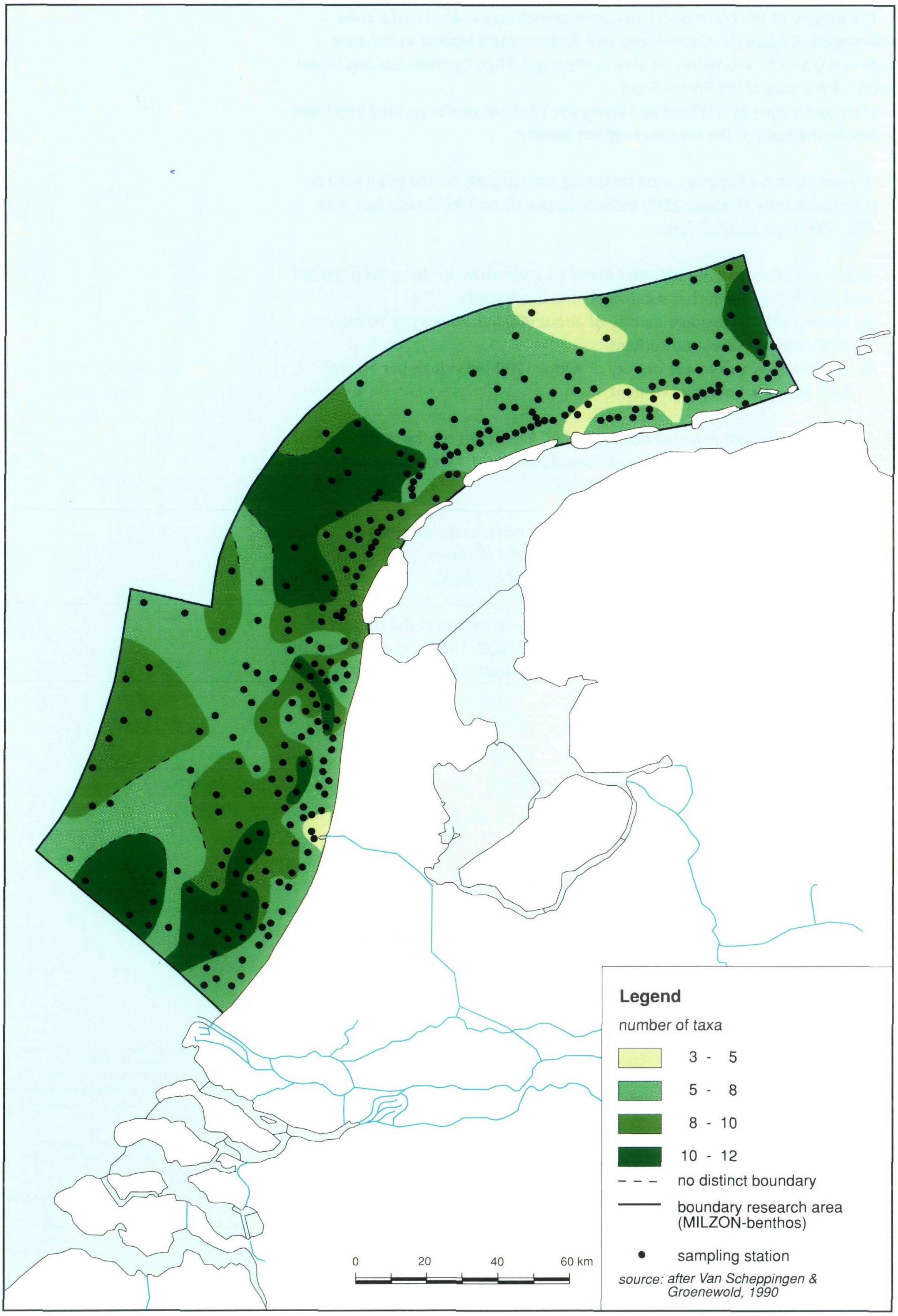
Small benthic fauna (meiozoobenthos) is defined as those benthic animals which are smaller than 1 mm. The meiozoobenthos consists primarily of the taxa *Nematoda* (roundworms), *Copepoda*, small *Crustacea* and *Protozoa*. The map shows the number of taxa which occur in the coastal zone. The number varies between 3 and 11 per sampling station. An average of seven taxa occurs in the coastal zone. The nematods are the most numerous, accounting for an average of 80% of the number of individuals. Copepods occur mainly in the transition from coastal waters to offshore waters. The variation in meiozoobenthos taxa in the seabed of the North Sea is generally related to the grain size of the sediment. Nematods, for example, occur mainly in areas of fine sediment.

The meiobenthic fauna feeds on algae, organic debris and on each other. Their total biomass is small, but the metabolic activity is high in comparison with the macrozoobenthos. Reproduction of the meiozoobenthos is tied to a minimum temperature and can occur several times a year. The relatively short lifespan of the meiozoobenthos makes these organisms suitable as bio-indicators, because the composition of their communities reacts quickly to changing conditions. Thus the ratio of nematods to copepods (N/C ratio) can be used where there are marked pollution gradients.

The results have been derived from sampling programmes in the context of the Environmental Zoning project (MILZON-BENTHOS, 1988 and 1989) and the Voordelta project (1987-1989), reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:
Groenewold, A., van Scheppingen, Y.C.M (1990). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Noord-Nederlandse kustzone 1989. V&W/RWS/ DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-01, p. 1-24.
Huys, R., Heip, C.H.R., Herman, P.M.J., Soetaert, K. (1990). The meiobenthos of the North Sea: preliminary results of the North Sea Benthos Survey. ICES. C.M. 1990/Mini:8.
Van Scheppingen, Y.C.M., Groenewold, A. (1990). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Nederlandse kustzone: overzicht 1988-1989. V&W/RWS/ DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-03, p. 1-27.

Small benthic fauna: number of taxa in the coastal zone



Small benthic fauna: density in the coastal zone

The density of the commonest meiozoobenthos taxa in the coastal zone (*Nematoda*, *Copepoda*, *Gastrotricha* and *Turbelleria*) is highest in the zone between 0 and 12 kilometres parallel to the coast. High densities are also found south of the area of the Frisian Front.

The coastal zone off Holland and along the Wadden can be divided into three zones on the basis of the meiozoobenthos density:

1. A zone up to 5 kilometres wide bordering immediately on the coast with an average density of about 2500 individuals per 10 cm^2. N/C ratio (see map 44): 458. High mud content.

2. A western offshore zone between 5 and 65 kilometres off the coast of Noord and Zuid-Holland, which is subdivided into 2 subzones:
   a. an area with an average density of about 900 individuals per 10 cm^2. N/C ratio 15. Low mud content.
   b. an area with an average density of about 1700 individuals per 10 cm^2. N/C ratio 19. Low mud content.

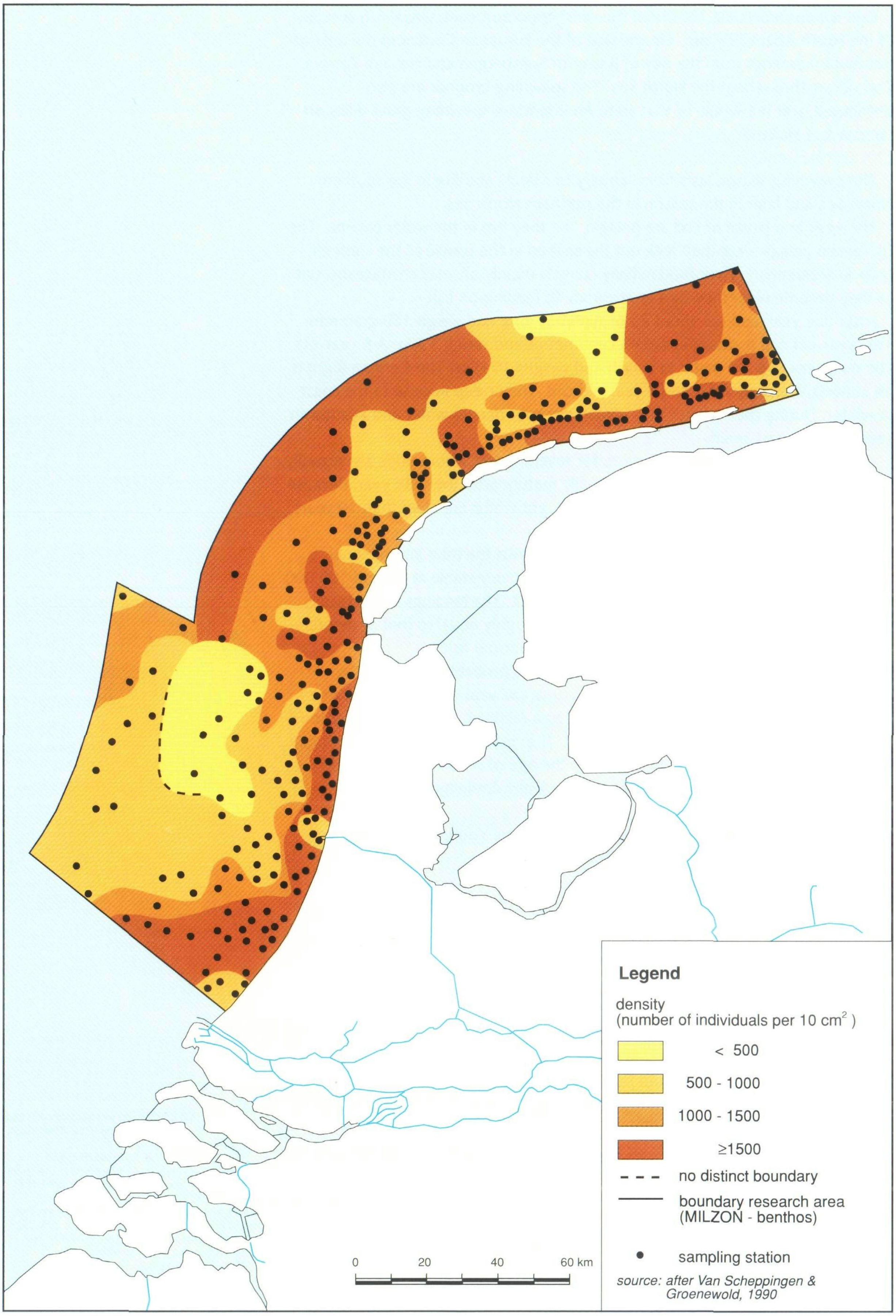
3. A northern offshore zone between 5 and 40 kilometres off the coast north of the Wadden Islands with an average density of about 1100 individuals per 10 cm^2. N/C ratio 101. Average mud content.

The Voordelta (coastal zone of Zeeland) has a rich meiozoobenthos community. The area off the Brouwers Dam and the channels, in particular, score high in numbers of individuals and volume of biomass.

The results have been derived from sampling programmes in the context of the Environmental Zoning project (MILZON-BENTHOS, 1988 and 1989) and the Voordelta project (1987-1989), reworked for the North Sea Atlas by S.A. de Jong (DNZ).

Source:
Craeymeersch, J.A., Hamerlynck, O., Hostens, K., Vanreusel, A., Vincx, M. (1990). De ekologische ontwikkeling van de Voordelta. Deelrapport 1. De huidige ekologische situatie van de Voordelta. Delta Institute for Hydrological Research/University of Gent, p. 1-92
Groenewold, A., van Scheppingen, Y.C.M. (1990). De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Noord-Nederlandse kustzone 1989. V&W/RWS/ DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-01, p. 1-24
Van Scheppingen, Y.C.M., Groenewold, A. (1990): De ruimtelijke verspreiding van het benthos in de zuidelijke Noordzee, de Nederlandse kustzone: overzicht 1988-1989. V&W/RWS/ DNZ&DGW & Stichting ter bevordering van de Nederlandse Oceanografie MILZON report 90-03, p. 1-27.

Small benthic fauna: density in the coastal zone



Distribution of one-year old cod

Cod (*Gadus morhua L.*) is one of the most important commercial fish species of the North Atlantic Ocean. On the side of the European Continent the area of distribution extends from the Bay of Biscay to Spitsbergen and Novaya Zemlya. Cod occurs throughout the North Sea. The spawning grounds are also distributed over the whole of that area. An important spawning ground lies off the coast of Holland.

The spawning season lasts from January to March, starting in the southern North Sea and later in the season in the northern North Sea.

The eggs and larvae of cod are pelagic, i.e.: they live in the water column. The fry remain pelagic until they seek out the seabed in the course of the summer (July to September). Their food initially consists mainly of small crustaceans, but as they become older they turn increasingly to feeding on fish.

After one year, cod are about 25 centimetres long and weigh 160 grammes. Two year-old cod measure about 45 centimetres and weigh 1 kilo. A 6 year-old cod measures about 1 metre in length and weighs 10 kilos. The German Bight is an important nursery for 1 and 2 year-old cod. They creep in close to the coast in winter. During the summer they spread out over deeper water and in autumn seek out the coast again.

Cod do not become sexually mature for several years. About 60% are sexually mature at four years old. 100% are sexually mature after the sixth year. Because of the intensive fishing only a few fish are caught which are older than 10 years.

From the beginning of this century until the 1960s the total international landings of cod from the North Sea remained relatively stable at around 100,000 tons. A peak of 340,000 tons was reached in 1972. The landings have steadily fallen since 1981 to the present level, which is roughly equal to that of before 1960. The catches consist mainly of 1, 2 and 3 year-old fish.

The rapid increase in the catch in the 1960s was probably related to the succession, from 1963, of a series of very numerous year classes. At the same time, fishing mortality also slowly increased to a relatively constant, but far too high, level, that was reached in about 1980. The result of this was that young cod simply did not get the chance to reach the age of sexual maturity. As a result, the spawning population has been gradually declining since 1970.

The data have been derived from the International Young Fish Survey, 1983-1987, and reworked by H.J.L. Heessen (RIVO).

Source.

Daan, N (1978) Changes in cod stocks and cod fisheries in the North Sea Rapp P -v Réun Cons. int Explor Mer, 172 39-57

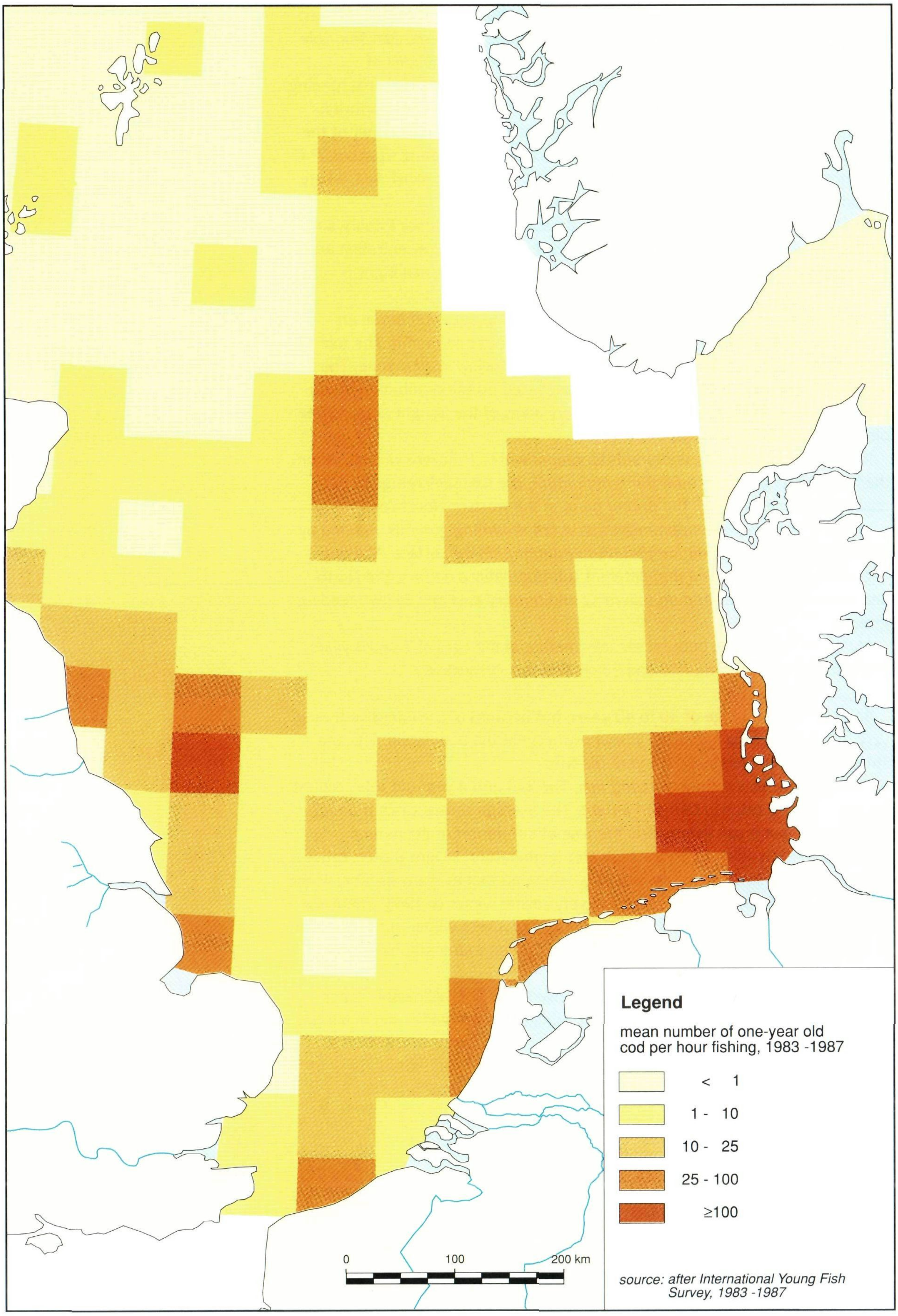
Heessen, H.J L (1983) Distribution and abundance of young cod and whiting in the South-eastern North Sea in the period 1980-1982 ICES C M 1983/G 30

Heessen, H.J L (1990) Visserij In de Wolf, P , (ed) De Noordzee Terra Zutphen, pp 139-152

International Young Fish Survey, 1983-1987 Adapted by H.J.L Heessen (RIVO)

Rijnsdorp, A D , Daan, N , van Beek, F A , Heessen, H.J L (1991) Reproductive variability in North Sea plaice, sole and cod J Cons int Explor Mer, 47 352-375

Distribution of one-year old cod



Distribution of one-year old sole

The area of distribution of sole (*Solea solea*) extends along the Atlantic coast from Africa to Northern Ireland. Sole also occur in the Mediterranean Sea. Sole are generally found in water less than 50 metres in depth. The area of distribution in the North Sea is bounded on the north side by a diagonal running from the English east coast (Flamborough) to the Skagerrak in the northeast. This line corresponds with the division between the cold stratified water of the central and northern North Sea, which has a bottom temperature of about 7° C in summer, and the warm, fully mixed water of the southern North Sea, where the bottom temperature rises to 17° C in summer.

The most important spawning grounds for sole are the Thames Estuary and the coastal zone of the continent south of 55° N. There are concentration areas in the Belgian-Zeeland coastal zone, off Texel and in the German Bight.

The spawning season lasts from March to June. The eggs and larvae are pelagic, i.e.: suspended in the water column, for about one month. The sole fry establish themselves during metamorphosis in the shallow coastal zone. The map shows the most important nursery areas based on the distribution of one year-old sole in the third quarter. The nursery areas of the nought and one year-old sole all lie within 12 miles of the coast.

In autumn, sole migrate westwards to deeper water. In severe winters, when there is a steep fall in the seawater temperature, the sole seek refuge in the relatively warmer water of the deeper parts of the western North Sea.

In spring there is a west-east migration to the spawning grounds, assisted by the tides. The sole can then be observed swimming on the surface. Marking experiments have revealed that different sub-populations occur in the North Sea, each of which has its own spawning and nursery area and its own feeding grounds.

Male and female sole become sexually mature at the ages of 2 and 3 years, when they reach lengths of 18 and 28 centimetres, respectively.

Sole can live to an age of 30 to 40 years, but because of the intensive fishing, very few fish over the age of 15 years now occur in the population. The age structure is dominated by 0 to 4 year-old fish.

The catch consists mainly of young fish. The 2, 3 and 4 year-old sole account for over half the catch in terms of weight. The average annual catch is about 20,000 tons, but it can vary widely because of differences in the natural increase, which is affected by the seawater temperature. Severe winters cause a higher mortality among juvenile sole. It is estimated that as many as 60% of the adult sole died from the cold during the very severe winter of 1963. There is a good chance of a large natural recruitment after a severe winter, however. The highest annual cohort strengths, five times the average strength, have been observed after a cold spring.

Fishing for North Sea sole has been controlled by a Total Allowable Catch since 1975. Technical measures, such as a minimum mesh width and minimum landing dimensions, also apply [95].

Source:

Bannister, R.C A. (1978) Changes in plaice stocks and plaice fisheries in the North Sea. Rapp. P -v. Reún. Cons int. Explor. Mer 172 86-101.

Van Beek, F.A., Rijnsdorp, A.D., de Clerck, R. (1989). Monitoring juvenile stocks of flatfish in the Wadden Sea and the coastal areas of the south-eastern North Sea. Helgolander Meeresunters. 43: 4761-477.

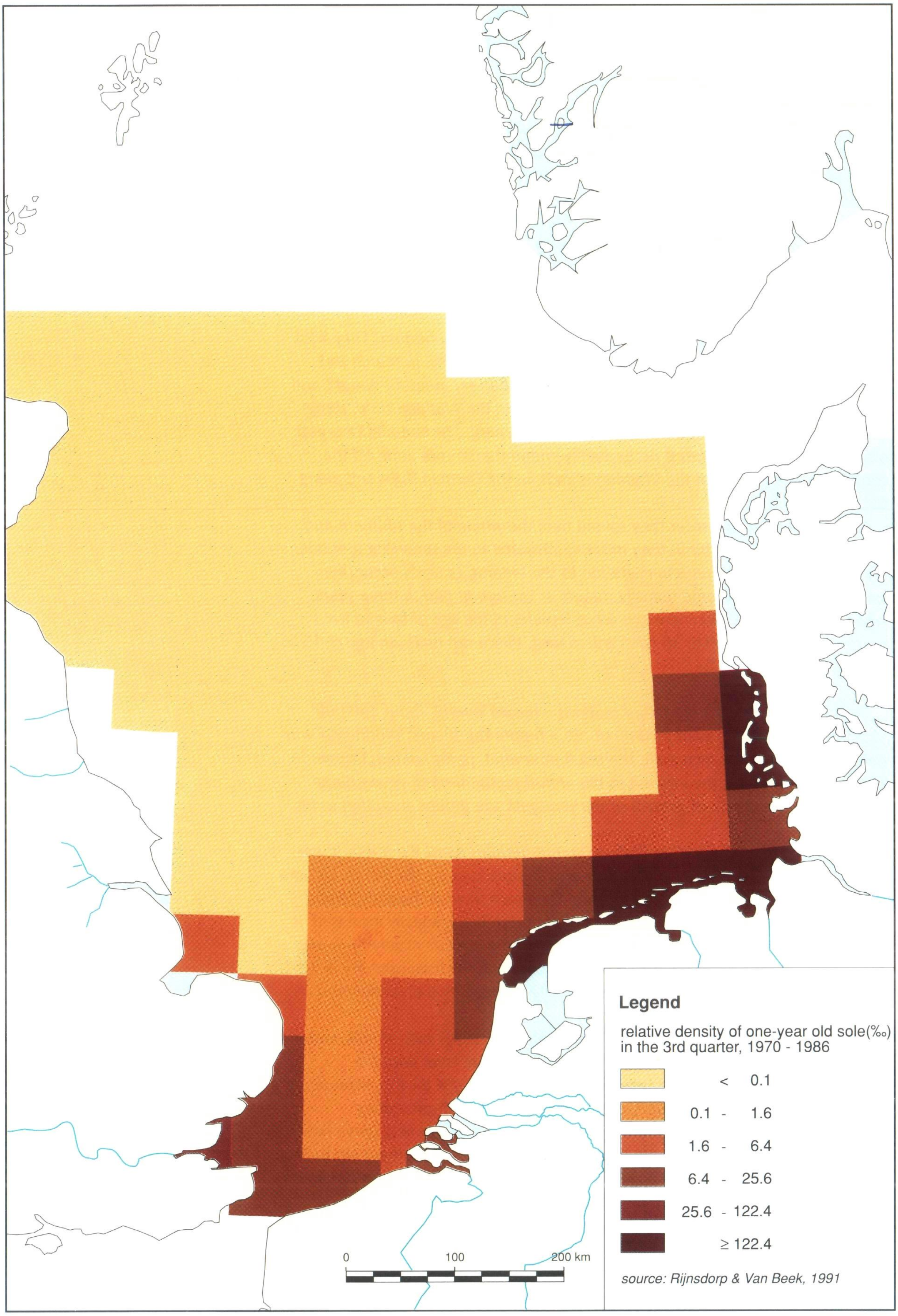
Harding, D., Nichols, J., Tungate, D.S. (1978). The spawning of the plaice, Pleuronectes platessa L. in the southern and English Channel. Rapp. P.-v Réun. Cons. int. Explor Mer 172: 102-113.

Rijnsdorp, A D., van Beek, F.A. (1991). Changes in growth of plaice Pleuronectes platessa L. and sole Solea solea (L.) in the North Sea Neth. J Sea Res. 27: 441-457.

Rijnsdorp, A.D., Daan, N., van Beek, F.A., Heessen, H.J.L (1991). Reproductive variability in North Sea plaice, sole and cod. J. Cons. int. Explor. Mer 47: 352-375.

De Veen, J.F. (1978). Changes in North Sea sole stocks (Solea solea L.) Rapp P -v. Réun. Cons. int Explor. Mer 172: 124-136.

Distribution of one-year old sole



Distribution of one-year old plaice

The area of distribution of the plaice (*Pleuronectes platessa L.*) extends from the Iberian peninsula in the south to Iceland and the Barents Sea in the north. The most important stocks occur in the North Sea, in Faxabay (Iceland) and in the Barents Sea. In the North Sea, plaice live in the southern and central parts up to a maximum depth of 100 metres.

The most important spawning grounds are situated in the southern and southeastern North Sea, including the eastern part of the English Channel at a depth of over 20 metres. There is local spawning along the east coast of England and Scotland.

The spawning period runs from December to late March, with a peak which shifts from early January in the eastern part of the English Channel to mid-February in the German Bight. A plaice can lay several hundreds of thousands of eggs.

Plaice eggs and larvae are pelagic; i.e. independent of the bottom. They float around passively in the sea for a period of about two months. In March and April they enter the estuaries. The most important nursery areas for nought and one year-old plaice (<18 centimetres) are situated in the Wadden zone, along the continental coast from the Netherlands to Denmark. The one and two-year old plaice (18-27 centimetres) occur mainly within the 30-mile zone off the continental coast north of the Wadden Islands, in the German Bight and along the coast of Jutland.

As the plaice become older they spread over the whole of the southern and central North Sea. In autumn they move southwards to the spawning grounds, assisted by the tides. A reverse migration to the feeding grounds occurs in spring. Male plaice become sexually mature at the age of two to three years, when they are 20 to 24 centimetres long; females at the age of four to five years, when they are 30 to 35 centimetres long. Plaice can reach an age of 15 to 25 years.

The plaice catch in the North Sea reached a record level of about 150,000 tons in the 1980s. The average level of catch before the Second World War was only 50,000 tons. This increase is the result of several, partly related, factors. The most important is the increase in the annual recruitment of young plaice. The increase in the rate of growth of the youngest age groups also plays some part.

Plaice fishing has changed radically in recent decades. Until the 1960s it was practised mainly by the United Kingdom and Denmark, using the otter trawl and the Danish seine. Since the introduction of the beam trawl in the early 1960s, the share of the Netherlands in the total plaice catch has gradually increased. It amounted to over 60% in the 1980s. The catch now consists mainly of young fish. The 2, 3 and 4 year-old fish account for over half the total catch by weight. This means that the catch prospects are greatly affected by the variations in annual recruitment.

The size of the latter fluctuates less than with fish species such as sole, cod and haddock. Recruitment has been at a higher average level since the mid-1970s than in the preceding twenty years. The reasons for this increase are not yet known. It may be related to the introduction of fish-protecting processing equipment (rinsing sorting machines) and selective nets (sieve nets) in the shrimp fishery. The change in the hydrography of the southern North Sea may also play a part. The civil engineering works in the Southwest Netherlands may have made the estuaries more accessible to plaice larvae. See the commentary to map 95 for control measures.

Source:

Bannister, R.C.A. (1978). Changes in plaice stocks and plaice fisheries in the North Sea. Rapp. P.-v. Réun. Cons. int. Explor. Mer 172: 86-101.

Van Beek, F.A., Rijnsdorp, A.D., de Clerck, R. (1989). Monitoring juvenile stocks of flatfish in the Wadden Sea and the coastal areas of the south-eastern North Sea. Helgolander Meeresunters.43: 4761-477.

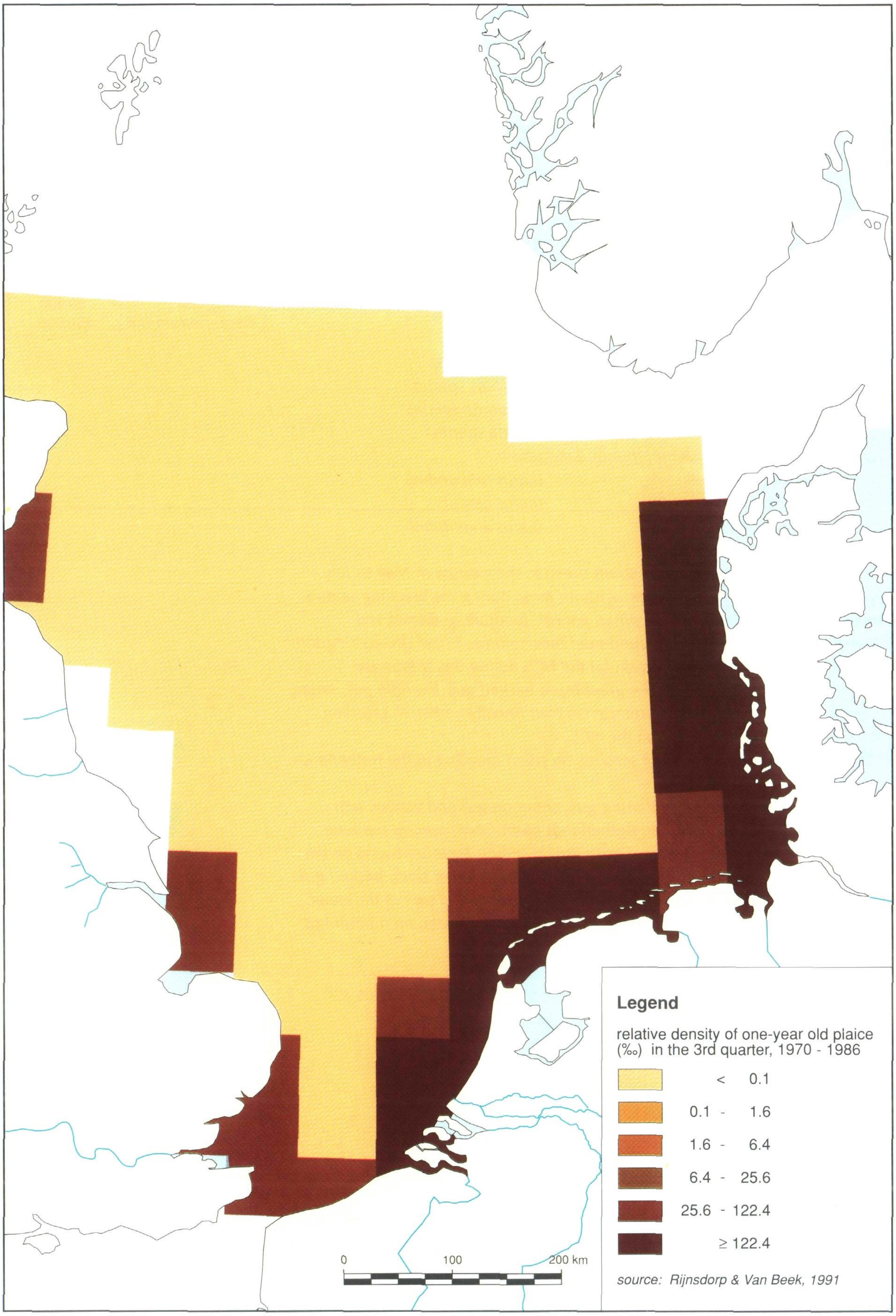
Harding, D., Nichols, J., Tungate, D.S. (1978). The spawning of the plaice, Pleuronectes platessa L. in the southern and English Channel. Rapp. P.-v. Réun. Cons. int. Explor. Mer 172· 102-113.

Rijnsdorp, A.D., van Beek, F.A. (1991). Changes in growth of plaice Pleuronectes platessa L. and sole Solea solea (L.) in the North Sea. Neth. J. Sea Res. 27: 441-457.

Rijnsdorp, A.D., Daan, N., van Beek, F.A., Heessen, H.J.L. (1991). Reproductive variability in North Sea plaice, sole and cod. J. Cons. int. Explor. Mer 47: 352-375.

De Veen, J.F. (1978). Changes in North Sea sole stocks (Solea solea L.) Rapp. P.-v. Réun. Cons. int. Explor. Mer 172: 124-136.

Distribution of one-year old plaice



Seabird species in the breeding season

The seabirds of the Netherlands Continental Shelf (NCS) can be divided generally into four different groups:

Birds of the open sea:	
Fulmar	*(Fulmarus glacialis)*
Gannet	*(Sula bassana)*
Razorbill	*(Alca torda)*
Guillemot	*(Uria* species*)*
Gulls with a seawards distribution:	
Kittiwake	*(Rissa tridactyla)*
Great Black-backed Gull	*(Larus marinus)*
Lesser Black-backed Gull	*(Larus fuscus)*
Skuas	*(Stercorarius* species*)*
Little Gull	*(Larus minutus)*
Coastal species:	
Divers	*(Gavia* species*)*
Grebes	*(Podiceps* species*)*
Seaducks	*(Melanitta* species*)*
Terns	*(Sterna* species*)*
Gulls with a coastal or fishing grounds distribution:	
Black-headed Gull	*(Larus ridibundus)*
Common Gull	*(Larus canus)*
Herring Gull	*(Larus argentatus)*

Depending upon the species, seabirds breed in the months of May to July. There are generally few birds in the offshore areas during the breeding season. The pelagic seabirds such as the fulmar, gannet, razorbill, guillemot and kittiwake are then mainly to be found near their colonies in the United Kingdom and Norway. The birds which remain on the NCS during this season are non-breeding, immature birds. The great black-backed gull, the little gull, skuas, divers, grebes and seaducks also remain on their (mostly northern) breeding grounds and are therefore rare on the NCS.

The table gives the numbers of seabirds (in pairs) breeding in the Netherlands.

The lesser black-backed gull, herring gull, common gull and various tern species breed scattered along the Netherlands coast. Some species are even limited to a few colonies. The most important breeding areas are found on the Wadden Islands and in the Delta region. Terns and the lesser black-backed gull forage mainly in areas of clear water. Other gull species and part of the lesser black-backed gull population feed mainly behind fishing boats, on rubbish tips, in the inter-tidal zone and farther inland.

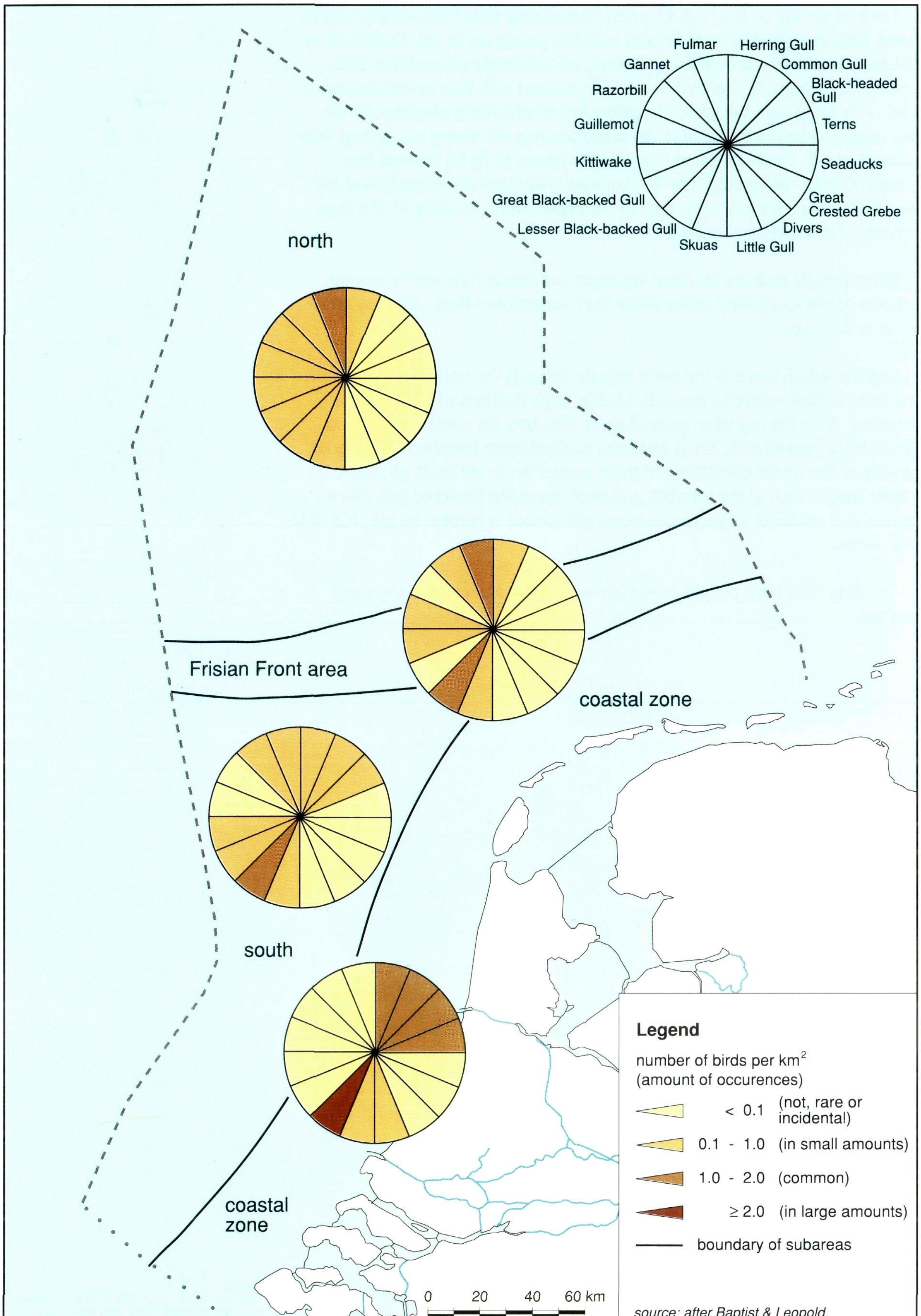
The data have been derived from systematic counts taken from ships and aircraft [9] and from counts taken on land.

The number of seabirds breeding in the Netherlands

species	number of pairs
Little Gull	45
Mediterranean Gull	125
Little Tern	450
Arctic Tern	1500
Sandwich Tern	9000
Common Gull	11.000
Common Tern	19.000
Lesser Black - backed Gull	19.000
Herring Gull	90.000
Black - headed Gull	250.000

Source:
Baptist, H.J.M. (V&W/RWS/DGW), Leopold, M.F. (NIOZ) (1990, 1991): unpublished data.
SOVON and Meininger, P.L.M. (V&W/RWS/DGW): oral information.

Seabird species in the breeding season



source: after Baptist & Leopold, 1990 en 1991

Seabird species in the migration season

The bird density on the NCS is highest immediately after the breeding season, when both the breeding birds (adults) and their young are at sea. Guillemots on the NCS, especially the northern guillemot, are extremely vulnerable at this season (June-August). The birds leave their colonies with their immature young and swim away from the United Kingdom in a southeasterly direction. When this migration begins the adult males accompanying the young are starting their autumn moult. This means that they lose the power to fly for three to four weeks. One to two months after the colonies have been abandoned there are about 10,000 guillemots in the area of the Frisian Front, foraging on the large schools of sprat which abound there.

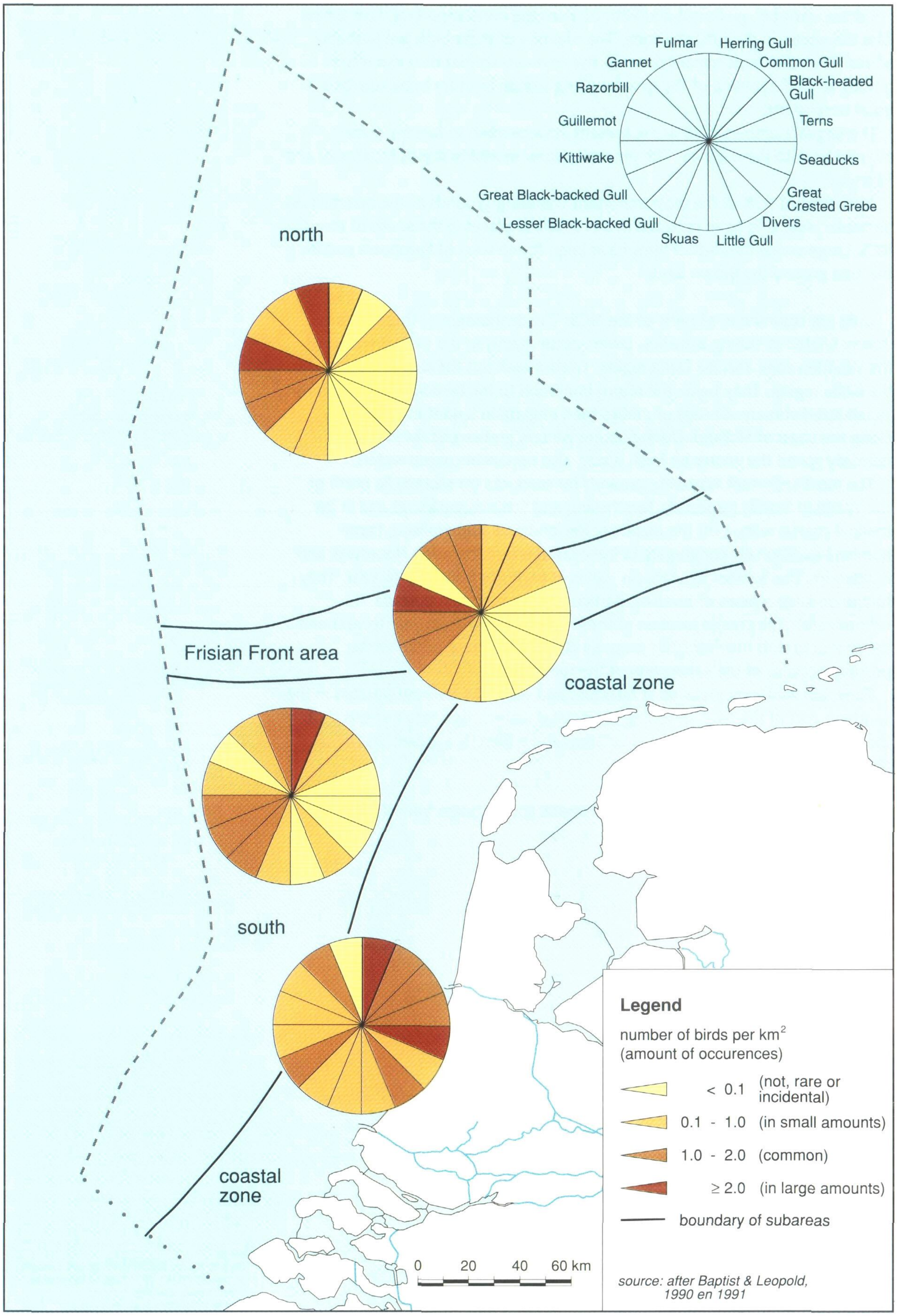
Other pelagic seabirds are more dispersed and concentrate mainly around schools of fish and fishing boats, which they sometimes follow until they are close to the coast.

Seabirds which breed in the north migrate through the North Sea in autumn en route to their wintering grounds. Locally, large numbers of birds may be involved. After the migration peak (August-October) the number of gannets, lesser black-backed gulls, skuas and terns declines again because the centre of gravity of the winter distribution of these species lies in the south of the NCS. Other species such as the razorbill, guillemot, great black-backed gull, divers, grebes and seaducks (or scoters) increase still further in number on the NCS until the winter.

The data have been derived from systematic counts taken from ships and aircraft.

Source:
Baptist, H.J.M. (V&W/RWS/DGW), Leopold, M.F. (NIOZ) (1990, 1991): unpublished data.
SOVON and Meininger, P.L.M. (V&W/RWS/DGW): oral information.

Seabird species in the migration season



Seabird species in winter

Fulmar, razorbill, guillemot and kittiwake are the most important birds which pass the winter in the offshore zone. The majority of these birds are probably adults. The adult birds remain closer to the colonies, so that they can return quickly at the beginning of the new breeding season in order to be sure of a good nesting site.

The largest numbers of birds are present in December; in January some migrate back to the colonies. The greatest winter mortality occurs in January and February.

A southward shift of the most important wintering grounds of the razorbills, in particular, seems to have occurred in the 1980s to places in the south of the NCS. Large concentrations of birds have been found west of Europoort and in the area around the Brown Bank.

Gulls are common in all parts of the NCS. The distribution of these birds is closely related to fishing activities. Divers occur mainly in the coastal waters of the Wadden zone and the Delta region. Grebes seek out the calmer waters of the Delta region. They begin the return migration to the breeding areas as early as January-February. Groups of grebes then migrate in a northerly direction along the coast of Holland. During severe winters grebes and ducks, which normally spend the winter on fresh water, also remain in coastal waters.

The most important wintering grounds for seaducks (or scoters) lie north of the Wadden Islands (especially Terschelling and Schiermonnikoog) and in the shallow coastal waters off the islands of Zeeland and Zuid-Holland. Large numbers occasionally congregate in the coastal waters between Noordwijk and Zandvoort. The number of seaducks varies at each site from year to year. They forage on large masses of bivalves, particularly the surf clam (*Spisula subtruncata*). The precise location of these masses varies from year to year and the seaducks shift their foraging grounds during the course of the winter, possibly because of the exhaustion of the food source.

The main wintering grounds of razorbills and seaducks are now situated in the southern part of the NCS, including the coastal waters. As a result of this shift the birds are now overwintering in an area where there is a greater risk of oil pollution.

The data have been derived from systematic counts taken from ships and aircraft.

Source:
Baptist, H.J.M. (V&W/RWS/DGW), Leopold, M.F. (NIOZ) (1990, 1991): unpublished data.
SOVON and. Meininger, P.L.M. (V&W/RWS/DGW): oral information