COOPERATIVE RESEARCH REPORT

Series A, No.15

REPORT OF THE ICES WORKING GROUP

on

OF THE BALTIC SEA

https://doi.org/10.17895/ices.pub.8118

ISBN 978-87-7482-736-8

ISSN 2707-7144

International Council for the Exploration of the Sea
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Denmark

February 1970

FOREWORD

The pollution conditions of the Baltic Sea have been much discussed during the last years. However, there has been a lack of virtual information of the conditions as a whole. Therefore the International Council for the Exploration of the Sea decided in 1968 to establish a Working Group on Pollution of the Baltic, with the aim to survey the present situation. The survey, presented in this paper, has been made in close co-operation by representatives from all countries around the Baltic.

Care has been taken to ensure, as far as possible, the accuracy of the data given, but final responsibility rests upon the national sources from which they have been derived.

I wish to convey to my Colleagues in the Working Group my great appreciation for all the work they have laid down to provide suitable information for the Report.

Bernt I. Dybern
Chairman of the Working Group

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INTRODUCTION

In 1967 the International Council for the Exploration of the Sea established a Working Group within the Fisheries Improvement Committee "for the purpose of assembling data regarding substances harmful or potentially harmful to fisheries being discharged or likely to be discharged into the North Sea and adjacent seas". The Working Group presented its report to the 1968 ICES Statutory Meeting in Copenhagen (paper C.M.1968/E:5). In 1969 the report was published by the Council as a Cooperative Research Report (Series A, No. 13).

At the 1968 Statutory Meeting the following resolution was passed:

> "in view of the need for basic factual information on pollution in all areas, a Working Group be established in association between the Fisheries Improvement Committee and the Hydrography Committee to consider the situation in the Baltic with terms of reference similar to those of the Working Group on the Pollution of the North Sea, with a view to presenting a report at the 1969 Statutory Meeting" (C. Res. 1968/2:9).

The Working Group on Pollution of the Baltic Sea thus established held its first meeting in Copenhagen on 10-12 February 1969 when the following representatives attended:

Mr. J. Boëtius	Denmark
Prof. Dr. H. Mann	Federal Republic of Germany
Dr. G. Weichart	Federal Republic of Germany
Dr. A. Voipio	Finland
Mr. J. Rybiński	Poland
Mr. F. Jastrzebski	Poland
Mr. B.I. Dybern	Sweden
Dr. S.H. Fonselius	Sweden

The "Conference of Baltic Oceanographers" was invited to take part in the discussions and, through them, Mr. K.-H. Rohde, Rostock, gave by correspondence some information from Eastern Germany.

Information was given by the representatives concerning their respective countries as to the following items:

Legislation controlling water pollution.
The hydrographic conditions of the Baltic.
Pollution by sewage.
Industrial pollution.
Pollution by pesticides etc.
Pollution by oil, oil-derivates and certain detergents.
Warm water pollution.

Other kinds of pollution, e.g. pollution from ships and from the air.
Radioactive pollution (only briefly).
Research work being carried out.

A second meeting of the Working Group was held in Helsinki on 3-5 June 1969, and was attended by the following experts:

Mr. J. Boëtius	Denmark
Mr. L. Andrén	F.A.O.
Prof., Dr. H. Mann	Federal Republic of Germany
Dr. G. Weichart	Federal Republic of Germany
Dr. P. Bagge	Finland
Dr. A. Voipio	Finland
Mr. B.I. Dybern	Sweden
Dr. S.H. Fonselius	Sweden
Dr. A. Aitsam	U.S.S.R.
Mr. K.-H. Rohde	representing "Conference of Baltic Oceanographers"

Mr. L. Andrén acted as an observer for FAO.

At this meeting the draft report from the first meeting was discussed and completed and the outlines for the final report were laid down.

THE SEA AREA CONCERNED

The Baltic Sea area includes the Baltic proper, stretching eastwards from the sill of Darss, the Bights of Mecklenburg and Kiel, the Gulf of Finland, the Bothnian Sea and the Bothnian Bay (Figure 1).

Due to the importance of conditions in the Öresund, the Danish Belt Sea and the Kattegat to the Baltic area, it was agreed to consider also these areas.

SUMMARY OF LEGISLATION CONTROLLING WATER POLLUTION

Denmark

Pollution of rivers, lakes and marine waters is governed by the Watercourse Act of 11 April 1949 and subsequent amendments to this Act in 1963, and an ordinance of 1945 concerning measures for purifying watercourses. Under this Act no material such as earth, sand, stones, etc. may be deposited so near a watercourse that a risk of their being washed into it arises. This also applies to

solids or liquids, such as pesticides, which may pollute the water. Section 5 of the Act states that waste waters from towns and factories must not be discharged into a watercourse, including the sea, in such a way that "considerable pollution" arises. The decision as to what constitutes "considerable pollution" is left to the Water Courts.

The Water Courts are constituted on a local basis and there are about one hundred of them. Each case of pollution is considered separately by the Water Court concerned and the various interests involved are taken into consideration. Experts may be called if the Court feels this to be necessary but the Water Court must in any event notify the Ministry of Fisheries of the case. After considering all the facts the Court can impose limits if they feel this to be necessary. The decision of the Water Court is open to appeal but in practice this course is rarely taken.

The costs of a pollution investigation ordered by a Water Court are usually imposed on the industry or community in question. The fishery expert, however, is paid by the State (Ministry of Fisheries).

In general all sewage and other waste waters should be treated prior to discharge to the sea. In the case of fjords and other such waters the Ministry of Agriculture, after consulting the Ministry of Fisheries and the Ministry of the Interior, may prohibit the discharge of untreated or insufficiently treated wastes. Responsibility for the supervision of the provisions concerning effluent quality rests with the Police and Fishery Control, whereas supervision of the watercourses is by the Ministry of Agriculture. Failure to comply with the provisions of the Watercourse Act, or rulings by the Ministry of Agriculture or Water Courts is punishable by fines.

There is no control of dumping of wastes outside territorial waters, but up to the present no such disposals of wastes are known to have occurred. There have been a few proposals and these are now being considered by the Ministry of Fisheries which, however, can only advise. Denmark has ratified the London Oil Pollution Convention.

Federal Republic of Germany

The Federal Republic of Germany passed a law in 1957 (Bundesgesetzblatt 1957, Part I, p. 1110) controlling the pollution of inland waterways. This was modified on 15 August 1967 (Bundesgesetzblatt 1967, Part I, p. 909) so as to bring coastal waters under the

same legislation. The section relating to pollution of coastal waters became operative on 1 January 1968. Under the new law it is only possible to discharge solids or liquids into coastal waters with the permission of the authorities. If there is any likelihood of dangerous effects the authorities can withhold their permission or impose certain conditions. The authorities have the additional right to withdraw or modify their consent if damage becomes apparent at a later date. It is forbidden to store dangerous materials near waterways in such a way that the waters may become contaminated. Failure to comply with these regulations means that the person or persons responsible for the pollution may be liable to heavy penalties. There are rules and regulations to the Federal Water Law (Bundesgesetzblatt 1957) which apply in the various States of the Federal Republic (Wassergesetze der Länder).

The rules relating to pollution of coastal waters only apply to territorial waters. Disposal of waste - except oil - beyond this zone is not controlled by law but in practice anybody wishing to dump waste in the open sea asks the Ministry of Transport for permission. The Ministry of Transport may then consult the German Hydrographic Institute (Deutsches Hydrographisches Institut, Hamburg (D.H.I.)), the Federal Research Board for Hydrology (Bundesanstalt für Gewässerkunde, Koblenz), the Federal Research Board for Fisheries (Bundesforschungsanstalt für Fischerei, Hamburg) and the Biological Station Helgoland (Biologische Anstalt Helgoland, Hamburg). Each proposal is considered according to a standard set of criteria, e.g. is it possible to treat the material on land and where is a suitable area for disposal at sea? If the material is to be disposed of at sea, it is given a danger classification and must be disposed of accordingly (Weichart, 1968). The legal basis for this procedure will be created within the scope of the law of approval (Zustimmungsgesetz) to the Agreement on the High Sea (Article 25), which will shortly be forwarded to the legislative bodies.

Coastal pollution investigations are mainly carried out and paid for by Federal or State authorities or institutes.

The Federal Republic has ratified the London Oil Pollution Convention. The country takes part in the international preparatory work for the creation of an agreement on the liability for tanker accidents.

Finland

The present Water Law, which came into force on April 1st, 1962, and which replaced the previous, 60-year-old legislation on the subject, is very extensive with more than 500 paragraphs. Three separate Decrees have been given by virtue of this law.

The Water Law controls the utilization of river and lake systems and the territorial waters, for various purposes, such as drawing of water, building of hydroelectric plants, regulations of basins, etc. It also contains provisions concerning implementation of this control, and procedure in water disputes. The Water Law includes a general prohibition against pollution of these basins, which applies to industry as well as to anybody else who discharges polluting waste water into a watercourse or a sea area. According to this provision, nobody is allowed, without permission from a Water Court, to take any measures which may cause pollution of a sea area. The following measures are not permissible: discharging of dirt, waste, liquid, gas, bark of timber or other similar substances into a water basin in such a way that causes, either immediately or in the course of prolonged practice, detrimental decrease of depth of water, harmful change in quality of the water, obvious damage to the fish population, considerable diminution in amenities of the surroundings, health risk, or some other comparable violation of a private or public interest.

Anyone who wants to get permission for a measure which is forbidden by the general prohibition against pollution of water shall apply to the Water Court. To the application shall be appended necessary plans and expositions, as specified in a Decree.

The Decree concerning preliminary measures relating to water pollution control prescribes that notice shall be given to the Water Authorities in good time and in any event not later than three months before starting the discharge of wastes. The notice shall be accompanied by a plan for discharge and treatment of the waste water, together with such explanatory remarks as may be necessary.

The above-mentioned notice is further passed to the Bureau for Water Conservation, which has to examine it together with the attached plan. In case the Bureau considers that the discharge of effluents will cause water pollution, it shall ask the notifying party to alter the plan where necessary or, as far as such discharge of waste water is concerned for which permission may be granted, to apply for appropriate permission for the measure in the order

prescribed by law.

The general condition for granting permission to undertake a measure causing pollution is, that the activity must not endanger public health or cause considerable and widespread detrimental changes in the environment or greatly impair the housing or trade conditions of the region.

Otherwise, the granting of permission implies that the detriment caused by the measure can be considered comparatively minor as viewed against the benefit derived from it and that disposal of waste water or of any other substance which pollutes the sea area is not possible by any other means at reasonable cost.

When granting a permission the Water Court also indicates which technical and other measures, including the monitoring of the effects of waste water discharges, must be taken to reduce the damage. Any damage, detriment or other loss of benefit caused by the measure shall be indemnified.

Anyone who gets a permission to discharge waste water may be charged to pay a special "water protection payment" to the Government. The sum mostly amounts to two per cent of the savings gained, e.g. when, in one way or other, he is exempted from the obligation to take certain measures to prevent pollution of a water area. The funds thus collected are to be used to compensate for the governmental expenses caused by the water protection activity, especially research works, or, in some cases, by the measures to preserve fish populations.

The regulations provided together with a permission may be changed at a later date or the permission may be withdrawn in case considerable pollution in the water area is caused in spite of the protective measures.

Special rules are given for protection of natural waters against radioactive pollution.

Finland has ratified the London Oil Pollution Convention. According to a law of 5 March 1965 the open sea must not be damaged by wastes from the Finnish territory or from Finnish ships.

Eastern Germany

According to Article 15 of the Constitution (6 April 1968) the appropriate State authorities (and with that the individual citizens) have to guarantee the purity of air and natural waters.

The Water Law of 1963 (Gesetzblatt der DDR I, Nr. 5, 1963) states that conveying and treatment of waste waters is a main water management task, in order to protect the natural water resources. Coastal waters are brought under the same rule according to the first regulation to the Water Law (GBL. II, Nr. 43, 1963).

The supreme authority for water control is the State Office of Water Management, subordinated to the Government. This Office, local Water Management Boards and Waterway Authorities control all kinds of utilization of the waters. The Water Law prescribes that at all new constructions precautions must be made in such a way that water pollution is avoided, and the State Office of Water Management has stipulated the highest permitted concentrations of different substances. If the quantity or general character of the natural water must be changed, this is only allowed after special permission. Breach of the rules is punished.

According to legislative rules of 19 February 1969 (GBL. III, Nr. 3, 1969) the appropriate authorities are responsible for the riskless use of all natural resources. Measures to keep waters and the air clean or to purify them shall systematically be taken. These rules strengthen the intentions of the Water Law.

Other legislative rules regulate the use of waters from the hygienic point of view, the controlling power ultimately being exercised by the Ministry of Health.

The State Office of Radiation Protection controls the radioactive contamination of air, rain and surface waters according to special rules of 10 June 1964 (GBL. II, Nr. 76, 1964).

Oil pollution is controlled by the Water Management Boards. Persons responsible for oil pollution accidents are punished (GBL. II, Nr. 21, 1969). Eastern Germany has not signed the London Oil Pollution Convention, but according to instructions of the State Board of Navigation, in 1962, it is prohibited to discharge oil into the sea, in accordance with the rules of the Convention.

All rules are applicable also to the coastal waters inside the territorial border. There is no legislation as to international waters.

Poland

Water management is considered an integral part of the country's economy and the subject of central planning.

The current Water Law is from 1962 and contains rules for all kinds of utilization of the natural water resources. It also gives rules for water pollution control. A governmetal decree of 1962 gives detailed regulations concerning the desired quality of the natural waters, for instance, after waste water discharges. Breach of the provisions is punished.

The rules of the Water Law are also in force concerning the coastal waters inside the territorial border. Some special provisions against pollution are included in the regulations of the bigger ports.

To provide an efficient water pollution control a Central Water Resources Administration was founded in 1960. It surveys all water management. A special department is the State Inspection for Water Pollution Control, closely co-operating with Water Resources Departments linked to the National Councils of most provinces. In important areas such Departments are also established at the district level. All Departments co-operate with laboratories for water and waste water analyses.

As a whole, the water pollution control has hitherto been effectuated mainly concerning inland waters but is now becoming extende to the coastal waters. This is especially true of the hygienic control of the water quality.

Poland has ratified the London Oil Pollution Convention.

Sweden

A new Law of Protection against activities which may damage the natural or human environment came into force on 1 July 1969. This law implies, among other things, general legislation concerning most kinds of discharges into the air and natural waters and several other activities which may bring about negative changes to these media. The law is applicable to both existing and future establishments.

As to the inland and coastal waters the law states that wastes must not be discharged in such a way that "considerable inconvenience is caused". This means for most communities and industries at least some form of waste water treatment and in many cases the erection of big and expensive treatment plants.

The observance of the law is exercised mainly by the National Nature Conservancy Office in collaboration with other State authorities and the County Government Boards. The Office also works

out standard values for permitted concentrations of different waste substances.

All more important water pollution questions are submitted to a State Concession Office which decides the quantities and concentrations of wastes, the discharge of which may be permitted in the sense of the law. Questions of minor importance are treated by the National Nature Conservancy Office or by regional Nature Conservancy Councils of the County Government Boards. In all relevant cases water pollution and air pollution are considered together.

The old Water Law (1918, with later alterations) is valid for pollution cases which have been brought to procedure under the provisions of this law (decisions by special Water Courts).

Breach of the rules of the law will be punished.

Sweden has ratified the London Oil Pollution Convention.

U.S.S.R.

The first legislative act concerning water pollution protection was passed by the People's Commissariat of Health in 1923, since when it has been complemented and changed many times.

The water pollution laws in force nowadays are based on the Enactment of the Council of Ministers of the U.S.S.R. of 22 April 1960 (No. 425: "About the control of the use of and the protection of the water resources of the U.S.S.R."). According to this Enactment the water pollution control is exercised by the Boards of Water Resources Exploitation and Protection, of the Ministries of Land Improvement and Water Economy of the different Republics, together with official sanitary, shipping, fishery, municipal and agriculture inspection authorities.

To use natural waters and discharge wastes into them it is necessary to obtain permission from the Board of Water Resources Exploitation and Protection - and also from fishery and public health inspection authorities. Such permission includes stipulations of what is required as to waste treatment. Thus, for instance, a new factory must not begin operation without a waste water treatment plant. In case the requirements should not be observed by the water user the Board can, if necessary, withdraw permission.

The Enactment No. 425 also states that standard values for water quality shall be worked out by the Ministry of Public Health. At present the Ministry has passed two laws concerning water pollution:

one for inland waters (Regulation No. 372-61) and the other for coastal waters (Regulation No. 483-64). Both laws regulate the wat quality characteristics in relation to the use of the water and gi the highest permitted limits for more than 100 toxic substances.

Water pollution investigations are mainly ordered and paid by the State but local pollution investigations might be ordered and paid by communities or industries.

The U.S.S.R. has not signed the London Oil Pollution Convention but according to the above-mentioned Regulation No. 483-64 it is prohibited to discharge oil into the sea nearer than 50 miles from the coast.

A new, more extensive, water law, referring to both inland and coastal waters will be passed in the near future.

General

All countries have laws against water pollution, the controllin power being exercised by special national or regional authorities. The degree of control varies from country to country but, as a rule the general trend is to protect the waters from being too seriously damaged according to the purposes for which they are used.

The laws refer also to coastal territorial waters, the U.S.S.R. having special regulations protecting these, but at present the controlling power is generally considerably weaker than for the inland waters. In most cases there is no or only primary treatment of sewage and industrial wastes discharged into the sea. However, in all countries there is a trend to strengthen the control of coastal pollution.

According to the new Swedish law, water pollution must in the future be considered together with any other kind of pollution, e.g. air pollution. Similar regulations have also been discussed in some other countries.

Dumping of wastes from ships, except dumping of mud from harbours and treatment plants, etc., is not allowed or at least not recommended within the territorial borders of any of the countries.

Discharge of wastes harmful to the open sea is prohibited from Finnish territory or Finnish ships in accordance with the 1958 Geneva Convention (approved by the U.N. Conference of the Law of the Sea). This Convention will probably be ratified by Denmark and the Federal Republic of Germany in the near future. In the last-

mentioned country discharges outside the territorial border are the subject of voluntary control.

All countries but two, Eastern Germany and the U.S.S.R., have ratified the London Oil Pollution Convention. The U.S.S.R., however, has some special rules for avoiding oil pollution within 50 miles of the coast, and Eastern Germany, in practice, uses rules similar to those of the Convention.

ON THE HYDROGRAPHIC CONDITIONS OF THE BALTIC

The following account is based mainly on works by Hela (1960), Voipio (1968) and Fonselius (1969).

The Baltic Sea (Figure 1) is separated from the North Sea, or more exactly from the Kattegat area, by very shallow sills. The maximum sill depth is 17-18 m and the cross sections of the inlets are: the Sound 80 000 m^2, the Great Belt 225 000 m^2 and the Little Belt 16 000 m^2. Therefore the fjord character of the Baltic Sea is very pronounced. Because of the positive water balance the vertical circulation has an estuarine character as well.

The amount of fresh water annually flowing into the Baltic, i.e., the runoff and precipitation, largely exceeds the annual amount of evaporated water

Runoff	+	Precipitation	+	Inflow	=	Evaporation	+	Outflow
470 km^3		200 km^3		430 km^3		180 km^3		920 km^3

Owing to this excess of fresh water the outflow is about twice the amount of the inflowing more saline water. However, the tide is here extremely weak as a result of the complicated sound system that separates the Baltic from the North Sea. The Kattegat area is mainly very shallow with a mean depth of about 25 m. The volume of the Kattegat is some 580 km^3. The volumes of the different basins in the Baltic Sea are given in Table I (p. 53). Keeping in mind that the total volume of the Baltic is about 20 000 km^3, we arrive at a "residence time" of about 21 years for the Baltic water.

In Figures 2-4 (p.56 ff) are shown bottom profiles and temperature, salinity and oxygen conditions in the Baltic proper, the Bothnian Sea and the Bothnian Gulf. The values were obtained during cruises with the Finnish research ship "Aranda" in July 1959 and June-July 1960, and they show rather typical summer conditions.

The coast line of the Baltic is extremely varying. In the southern parts of the Baltic it is often very simple while there are, especially in the northern parts of the Baltic proper, several widespread archipelagos. In the sea areas between the islands and in the semi-enclosed embayments, often with shallow sills, the exchange of water with the open sea may be relatively small.

In the Baltic proper the less saline water layer extends from the surface to the depth of about 50-70 metres. At this depth there is a sharp salinity discontinuity layer, which exists the whole year round and is called the permanent halocline. This halocline is an impediment to the exchange between the deep water and the surface water. There occurs, however, a slow mixing through the halocline giving the surface water a certain salinity.

The general circulation of the Baltic surface water is counter-clockwise but the actual currents are mainly governed by wind conditions.

During recent decades the oxygen content of the Baltic deep water has decreased. Figure 5 shows this decrease of dissolved oxygen for a characteristic station (F 74) in the northern part of the Baltic proper. Figure 6 shows the mean values for dissolved oxygen below the halocline at station F 78. This station is the Landsort Deep, the deepest spot in the Baltic (459 m), which is separated from the northern central basin by a 138 m deep sill. The latest measurements, in November 1968 and January 1969, show that H_2S has now - for the first time - appeared in the Landsort Deep. If this development continues in the Baltic deep water, the whole water mass below the halocline will probably turn into a lifeless "oceanic desert" such as is found in the Black Sea.

The Gulf of Finland is not separated from the central basin by any sills, and it may be regarded as a part of it. A decrease of oxygen has been recorded there too.

There are no deep stations west of Gotland with a long record of oxygen measurements, but at present the conditions are just as bad there as north of Gotland and there is no reason to believe that the development has been different in that area. H_2S has been found there on several occasions.

The Gulf of Bothnia is separated from the Baltic proper by a sill with a sill-depth of approximately 45 m, but there are indications of the existence of a narrow 70 m passage to the Åland Sea. Because the halocline in the Baltic proper is located at around 60 m

depth, there may be a small supply of Baltic deep water to the Åland basin. The oxygen supply has decreased slightly in the deep water of the Åland sea.

The Bothnian Sea has always been regarded as a sea with a very good yearly aeration due to convection during the winter. Figure 7 shows the oxygen values at station F 24 in the Bothnian Sea. The values are from 175-200 m depth, plotted in same manner as in the previous figures.

Here we also get a decrease of the oxygen values in the deep water from 1900 to 1961. F 24 is located near Ulvön at the Swedish coast. It is known to be the deepest spot of the Bothnian Sea. The aeration of the deep water does not seem to be as good there at present as it was in the beginning of the century. Another possibility may be that the consumption of oxygen in the deep water has increased during this time due to industrial wastes. No such effect can be detected in the Bothnian Bay owing to the good convection every winter.

It is a well established fact that the salinity of the Baltic water has increased since the beginning of the 20th century. This increase has occurred both in the surface water and in the deep water. It may best be followed in the deep water where the annual variations of the river water discharge will not cause direct and rapid fluctuations of the salinity. Figure 8 shows the salinity fluctuations in the Gotland basin at station F 81 from the beginning of the century until 1968. From the figure we can see a decrease in salinity during the 1930's. This decrease occurred both in the surface water and the deep water. During 1938-39 an inflow of more saline water into the bottom layers began. This process has probably continued, though fluctuating, until the present time.

The isohaline for 8 ‰ is often considered to be the upper limit for the halocline. From Figure 8 it can be seen that the increased salinity of the deep water has forced the halocline to rise. This salinity increase, observed in all parts of the Baltic, will cause an increased stability of the halocline. The result of this increased stability will be that the exchange of oxygen through the halocline will decrease in all parts of the Baltic and that the winter convection in the Gulf of Bothnia will not as easily as before reach the deepest parts of the basin.

The nutrient content of Baltic surface waters is rather low when compared to the concentrations found, e.g., in the waters of the

North Sea. The phosphate-phosphorus concentration of the Baltic surface waters usually varies from about 0.1 to 0.5 µg-at/l. Analyses of inorganic phosphorus were carried out in the Baltic already during the 1930's. Unfortunately very few values have been published. Figure 9 shows the mean values for phosphate from 100, 200, 300 and 400 m depths in the Landsort Deep from 1954 to 1967. One value from 1938 is included. As can be seen the phosphate has increased continuously during this time from about 1 µg-at/l to nearly 3 µg-at/l. This means that the phosphate concentration is now three times higher than it was 15 years ago. Other stations show the same trend. Present estimates give about 300 000 to 400 000 tons of P in the deep water of the Baltic proper.

A rough estimation of the amount of oxygen at present dissolved in the deep water of the Baltic proper, can be made. The volume of the central basin below the halocline is some 3500 km^3. If we assume that the water there, on an average, contains 0.5 ml oxygen/l, we will get a total of 2.5×10^6 tons. We can assume that normally during longer periods the oxygen which has been brought into the deep water, has generally balanced the oxygen consumption there. Otherwise, the deep water of the Baltic would have lost its oxygen long ago. The reasons for the now observed decrease of the oxygen concentration in the water may be (1) a decrease of the oxygen supply with the inflowing water through the Belts, (2) an increase of the stability of the permanent halocline, (3) an increase of the primary production in the surface layers intensified by increased "fertilisation" which increase the amount of dead organic matter in the deep water, (4) a direct supply of organic matter brought into the deep water from disposal of sewage and wastes from communities and industries.

It is not easy to predict how the conditions in the Baltic will develop in the future. We do not know enough about the fundamental processes regulating the oxygen supply to the deep water and the effects of waste disposal into the Baltic.

SEWAGE POLLUTION

For each country estimations have been made of the organic load of directly and indirectly (by rivers etc.) discharged sewage, expressed as BOD_5 and phosphorus content.

BOD_5 figures, as a rule, give only part of the real organic load carried by waste waters and the value of BOD_5 estimations have many times been discussed in the literature. Nevertheless they are considered to give a hint of the pollution load of a recipient.

The BOD_5 figures have been calculated from the basic assumption that the organic load of discharged sewage is equivalent to about 25 kg O_2 per person and year. The phosphorus content has been calculated from the basic assumption that the discharge is equivalent to 1 kg per person and year. The phosphorus figures may also include some industrial phosphorus, which is, however, only a minor part of the total sum.

The calculated BOD_5 and phosphorus figures have in many cases been "corrected" in relation to the degree of sewage treatment or other local circumstances known to be important for the estimations.

It is stressed that the figures are approximations. This is especially true of those which refer to indirect discharge. The basis of calculations has also varied somewhat among the members of the Group. After having discussed the difficulties in expressing pollution conditions in more exact ways, the members, however, decided to put the figures into the report.

Denmark

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Baltic proper	0.060	0.020	1 500	500	60	20
Belt Sea	0.800	1.300	30 000	13 000	800	1 300
Öresund	1.400	0.200	35 000	2 000	1 400	200
Kattegat	0.100	0.200	4 000	2 000	100	200

Treatment plants for primary or biological treatment are, as a rule, situated inside the coastal areas. The figures for indirect BOD_5 are rather low due to treatment and supposed biological self-purification in the slowly floating rivers.

Copenhagen and some other towns lead out sewage through short pipelines.

The Öresund, the northern part of the Little Belt, most fjords

and some other areas are more or less influenced by sewage pollution.

There is a slow improvement of the sewage pollution situation in Danish waters by construction of new treatment plants.

Federal Republic of Germany

Area	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Belt Sea	0.350	0.900	9 000	0	400	1 100

The directly discharged sewage is generally not or only primarily treated. Most of the untreated sewage is discharged through a pipeline at Bülk, near Kiel. The indirectly discharged sewage undergoes, as a rule, different degrees of treatment. To keep the coastal waters as clean as possible with regard to tourism the indirect discharges are made into inland waters, where they are depleted of oxygen-demanding substances before they enter the sea.

The narrow inlets to Flensburg, Schleswig and Lübeck and a small area outside Bülk are somewhat influenced by sewage pollution. Increased treatment of directly discharged sewage is expected to improve the conditions.

Finland

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Bothnian Bay	0.140	0.100	3 500	3 000	160	120
Bothnian Sea	0.310	0.350	7 750	9 000	400	400
Gulf of Finland	0.578	0.550	14 450	13 000	750	720

The BOD_5 of sewage water is small compared with that of the industrial discharges. Most of the sewage is untreated or undergoes only primary treatment.

Disturbances in the marine environment due to sewage pollution are generally considered to be of minor importance, except outside the biggest cities and towns. In the archipelago off Helsinki, where an extensive investigation is being made, a considerable influence of sewage water on the flora and fauna has been demonstrated.

No pipelines are as yet carrying out sewage into the sea but prospecting is being made for the discharge of sewage from Helsinki through one (after biological treatment).

Eastern Germany

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Baltic proper	0.070	0.410	1 700	8 000	70	400
Belt Sea	0.045	0.400	1 100	8 000	40	410

About half the sewage is untreated and the rest primary treated. The summer tourism is very comprehensive and influences the coastal waters to some degree.

The water renewal outside the coast is good but some local areas are, to a certain degree, influenced by sewage pollution, viz. outside Rostock, Stralsund and Wismar.

There are no pipelines leading sewage out into the sea.

Poland

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Baltic proper	0.750	0.400	6 200	3 600	750	400

Most sewage is untreated. The water exchange along the open Polish coast is good and sewage pollution is considered to be restricted. Some local influence is known from the areas of Szczecin and Gdynia - Gdańsk.

No pipelines exist. Because of the importance of the coastal area for tourism it is intended to build more treatment plants.

Sweden

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Bothnian Bay	0.090	0.067	2 100	1 500	130	100
Bothnian Sea	0.255	0.145	5 900	3 200	380	200
Baltic proper	1.125	0.700	18 500	4 500	1 700	1 000
Öresund	0.370	0.110	5 600	600	560	150
Kattegat	0.525	0.160	12 000	3 000	790	200

As a whole, the BOD_5 sum is much smaller than for industrial discharges. The phosphorus values are high, mainly due to the extensive use of synthetic washing powders.

The following table shows the number of inhabitants giving rise to sewage directly or indirectly discharged into the sea, and the percentage of the inhabitants connected to primary treatment plants with both primary and biological treatment. The calculations are made from the "Statistics of municipal water and treatment plants" for 1966.

Area	Direct discharge			Indirect discharge		
	A	B	C	A	B	C
Bothnian Bay	90 000	20%	-	67 000	15%	2%
Bothnian Sea	255 000	15%	2%	145 000	30%	3%
Baltic proper	1 125 000	70%	20%	700 000	85%	80%
Öresund	370 000	50%	45%	110 000	95%	90%
Kattegat	525 000	25%	20%	160 000	45%	20%
Skagerak	81 000	70%	45%	24 000	50%	10%

A = number of inhabitants
B = approximate percentage of inhabitants connected to primary treatment plants
C = approximate percentage of inhabitants connected to primary + biological treatment of varying degree

From the table it can be seen that sewage treatment is better inside the coast. There is a slow increase of the number of treatment plants also in the coastal communities. In the inland a few plants for chemical treatment have been built.

Owing to the complexity of many parts of the Swedish coast, the water exchange with the open sea may be more or less restricted. Sewage discharges therefore influence marine life and fisheries in several local areas. The largest polluted areas are the archipelagos off Stockholm and Göteborg, and the Öresund.

There are, as yet, no long pipelines carrying out sewage, but they have been discussed in connection with the pollution problems of some communities, e.g. Stockholm and Göteborg.

U.S.S.R.

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Gulf of Finland	4.290	0.247	107 000	6 200	4 300	250
Baltic proper	1.330	0.535	33 000	13 400	1 300	540

Most sewage is untreated or only primary treated. The influence of treatment on the *indirect* discharge is not considered above. Therefore the BOD_5 figures might be 20-30% less.

The water exchange along the open coasts of the Lithuanian S.S.R. and Latvian S.S.R. is sufficiently good. Thus sewage pollution does not have any accountable influence on the marine life. On the other hand, the water exchange in some semi-enclosed bays is somewhat restricted and sewage may have a negative influence on their biology. The largest polluted areas are the Gulf of Finland near Leningrad and partially the Bays of Tallinn, Riga and Kura.

No pipelines for sewage exist hitherto along the Baltic coast but some are being prospected in Pärnu, Riga and Tallinn. The sewage water will be treated mechanically or biologically before entering the pipelines.

General

In Table III on page 32 the sewage BOD_5 and phosphorus content figures previously given for the different countries are summarized. A more detailed discussion is postponed until after the chapter on industrial pollution. Below are, however, mentioned some facts concerning sewage pollution in the area concerned.

The quantities of sewage carried out into the Bothnian Bay and the Bothnian Sea are small, those brought out into the Baltic proper, the Belt Sea and the Kattegat are moderate. Those carried out into the Bay of Finland and the Öresund are, however, big, due to dense population areas, especially the Leningrad and Copenhagen-Malmö regions.

Most of the directly discharged sewage is not treated or undergoes only primary (mechanical) treatment. There are some biological treatment plants, but as far as is known no treatment plant for chemical precipitation of phosphorus compounds, etc., has been built on any of the coasts. In all countries much greater efforts have been made hitherto to avoid pollution of the inland waters.

In some of the countries pipelines are constructed or planned in order to protect near-shore areas from sewage pollution. It was agreed that this is generally not a good way to dispose of either sewage or industrial wastes, unless they are sufficiently treated. Even if careful consideration is paid to fishery, the heavy load of nutrients carried out by pipelines can eventually influence the conditions of such a closed area as the one dealt with in this report.

A number of mostly coastal areas are more or less influenced by sewage brought out directly or indirectly, often in combination with some local industrial wastes.

Heavy organic load, causing among other things *reduced oxygen content* of the water, followed by changes in the marine flora or fauna, have been reported from, e.g. the fjords of Schleswig-Holstein (Kändler, 1953, 1956), the Bay of Lübeck (Schulz, 1968), the archipelagos of Stockholm (Cronholm, 1965), Turku (Tulkki, 1964) and Helsinki (City Water Authorities).

Even if there is no remarkable oxygen decrease, sewage pollution may contribute to changes among the organisms. In the heavily polluted archipelago off Göteborg there is a good oxygen supply but a thick sediment layer contributes to a decreased number of hard-bottom animals and the water turbidity seems to prevent the distribu-

tion of some fish species, e.g. labrides and *Trisopterus (Gadus) minutus* (Dybern, 1969). In the same area the number of soft-bottom species has decreased but the number of individuals has increased (Andrén, Nyholm & Olsson, 1968).

In several parts of the Öresund changes in the bottom fauna caused by pollution have been established, e.g. an increase of *Capitella capitata* and other pollution indicator organisms (Henriksson, 1967). It has not been possible to show that fishes in general except perhaps herring avoid the waters of the Sound (Bagge & Jensen, 1967), but some scientists consider the reproductive ability of some species to be reduced. The fish population, however, seems to be replenished, mainly from the Kattegat.

Heavy blooms of marine algae, indicating pollution conditions, are known to have occurred in some of the coastal areas, e.g. in the Stockholm and Helsinki regions.

Virus and bacteria, harmful to man have been reported from some places. A case of epidemic caused by adeno-virus from the Stockholm sewage has been described (Kallings, 1961). In the water of the Öresund different micro-organisms causing epidemics, as *Salmonella* spp., have been shown to survive for a considerable time (Bonde, 1967). *Salmonella*-virus has also been shown in rather big quantities in the Puck and Gdańsk Bays (Institute of Naval Medicine, Gdynia). All countries have hygienic control of the content of coliform bacteria in bathing waters.

The anaerobic bacterium *Clostridium botulinum*, type E, which may be common in sewage and which may render fish products very toxic, has been found in both bottom sediments and fish of the Öresund (Johannsen, 1963). Other toxic micro-organisms have not been reported.

INDUSTRIAL POLLUTION

Although easily put into the category of industrial pollution the following items are in the main treated separately:

pollution by pesticides etc. including mercury pollution
pollution by oil
pollution from electrical power stations.

Denmark

Denmark has a varity of food industries (sugar works, dairy plants and potato-starch industries) and chemical industries (herbicides, pesticides, drug-industries and smaller paper mills). The main pollutants brought into the sea directly or indirectly by rivers are oxygen-demanding matters, heavy metals (Hg and others), cyanides, chlorinated phenols etc. The BOD_5 is high in several cases. Thus the discharges of a drug-industry ("enzymes"), treated by a court in the Great Belt area, have been estimated to be 2 000 tons BOD_5 per year which equals about 2% of the estimated national contribution of sewage BOD_5.

No special efforts are made to lower the BOD_5. Toxic matters are reduced to the levels demanded by the local courts. Some industries (sugar, pulp and a few chemical ones) lead their wastes into the sea through pipelines. These are usually shorter than 1 km.

The marine environment is considered to be moderately influenced by industrial wastes mainly in the Öresund, especially south of Copenhagen, and in the northern part of the Little Belt.

As far as is known, no dumping of industrial wastes occurs inside the territorial border. A few dumpings outside the border seem to have occurred during recent times.

Federal Republic of Germany

The whole coast on the Baltic is very important for tourism. Therefore very few industrial plants are located in this area. Most of those to be found are food industries and the remaining are paper mills, iron industry and shipbuilding yards.

The wastes of the food industry and paper mills are partly treated and those of the iron industry both mechanically and biologically treated. The total BOD_5 is estimated to 1000 tons per year in direct discharges. The influence of industrial discharges on the marine environment is, as a whole, very small or negligible.

There has been no recent dumping of industrial wastes into the Baltic waters.

Finland

The principal industry causing water pollution is the wood-processing industry, especially the paper and pulp mills which have expanded considerably during the last two decades. Although most polluted water areas are situated in the inland, where several lakes are heavily polluted, there is a heavy discharge of wastes into the sea, too, both directly and indirectly through rivers. Most pulp production was earlier based on the sulphite method, but during the expansive period there has been a rapid change towards the sulphate method. The pollution load of the sulphate mills is smaller and easier to keep under control.

The figures in the table below showing the organic load (expressed as BOD_5), discharged into the sea from the Finnish industry, refer almost exclusively to the paper and pulp industry. Big quantities of fibres and other waste material are also discharged. The coastal areas mostly influenced are in the regions of Kotka (Gulf of Finland), Pori (Bothnian Sea) and Oulu-Kemi (Bothnian Bay).

Areas	BOD_5 tons/year	
	Direct	Indirect
Bothnian Bay	69 000	73 000
Bothnian Sea	25 000	8 000
Gulf of Finland	34 000	22 000

The difficult pollution problems, especially concerning the inland waters, together with a wish to modernize the pup mills have favoured installations of arrangements for fibre-separation, liquor evaporation and alcohol fermentation, but much remains to be done.

There are some other kinds of industries, e.g. shipbuilding yards, metallurgical and chemical industries, but they do not contribute very much to the pollution problems, except, perhaps, some factories making fertilizers, from which, however, no sufficient discharge data exist.

As far as is known, no dumping of industrial waste material occurs inside or outside the territorial border.

Eastern Germany

The coastal area is not so heavily industrialized as several other parts of the country. Shipbuilding yards and food industries (fish-processing and sugar factories etc.) lie, as a rule, at the lower parts of the rivers and at the shallow inlets called "Bodden" and "Haffe".

The discharges from the food-industries have a heavy organic load. Thus waste waters from fish-processing factories have an average content of about 4000 mg BOD_5 per litre (Ventz & Zänger, 1966), but only the fish-processing factory of Sassnitz, equal to about 30 000 person-equivalents, discharges directly into the Baltic. Some inner coastal areas are locally polluted, due to other industries.

Treatment of industrial waste waters is generally combined with primary sewage treatment. Part of it is untreated. The construction of better treatment arrangements for both sewage and industrial waste waters is now being discussed because of the great importance of the coastal area for tourism.

No pipelines exist, nor is there any known dumping from ships inside or outside the territorial border.

Poland

The Polish coastal area plays an increasing role for the economy of the country. Although there are few industries hitherto (mainly shipbuilding yards and food-processing industries) construction of new ones is planned. The new industries will often belong to those using great quantities of water in their production, e.g. paper and pulp mills.

The present influence on the marine environment is considered to be very moderate and arrangements will be made to keep the future situation under control.

Some industrial wastes reach the coastal area through the two biggest rivers. It has been observed that the migration of salmon upstream the Wis a is to a great extent hindered, probably due to some wastes causing avoidance reactions or fish-death.

Poland intends to build a pipeline which will carry great amounts of gypsum. It is being discussed at present what precau-

tions must be taken to restrict the eventual influence on the environment as much as possible.

As far as is known no dumping of industrial wastes occurs.

Sweden

Sweden is heavily industrialized and the industrial capacity is doubled each 15-20 years. There is a tendency for heavy industries to move towards the coasts.

Most industrial wastes (about 70%) derive from the forest industries, such as paper mills, mechanical and chemical pulp mills, fibre-board and cellulose plants etc. There are about 100 such factories scattered along the whole coast and outside many of them there is local or sometimes even regional pollution, with more or less pronounced damage to marine life and fisheries. The following table shows the estimated discharge into the sea of wastes from the forest industries, measured as BOD_5 and lignin (partly after Bruneau). To this comes smaller amounts of BOD_5 caused by wastes from other kinds of industries.

Areas	BOD_5 tons/year	Lignin tons/year
Bothnian Bay	16 000	10.800
Bothnian Sea	350 000	639 600
Baltic proper	50 000	66 600
Öresund	0	0
Kattegat	20 000	?

The worst water pollution problems are caused by pulp industries using the sulphite method.

To-day there is a structural rationalization of most of the Swedish paper and pulp industry towards fewer and bigger units. There is also strong pressure from the authorities to persuade the industries to build effective treatment arrangements in order to decrease the pollution effect - as is also the case in Finland. It is considered that the highest "pollution peak" has been overcome and that in the future there will be a slow but steady improvement of the pollution situation. To this contributes also

a certain change from the sulphite to the sulphate method.

There are many other kinds of industries situated at the coast, or along rivers debouching into the sea, which cause pollution problems but, as a whole, to a smaller extent than the forest industry. These industries include many metallurgical plants, food-processing and chemical factories including those making plastic materials. The controlling power exercised upon them is generally strong, but so-called accidents are common, sometimes causing fish death and other damage to the environment. There is certainly also a slow leakage into the sea of very small, more or less undetectable, quantities of different toxic substances. From some industries very toxic polychlorinated biphenyls (PCB) are released. Thanks to improved methods of analysis of chlorinated hydrocarbons (Jensen, 1968) it has recently been shown that PCB compounds may be accumulated to high concentrations in fish, fish-eating birds and seals in the Baltic, far away from land (Jensen, Johnels, Olsson & Otterlind, 1969; cf. Table II, p. 54).

For many years, considerable amounts of mercury have been released from certain industries, especially those making bleaching powder for the paper- and pulp industry (the "chlor-alkali factories"). This, together with mercury from other sources, has in some regions caused high Hg-concentrations in aquatic organisms. The mercury problem will be further treated in connection with pesticides.

Dumpings of industrial wastes are known in several cases, both within the territorial waters and outside. Here are some cases, known to the authorities (after Hult):

In 1930-31 7 600 tons raw arsenic, mixed with concrete, were dumped into the Bothnian Bay. During 1931 another 310 tons raw arsenic were dumped without special packing. Big quantities of mercury-containing waste products have been dumped just outside the territorial border off Sundsvall, Bothnian Sea. In this area trawl fishery began in 1962 and since then several barrels have been found by fishermen. Different kinds of wastes containing mercury, certain catalysts, which must be stored under water, and other waste products have been dumped in iron-sheet barrels into the waters south of Stockholm. During the early 50's industrial wastes containing sulphuric and hydrochloric acid and probably chromium compounds were dumped off the central Baltic coast. Old

cars seem to have been dumped at least once into the Landsort Deep. Industrial and military wastes of different kinds have also been dumped into the deep parts of the Skagerak and in some coastal parts of the Baltic.

Evidently more dumping has occurred and occurs without the authorities being informed of it.

Pipelines are built from some of the pulp-mills.

U.S.S.R.

The main kinds of industries discharging wastes directly into the Baltic are paper and pulp-mills, shipbuilding yards, food and fertilizer factories and the oil shale ("burning stone") industry of Estonia.

The following table shows the estimated BOD_5 for wastes directly or indirectly discharged into the sea from the industry of the Baltic area.

Areas	BOD_5 tons/year	
	Direct	Indirect
Gulf of Finland	51 000	6 000
Baltic proper	37 000	13 000

Only very little of the industrial discharge undergoes (primary) treatment and it influences the marine environment especially in the eastern part of the Gulf of Finland and the Bays of Tallinn, Riga and Kura.

It is intended to provide most industries with treatment plants in the near future.

No pipelines for industrial discharge exist. As far as is known no recent dumping from ships has occurred.

General

In Table IV, page 133 an attempt is made to estimate the total BOD_5 of industrial wastes discharged into the sea area under consideration. This will be discussed in connection with sewage BOD_5.

The coastal waters of all countries around the sea area are contaminated with industrial wastes, often in combination with sewage. The worst problems seem, however, to affect the coasts of Sweden and partly the coasts of Finland, to a great extent depending on the large paper and pulp-industries, while the problems especially in the two German States and Poland are considered to be of minor importance.

In most countries there is, for different reasons, a more or less pronounced trend to increase industrialization of the coastal areas.

Wastes from the *cellulose industry* contain many substances influencing the marine environment. The following table (Vasseur, 1966) exemplifies the constituents of sulphite liquor by using spruce wood:

Component	% dry substance	% total BOD_5
Lignosulfonic acids	55	
Resins etc.	3	
Hexoses	14	
Pentoses	6	
Acetic acid, Formic acid	5	
Sugar acids etc.	7	
Ash	10	
Lignosulfonic acids, furfural etc.		13
Hexoses		42
Pentoses		21
Acetic acid, alcohol		13
Immediate oxygen demand (SO_2)		11

Liquors from pulp-industries are toxic and dark-coloured and may be inhibitory to the assimilation process. The break-down of organic material decreases the oxygen content of the water. Fish can be tainted by some of the components (Hasselrot, 1964). Sulphite liquor may contain about half the original quantity of wood in solution, the break-down of which equals 200-500 kg BOD_5 per ton produced pulp.

Fibres from different kinds of cellulose industries are often

discharged in big quantities. They accumulate on the bottom, suffocating the bottom-life and destroying fish spawning grounds. The break-down of the fibres also contributes to the decrease of the oxygen content of the water. There are several examples of this from the Swedish coast.

In both Finland and Sweden there is a move towards increased treatment of wastes from the cellulose industry. Some of the liquor substances can to-day be brought back into production. The rest, obtained by, e.g., evaporation, has to be neutralized in other ways, for instance, by burning. But this causes other problems, such as air pollution.

Toxic substances from *other kinds of industries*, e.g. heavy metals, cyan compounds, PCB, phenols and others, may be dangerous in the long run, even though they are discharged in very small quantities. This is especially true of such almost undestructible compounds as PCB. Many substances can be preserved through the capacity of organisms to accumulate them and even to transform less toxic compounds into more toxic ones. Certain substances are also known to act as catalysts, thus increasing the toxicity of others. The Swedish PCB investigations show that toxic substances can be met with in the open sea, brought there by organisms or water currents.

In connection with industrial pollution also the *transfer of pollutants from the air to the water* was discussed.

Different sulphur compounds seem to be the largest component in air pollution. They are hardly expected to influence the marine environment to any great extent. It is, however, known that considerable amounts of other substances, containing heavy metals like mercury, phosphorus compounds and chlorinated hydrocarbons are also carried through the air from industrial centres in Europe and may fall down into the Baltic waters with rain, snow or dust clouds. It is believed that part of the PCB found in different offshore organisms are brought there by the air.

Dumping of industrial wastes is generally avoided inside the territorial borders but has occurred outside. After World War II considerable dumpings of German war material were carried out into the Bornholm basin and other parts of the Baltic. Mustard-gas containers have spread to different parts of the Baltic and have even been found driven ashore. As late as the summer of 1969 some Danish fishermen in the Bornholm area were injured by mustard

gas, contaminating their trawls.

As a whole, there is now a trend in all Baltic countries to strengthen the control of industrial pollution, in the first hand in the coastal areas, but in the long run also in the open sea.

BOD_5 AND PHOSPHORUS

Table III summarizes the BOD_5 and phosphorus content figures previously given for the different countries concerning direct and indirect *sewage discharge* respectively.

Table III

Areas	Mill. inhabitants		BOD_5 tons/year		P tons/year	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Bothnian Bay	0.230	0.167	5 600	4 500	290	220
Bothnian Sea	0.565	0.495	13 650	12 200	780	600
Gulf of Finland	4.868	0.797	121 450	19 200	5 050	870
Baltic proper	3.335	2.065	60 900	30 000	3 880	2 370
Baltic Sea	8.998	3.524	201 600	65 900	9 760	4 060
Belt Sea	1.195	2.600	40 100	21 000	1 240	2 800
Öresund	1.770	0.310	40 600	2 600	1 960	350
Kattegat	0.625	0.360	16 000	5 000	890	400
Total	12.588	6.794	298 300	94 500	13 850	7 610

In Table IV is estimated the *industrial* BOD_5. It has in this case been impossible to distinguish between direct and indirect discharge.

Table IV

Areas	BOD_5 tons/year Direct + Indirect
Bothnian Bay	160 000
Bothnian Sea	385 000
Gulf of Finland	115 000
Baltic proper	~110 000
Baltic Sea	~760 000
Belt Sea	<10 000
Öresund	<10 000
Kattegat	~20 000
Total	~800 000

All figures in Tables III and IV are, of course, approximations. Nevertheless they give some hints of the pollution conditions in the sea areas concerned.

As to BOD_5, a comparison between the figures for sewage and industrial discharge shows that the Bothnian Bay and the Bothnian Sea are much more influenced by industrial wastes than by sewage. In the Gulf of Finland, the Baltic proper and the Kattegat the influence is about fifty-fifty. The Belt Sea and the Öresund are influenced mostly by sewage.

Most of the *phosphorus* compounds discharged derive from sewage but a minor part comes from industrial plants. A rough estimation, according to certain Finnish figures, suggests that this part lies within 10-30% of the total sum. Since thus only rather small amounts derive from the industry, most of the phosphorus is discharged where the population density is highest, viz. around the Gulf of Finland, many parts of the Baltic proper, the Belt Sea, the Öresund and the Kattegat.

As mentioned before, the phosphorus figures have been calculated from the basic assumption that the person-equivalent is 1.0 kg per year. For some countries the figure is higher and, furthermore, the figures for all countries are successively increasing. In Sweden it is thus estimated that sewage wastes 10-15 years ago contained about 1.5 g P per person and day against about 4.0 g to-day. This increase

depends mainly on the increasing use of synthetic detergents, especially washing powders. A similar increase is shown for other countries, and the increased use of certain fertilizers in the agriculture is also in some countries of importance in this connection.

As seen in Table III the total phosphorus supply from sewage and industries into the Baltic (excluding the Belt Sea, the Öresund and the Kattegat) is estimated at about 14 000 tons/year. If we include the Mecklenburg and Kiel Bights the sum lies around 16 000 tons/year.

When evaluating the *total* amount of phosphorus carried out into the Baltic Sea we must add to the 16 000 tons (1) air-borne P, (2) natural P carried out by rivers etc., and (3) the P content of the inflowing saline water.

Odén (Fonselius, 1969) estimates the quantity of air-borne P to be 3 000 tons/year. Some other scientists find this value too high.

According to Fedosov & Zaitsev (1959) the natural P amounts to 3 400 tons/year. There is some doubt whether some sewage P is included in this figure or not.

The inflowing quantity (through the entrance sounds) is estimated by Fonselius (1969) to be 6 100 tons/year, while Voipio (1969) considers it to be very small, only about one tenth of Fonselius' figure.

If the highest above-mentioned figures of carried out P are correct the total sum lies about 28 000 tons/year. The surplus P is obtained if we from the sum draw the outflow of P through the entrance sounds. This outflow is estimated by Fonselius (op.cit.) to be 7 600 tons/year and by Voipio (op.cit.) to be 10 000 tons/year.

According to the highest estimations a surplus of about 21 000 tons P/year remains in the Baltic Sea, while according to the lowest estimations (not in detail treated here) there remains between 8 000 and 10 000 tons/year.

The Working Group considers it to be an urgent need for further studies on the Baltic phosphorus balance, especially on the P exchange between the water and the bottom sediments in different parts of the Baltic area and between the Baltic and the sea outside it, as well as on the exchange between the coastal waters and the open sea.

Of the total BOD_5 of about 1 200 000 tons per year for the whole area 580 000 tons per year fall upon the *Bothnian Sea* and the *Bothnian Bay*. Here we also find many of the worst polluted coastal areas, especially on the Swedish side. The open parts of this sea area generally have a good water circulation, both horizontally and vertically. This reduces the influence of pollution on the open sea. The small phosphorus supply is considered to be of almost no importance.

The BOD_5 of waste waters brought into the *Gulf of Finland* is higher than that of the *Baltic proper* and in both areas also the phosphorus supply plays an important role. There are several examples of heavy coastal pollution, and the open sea areas *may* also be somewhat influenced. The results of investigations by Waern (Cronholm, *et al.*, 1969) thus show increased values for total phosphorus in the surface water from Stockholm through the archipelago towards the open sea.

As pointed out in the hydrographic chapter the nutrient content of the surface water of the open Baltic is rather low compared with the concentrations found in, for instance, the North Sea. In places with a sufficient water circulation and oxygen supply, an increased nutrient supply may therefore have a beneficient influence on the productivity and fishery. The good results of the herring fishery in the Bay of Riga (Lishev, 1966) may thus perhaps be connected with the rich supply of nutrients from the surrounding land (Otterlind, 1969). The special hydrographic conditions of the Baltic deep basins, however, make them very sensitive to increased nutrient supply from the surface layers.

In the *Öresund* the orthophosphate values are higher than those of the open Baltic and Kattegat, and orthophosphate seems to be accumulated from the southern to the northern part (Vallin, 1968). Waern has shown an increase of the surface-water values for total phosphorus in the Öresund. The values slowly decrease northwards along the Swedish *Kattegat*-coast, to increase again outside Göteborg (Water Authorities of Göteborg, 1968).

It is believed by some scientists, but not yet proved, that a slight decrease of the oxygen values of the Kattegat deep water observed recently (Corin, Fonselius & Svansson, 1969) depends on too heavy a supply of organic matter through pollution.

To summarize: pollution, described in terms of BOD_5 and

phosphorus values, negatively affects several coastal areas. In some cases the pollution influences stretches beyond the coastal zones, e.g. in the Öresund, the Little Belt, the Riga and Leningrad regions.

Even though more biological treatment plants were along the coasts, both for sewage and for industrial wastes, and the BOD_5 figures kept in check, very few or none of the plants seem to be provided with arrangements for phosphorus precipitation. If nothing else happens it must be expected that the phosphorus discharge into the sea will continue to increase. Attempts have been made, it is true, to eliminate some of the phosphorus compounds from washing-powders, among other things by compensating for them with other chemical compounds, such as nitrilotri-acetic acid (NTA). These attempts have, however, not yet proved to be very successful, as shown by investigations in the Federal Republic of Germany, but Swedish scientists seem to be rather optimistic. Illustrative for the situation in Sweden is the recent increase of the phosphorus content of a certain washing-powder from 28 to 52%, in spite of the fact that the makers of the powder are represented on a committee working to lower the phosphorus content of synthetic detergents.

PESTICIDES ETC.

DDT and mercury pollution are treated separately.

The use of pesticides in agriculture, horticulture, forestry and some industries, e.g. textile-industries, is common in all countries. Especially in Sweden and Finland similar substances have been extensively used in the paper and pulp-industry as slimecides and preservatives.

There is a wide range of substances, both inorganic and organic, used in the Baltic area. Accidents causing fish-death or other damage to the water environment are known from the freshwaters of all the countries. Considerable efforts are being made everywhere to get the situation under control, in accordance with the existing legislation.

In *Denmark* pesticides are supposed to be discharged into the sea partly from industries, partly indirectly in connection with

their extensive use in agriculture. Chlorinated phenols from the weedkiller industry have proved harmful to marine life (Boëtius, 1954). There are almost no figures for the content of pesticides in the coastal waters, but investigations are planned.

The influence of pesticides on the coastal waters of the *Federal Republic of Germany* is considered to be small. According to a special law, the use of several common compounds (e.g. aldrine, chlordane, dieldrine, endrine and heptachlor) is forbidden in connection with plant food-stuffs (Bundesgesetzblatt, Teil I, 1966, p. 667-675).

In *Finland* the contents of some pesticides in the water of several rivers debouching into the sea have recently been investigated. The concentrations were, however, under the detection limit. Of some of the 14 compounds studied the results were as follows:

DDT	$<2 \times 10^{-6}$	ppm
DDE	$<1 \times 10^{-6}$	"
Dieldrine	$<5 \times 10^{-7}$	"
Lindane	$<5 \times 10^{-7}$	"
Parathion	$<5 \times 10^{-7}$	"
Malathion	$<1 \times 10^{-6}$	"

No measurements of sea water or marine organisms have been carried out. Judging from the above-mentioned results the influence of pesticides on the coastal waters is thought to be small.

No investigations on the pesticide content of the coastal waters of *Eastern Germany* and *Poland* have been carried out. Influence on the marine environment is considered to be small, but the Polish representatives admitted that pesticides may be carried out but only by the main rivers. In Eastern Germany the use of aldrine, dieldrine and endrine as pesticides is not allowed.

In *Sweden* an extensive use of pesticides has caused considerable damage. In 1964 about 700 substances were in use, together making up about 2 400 tons (Wase, 1968). By special regulations the number has been reduced but pesticides are still used in excess in many connections. An unknown quantity is carried into the sea by rivers and air, and investigations have been started to estimate this. Pesticide residues of various kinds have,

however, already been demonstrated in coastal waters. Recently, for instance, the content of dieldrine was found to be so high in fish of the river Viskan, running into the northern Kattegat, that the lower part of it and a sea area outside had to be declared a prohibited fishing-area. This and other accidents have rapidly brought about prohibition of the use of aldrine, dieldrine and, partly, lindane from 1 January, 1970.

The use of pesticides in the Baltic area of the *U.S.S.R.* - especially in the Estonian S.S.R. - is about 0.8 kg per person and year (Simson, Lutsoja, Ilmoja & Ditrikh, 1968). From 1968 the use of several chlor-organic compounds has been stopped.No special investigations on the pesticide content of the Baltic coastal waters have been made, but it is assumed to be small.

DDT

DDT is perhaps the most wide-spread pesticide and there seems to be no part of the world not infested by it. The danger of too heavy a use is clearly demonstrated in many investigations. DDT has been used in all Baltic countries, but not so extensively as in many other parts of the world.

An extensive investigations is being carried out concerning th content of DDT, DDE and DDD (as well as PCB, mentioned before) in mussels, fish, fish-eating birds and seals from the Swedish west and east coasts. Table II (p. 54; quoted from Jensen, Johnels, Olsson & Otterlind, 1969) summarizes the results.

Although the samples were small, sometimes of only 3-4 individuals, there is an obvious tendency for the concentrations of DDT to be several times higher in the Baltic than off the Swedish west coast. Since DDT is much more easily dissolved in fat the concentrations in muscle tissue of the same animals were much lower, but the same general trend to higher amounts in the Baltic animals is shown.

According to the work quoted the DDT concentrations in seals from the Baltic seem to be up to 10 times as high as reported from North Sea seals and seals from the coast of Canada. The concentration in guillemot eggs is likewise several times higher than those reported for the same species at the British Isles. The Swedish guillemots live near the island Gotland in the middle of the Baltic.

As mentioned before, the PCB content of marine organisms is also high in fishes, sea-birds and seals from the Baltic (cf. Table II, p. 54). Since many of the animals investigated were caught in the open sea there must thus be a transport of pesticides and other toxic substances from land to the open sea. The water exchange between the Baltic proper and the North Sea is rather slow and many of the substances may be expected to stay in the Baltic for a considerable time, especially those which are very slowly broken down. This makes it possible for marine organisms to concentrate them to high, may be deleterious, concentrations.

DDT is found in the air. It is known that the break-down of plankton organisms may give rise to a very thin surface film of fat. Since DDT is easily dissolved in fat it might be expected that at least part of the DDT in the Baltic derives from air-borne DDT. From the surface film it can be carried downwards by water turbulence etc., affecting primary production. Wurster (1968) has shown that the photo-synthesis in certain planktonic algae is greatly influenced even by very small amounts of DDT.

Recent investigations in Canada have shown that sublethal DDT in such a small quantity as 20 ppb in 24 hours affects the learning ability of brook trout (Anderson & Prins, 1969). Although this result is from freshwater investigations and therefore not directly applicable to marine fish, it gives another hint of the very great sensitivity of animals to DDT.

Accumulation experiments on marine fishes have been started in Denmark and the Federal Republic of Germany.

The use of DDT in households and gardens will be prohibited in Sweden from 1 January, 1970. All other use will be prohibited by way of experiment for two years from the same date. Since 1968 DDT is not used in the U.S.S.R. and will be partly forbidden in Denmark from 1 November 1969.

Mercury

Mercury compounds are used as pesticides in the agriculture of some countries. In Sweden and Finland they have also been widely used as fungicides and slimecides in the paper and pulp-industry. Mercury-containing wastes also derive from a lot of

industries, from the burning of household waste, e.g. paper, and other sources.

Some of the mercury wastes are in themselves toxic to organisms, others may be transformed by organisms to be more toxic than from the beginning. Like many other industrial wastes and pesticides mercury compounds tend to accumulate in living bodies and bottom sediments.

Sweden has an extensive research programme concerning mercury. Several steps have also been taken to reduce the discharge of mercury-containing wastes into the natural environment. Thus the use of mercury in agriculture has decreased considerably and most of its use in the paper and pulp-industry is or will be forbidden. Efforts are also being made to bring down the discharges from the chlor-alkali factories.

However, considerable amounts of mercury are already accumulated in nature. The concentrations in fish from many inland and coastal waters are so high that these areas have been declared prohibited fishing-areas, which means that fish must neither be sold nor be given to other persons as gifts. The fisherman himself is, however, allowed to eat the fish at his own risk. The threshold value lies at 1 mg Hg per kg wet weight fish. About a dozen of the prohibited areas are coastal areas (c f., e.g., Löfroth, 1969).

In *Finland* the problems are very much the same as in Sweden, but fishing is not prohibited in any areas as yet, although the mercury content has been found to be high in some cases (Häsänen & Sjöblom, 1968). Attempts are, however, being made to eliminate the discharge of mercury compounds as much as possible in the same way as in Sweden.

Also in *Denmark* high mercury concentrations have recently been demonstrated in some marine fishes in the Öresund area (Dalgaard-Mikkelsen, 1969).

Hitherto it seems as if mercury pollution, as a whole, is more restricted to certain coastal areas than is DDT and PCB pollution. The results of investigations carried out in the Federal Republic of Germany on old cod from the open sea waters of the Baltic proper did not give evidence of a higher mercury content than is considered to be natural.

Since the use of mercury is now to a great extent forbidden, the Finnish and Swedish paper and pulp-industries have introduced new substances. At least one of these has been in common use, viz.

penta-chlor phenol (and also closely related compounds). Unfortunately these compounds have been shown to have a negative effect on fish (Weber, 1965, and others).

OIL POLLUTION

Denmark

Oil pollution from ships is a permanent but minor problem. One offshore accident, through wrecking of a ship, is known from the Kattegat.

Denmark has 4 refineries, on the coasts of the Belts and the Öresund. There are several small industries using oil-derivatives.

The damage caused by oil-discharges has been small, mainly affecting harbour waters and nearby bathing beaches and to a certain extent sea-bird life. There seems to have been little influence on the extensive local fishery, but in some cases bad tainting of fish by phenols and similar substances have been noted.

Oil has sometimes been removed from the surface by sinking, but solvent-emulsifiers now seem to be mostly used.

Federal Republic of Germany

There have been some small oil-discharges in the Bight of Kiel, but, as a whole, oil is no problem in this area in contrast to the German North Sea coast.

No refineries are situated on the Baltic coast.

Removal of oil has been by means of different methods, such as sinking, collecting with floating absorbent materials, burning and emulsifying.

Much research work has been made on the toxicity of different solvent-emulsifiers, e.g. by Rosenthal & Gunkel (1967) and Kühl & Mann (1967). Oil-degradating bacteria have been studied by Wallhäuser (1967), Gunkel (1967) and Gunkel & Trekel (1967). Organoleptic investigations are common and the effects on the flavour of marine and freshwater fish caused by oil and oil-derivates have been described, e.g. by Mann (1965, etc.). Studies on the influence of oil on the development of fish eggs are going on.

Kühnold (1969) has shown that the development of fertilized cod and herring eggs is seriously influenced by crude oil in the water. The influence is different for different kinds of oils.

Finland

Oil pollution occurs mainly in harbours and is mostly of local importance. Some accidents are known from the open sea, e.g. in the Quark area in 1968 and near Åland in May 1969.

Two refineries exist; no serious accidents from these are known. As yet there is very little industry based on oil-derivates.

Oil is destroyed by various means. Ashore-floating oil from the Åland accident was partly treated with emulsifiers, and partly burnt, which caused damage to the sea-birds and shore-life of many small islands.

Eastern Germany

Oil pollution from ships may locally influence the waters of the harbours. No refineries are built on the coast.

Poland

Oil pollution in Polish coastal waters is increasing. Most of it is considered to reach the coast from the open Baltic. Pollution of local origin occurs in the docks of shipbuilding yards.

No refineries are built in the coastal area. Some research on oil-pollution abatement is being carried out in the coastal area.

Sweden

The import of oil to Sweden is considerable. Many harbours have big bunker-installations and several refineries are situated along the coast.

Oil pollution is a rather serious problem. During 1968 125 discharges from ships (about 80 on the west coast) are known to

have occurred in the coastal area. They derived from both cargo ships and tankers. Most of them were rather small but together they caused considerable trouble and damage to bathing beaches, fishing gear and marine life, especially sea-birds. One of the bigger discharges was caused by a tanker running aground in the archipelago off Stockholm. A similar accident with a very big tanker outside Göteborg did not, fortunately, cause damage. In May 1969 a tanker of 71 000 tons collided in a thick fog with a cargo ship off the south coast of Sweden. The tanker carried 70 000 tons of crude oil. Fortunately only 1000 m^3 bunker oil leaked out, otherwise a catastrophe similar to the famous Torrey Canyon accident would have occurred.

Oil is removed by different means but methods are under development to collect it by means of floating absorbents or booms and to pump it into special vessels.

The number of industries based on oil-derivates is growing, but, generally speaking, very careful precautions must be taken not to influence the water environment. They are, however, permitted to release small amounts of a large number of substances.

Some investigations on the resistance of cod to glycol and tensides have been made (Swedmark, 1968).

U.S.S.R.

Oil pollution is located mainly to harbour areas. In the near future all U.S.S.R. harbours will be supplied with special installations for waste oil from ships and other sources.

No tanker accidents are known from the open sea near the Baltic coast. There are no refineries in the coastal area. There are some oil-pollution problems outside places where oil shale is exploited ("burning stone"), e.g. in eastern Estonia.

The results of investigations by Mironov & Lanskaya (1966) show that marine algae are very sensitive to oil and oil-products, which may cause the death of the algae or a retardation in cell-division. It is also shown that developing eggs of *Rhombus maeoticus* are very sensitive to oil derivates (Mironov, 1968).

General

All countries but Eastern Germany and the U.S.S.R. have ratified the London Oil Pollution Convention (1954 etc.). According to this Convention the whole area considered is a prohibited zone. The U.S.S.R. has a special 50-miles regulation and Eastern Germany has special regulations in accordance with the Convention.

Most tanker-routes go to Danish, Swedish and Finnish harbours. Most big oil-pollution accidents occur on these routes and there is a marked tendency for oil pollution to increase both in the coastal areas and in the open sea. There is also a tendency for the tankers to get bigger. Thus Finland is now building two tankers of about 105 000 tons. This size is slightly below what is possible to take into the Baltic proper.

In some of the Baltic harbours special installations for collecting oil waste have been established. They are, however, too few and often too expensive to be used by many ships.

It was agreed that the Baltic area is a very sensitive one and that a few disasters like the Torrey Canyon accident outside southern England in March 1967 could annihilate the marine life and fisheries.

At a meeting in Visby in September 1969 official representatives from all Baltic countries agreed in finding it necessary to increase the preparedness as to oil-pollution abatement in the Baltic area, among other things through international co-operation.

WARM WATER POLLUTION

Pollution caused by cooling water from electrical power stations using fossil or atomic fuel is, as a whole, of no importance in the area we are concerned with here. The existing power stations, mainly using fossil fuel, are relatively small and the influence on their recipients is very local and can mostly be ignored.

In the future, however, many very big nuclear power stations will be built. Sweden, for instance, is planning to build 10-12, each with a capacity of ca 3000 MW, along the coast in the next 25 years. Each of these power stations will discharge about

150 m^3/sec., about 10°C warmer than the water of the recipient. This quantity roughly corresponds to the average flow of a normal Swedish river. Similar nuclear power stations are also planned in other areas, e.g. at Greifswald in Eastern Germany and at Loviisa in Finland.

The possible influence on the marine environment by the future warm water outflow was briefly discussed. It was agreed that if the water currents are constant and go in the same direction they may have a beneficial effect,constributing to an increased production in local areas. The possibility of using the water for fish-farming was also considered.

It was, however, agreed that the influence may be negative, especially in areas already polluted by sewage or other wastes, including pesticides and radioactive materials. The food-chain cycles, for instance, may be accelerated, which will increase the possibility of accumulation of toxic substances within the organisms. In the recipients the flora and fauna components may be exposed to temperature changes. This will certainly eliminate some of them, including fishes. It was also pointed out that when cleaning the tubes, etc., different kinds of released substances may cause damage to the recipient.

OTHER KINDS OF POLLUTION

Radioactive pollution

Radioactive wastes were discussed only briefly since, similar to the agreement between the members of the Working Group on the Pollution of the North Sea, the representatives on the present Group considered it best to leave these problems to other, more specialized bodies.

It was, however, agreed that radioactive pollution must not be isolated from pollution questions as a whole. It was established that the Baltic waters are, indeed, to a certain extent contaminated with fallout radioactivity. At least in some parts it seems as if the concentrations have increased a little during recent years (Voipio & Salo, 1969) although the results of investigations in other parts (e.g. the Bays of Kiel and Lübeck) rather point to a *status quo*.

The pollution situation is subject to very strong control in all the countries and must remain so, since the establishment of the future nuclear power stations, etc. will cause the release of small additional amounts of radioactive matter, which otherwise, in combination with other pollutants, could be a potential risk for the marine environment.

There is no legislative hindrance for nuclear ships to pass the Belts and the Öresund and enter the Baltic Sea.

Pollution by ships (except oil)

The ship traffic of the Kattegat, the Danish waters and parts of the Baltic proper is considerable. It is, for instance, estimated that more than 20 million people travel across the Öresund every year and during summer trips may be made by about 500 passenger-ships, yielding between 250 and 400 m^3 waste, per day. On some routes, for instance, between Göteborg and northern Jutland many fishermen reluctantly traverse the ship routes owing to the many man-made things they get in their trawls. In some harbours, terminals for the collection of ship waste have been erected, but they are too small and too few as yet to bring down this kind of pollution.

In some archipelago areas waves and currents caused by ships hinder the local fishery. This is, for instance, the case near the most frequented ship routes in the archipelago of Åland.

Dumped fishing gear may sometimes be a hindrance for the fishery. It was in this connection that the "Fisheries Policing Convention", London 1967, according to which fishing boats should not dump things damaging fishery or fishes, was recalled.

Sand-sucking, stone and gravel collecting

Sand-sucking operations and stone and gravel collecting to get material for building purposes on land take place in many coastal areas, but are of international concern only in relation to sand-sucking in parts of the Öresund, which has been said to make the water turbid, to deplete the bottom water of oxygen and to destroy spawning grounds, causing fish to avoid the areas.

The results of recent investigations (Ackefors & Fonselius, 1968) make it probable that there may be some damage to the bottom fauna, which could locally influence the fishery.

Underwater prospecting

Most of the countries have started or intend to start underwater prospecting work to search for oil and gas. It must be expected that some local fishing areas will be disturbed by such operations. There may, for instance, be an increased turbidity and a certain leakage of special substances used in drilling. Recent accidents in the North Sea and at the Californian coast (e.g. the St. Barbara accident in January, 1969) show that considerable trouble may be caused by leaking oil or gas.

INTERNATIONAL COLLABORATION

Pollution research is carried out in all the countries in connection with special situations or as independent research programmes. There is a developing international collaboration in the hydrographical and marine biological field, partly through such international organisations as ICES, IOC, IMCO, IAEA and others, partly through more local organisations such as

- The Conference of Baltic Oceanographers (all countries)
- The Baltic Marine Biologists (all countries)
- The Committee on Pollution of the Öresund (Denmark and Sweden)
- The Committee on Pollution of the Gulf of Finland (Finland and U.S.S.R.)
- The Sub-Division for the Baltic area of the Cooperative Commission of the Academies of the Socialistic Countries for Planetary Geophysical Research (Eastern Germany, Poland and U.S.S.R.)
- The cooperative research work in the Odra (Oder) being carried out by the State Water Boards (Eastern Germany and Poland).

SUMMARY

All the countries have *laws against water pollution* which include the coastal waters inside the territorial borders. At present the controlling power is, however, weaker concerning the latter areas than concerning the inland waters.

All countries control oil pollution, most of them according to the London Oil Pollution Convention. As to other kinds of pollution the only legislative control of the open sea is the Finnish law against pollution of the open sea.

The *hydrographical conditions* are characterized by the water of the deep basins being more or less stagnant, causing oxygen deficit, and in some cases production of H_2S. The oxygen content of the deepest water layers, especially in the Baltic proper, shows a marked decrease since the beginning of the century, accompanied by an increase of the phosphorus content.

Considerable amounts of *sewage* are discharged into the coastal waters. Most of it is untreated or undergoes only primary treatment. Some coastal areas are heavily polluted, especially in semi-enclosed embayments and archipelagos where the water exchange with the open sea is restricted. Sewage pollution is also heavy in the Öresund and some other open sea areas near the coasts. A big part of the phosphorus introduced by man derives from the increased use of synthetic detergents and fertilizers during recent decades.

It is probable that the increasing sewage phosphorus discharge to some extent contributes to the increasing phosphorus values in the deep basins of the open sea. A moderately increased supply of nutrients including phosphorus compounds may stimulate the biological production and the fish yield in the sea. Because of the high natural amount of nutrients and low-oxygen conditions of the deep water of some Baltic basins the surplus amounts of nutrients discharged by man may, however, have a negative effect on fishery in the long run, for instance, by disturbing the oxygen balance or causing blooms of toxic plankton algae.

Industrial pollution influences many coastal areas. This is especially true of pollutants from the wood-processing industries of Finland and Sweden. The maximum pollution is, however, in this case considered to have been reached and a slight improvement is expected in the near future. Other kinds of industries locally

influence the coastal areas.

There is certainly a small leakage of more or less toxic substances from many parts of the coasts into the open sea. Polychlorinated biphenyls (PCB) are, for instance, shown to be accumulated in marine animals far from the shore, and concentrations reported from the Baltic and the Öresund exceed those found in some other sea areas.

Dumping of toxic substances has been made especially outside the Swedish coast and in the southern Baltic proper.

There is a transport of *pesticides*, as DDT, from land into the open sea. Mercury pollution seems, however, to be more restricted to the coastal waters.

Both industrial and other wastes may be deposited from the air on the sea surface.

Of *other kinds of pollution* oil pollution is increasing in most parts of the area. Pollution from ships, pollution caused by sand-sucking operations and dumping of mud and sludge have sometimes given rise to local problems for the fishery.

Warm water pollution and pollution caused by underwater prospecting are no problems at present but may be more important in the future. Radioactive pollution may increase after the construction of several planned nuclear power stations.

LITERATURE

References to the papers referred to in the report

Ackefors, H. & S.H. Fonselius, 1968. Preliminary investigations on the effect of sand-suction work on the bottom in the Öresund. - Meddel. Havsfiskelaboratoriet, Lysekil, Nr 58, pp. 10.

Anderson, J.M. & H.B. Prins, 1969. Effect of sublethal DDT on a simple reflex in brook trout. - ICES C.M. 1969/E:19.

Andrén, L., K.G. Nyholm & I. Olsson, 1968. Marinbiologi. - Göteborgs Vattenvårdsanläggningar. Undersökningar för havsutsläpp år 1966-1967, 130-149.

Bagge, O. & Å.J.C. Jensen, 1967. Fiskeri. - Report on the Investigations of the Swedo-Danish Committee on Pollution of the Sound 1959-64, 264-302.

Bonde, G., 1967. Bakteriologi. - Ibid., 133-195.

Boëtius, J., 1954. Foul taste of fish and oysters caused by chlorophenol. - Meddr. Danm. Fisk.- og Havunders., N.S. 1(4), 1-8.

Corin, C., S.H. Fonselius & A. Svansson, 1969. On the oxygen and phosphate conditions in the Kattegat and Öresund 1900-1968. - Meddel. Havsfiskelaboratoriet, Lysekil, Nr 62.

Cronholm, M., 1965. Föroreningsförhållandena i Stockholms skärgård. - Vattenhygien, 21, 34-46.

Cronholm, M., H. Ekelund, A. Hellgren & E. Lindström, 1969. Naturvetenskapliga synpunkter på storstadens miljö. - Svensk Naturvetenskap, 22, 208-242.

Dalgaard-Mikkelsen, S., 1969. Kviksølvforekomsten i miljøet i Danmark. - Nordisk Hygienisk Tidskrift, 50, 34-36.

Dybern, B.I., 1969. Fiskeribiologiska undersökningar i Göteborgs skärgård, Jan. 1968 - Mars 1969. - Report to the Water Court at Vänersborg.

Fedosov, M. & G. Zaitsev, 1959. Water balance and chemical regime of the Baltic Sea and its Gulfs. - ICES C.M. 1959/No. 66 (Hydr. Comm.).

Fonselius, S.H., 1969. Hydrography of the Baltic deep basins. - Fishery Bd. of Sweden, Ser. Hydr., No. 23, pp 97.

Gunkel, W., 1967. Experimental ecological investigations regarding the limiting factors of microbiological oil degradation in the marine environment. - Helgol. wiss. Meeresunters., 15, 210-225.

Gunkel, W. & H.H. Trekel, 1967. On the method of quantitative determination of oil decomposing bacteria in oil polluted sediments and soils, oil-water mixtures, oils and tarry substances. - Helgol. wiss. Meeresunters., 16, 336-348.

Hasselrot, T., 1964. Investigations with caged fish as an indication of pollution from craft pulp mills. - Vattenhygien, 20, 74-82.

Hela, I., 1960. The hydrographic features of the Baltic Sea and the disposal of radioactive wastes. - Disposal of Radioactive Wastes, IAEA, Vienna, 573-587.

Henriksson, R., 1967. Föroreningars inverkan på bottenfaunan i Öresund. - Report on the Investigations of the Swedo-Danish Committee on Pollution of the Sound 1959-64, 205-263.

Häsänen, E. & V. Sjöblom, 1968. Kalojen elohopeapitoisuu Suomessa vuonna 1967. - Suomen Kalatalous, No 36, pp 24.

Jensen, S., 1968. Miljögiftproblematik. - Flora och Fauna 1968 (5), 190-195.

Jensen, S., A. Johnels, M. Olsson & G. Otterlind, 1969. DDT and PCB in marine animals from Swedish waters. - Nature, 224, 247-250.

Johannsen, A., 1963. Clostridium botulinum in Sweden and adjacent waters. - J. appl. Bact., 26, 43-47.

Kallings, L.O., 1961. Adenovirusinfektioner. Möjligheter till vattenburen smitta illustrerade av Nackaepidemien 1959. - Vattenhygien, 17, pp 7.

Kändler, R. 1953. Hydrographische Untersuchungen zum Abwasserproblem in den Buchten und Förden der Ostseekuste Schleswig-Holsteins. - Kieler Meeresf., 9, 176-200.

Kändler, R., 1956. Die hydrologischen Verhältnisse in den Buchten und Förden der Ostseekuste Schleswig-Holsteins im Hinblick auf die Abwasserbelastung. - Arb. d. Dtsch. Fisch. Verbandes, 1956 (7), 17-24.

Kühl, H. & H. Mann, 1967. The toxicity of various oil-counteracting agents for sea and freshwater animals. - Helgol. wiss. Meeresunters., 16, 321-327.

Kühnold, W.W., 1969. Effect of water soluble substances of crude oil on eggs and larvae of cod and herring. - ICES C.M. 1969/ E:17. (mimeographed).

Lishev, M.N., 1966. Stocks of Baltic herring in the Gulf of Riga and prospects for their utilization 1965-1967. - Fish. Res. in the Baltic, Coll. 1, Riga. (In Russian).

Löfroth, G., 1969. Methylmercury. A review of health hazards and side effects associated with the emission of mercury compounds into natural systems. - Swedish Natural Science Council. Ecological Research Committee. Bull. No 4, 29 pp.

Mann, H., 1965. Effects on the flavour of fishes by oils and phenols. - Symp. Monaco April 1964. Pollutions marines par les micro-organismes et les produit pétroliers. CIESM, 1964, 371-374.

Mironov, O.G., 1968. Hydrocarbon pollution of the sea and its influence on marine organisms. - Helgol. wiss. Meeresunters., 17, 335-339.

Mironov, O.G. & L.A. Lanskaja, 1966. The influence of oil on the development of marine phytoplankton. - Int. Oceanogr. Congr., 2, Moscow.

Otterlind, G., 1969. Östersjön, syret och gifterna. - Ostkusten 1969 (1), 14-17.

Rosenthal, H. & W. Gunkel, 1967. Effects of crude oil-emulsifiers mixtures on marine fish fry and their food animals. - Helgol. wiss. Meeresunters., 16, 315-320.

Schulz, S., 1968. Rückgang des Benthos in der Lübecker Bucht. - Monatsber. d. Dtsch. Akad. d. Wiss., 10, 748-754.

Simson, O., Kh. Lutsoja, K. Ilmoja & M. Ditrikh, 1968. O zagryaznennosti vneshneĭ sredy ostatkami pestitsidov za 1964-1967 gg. v Estonskoĭ SSR. - Tezisy dokl. VI. nauchn. konf. Pribaltiĭskikh respublik po zashchite rasteniĭ. Tartu, 1968, I.

Swedmark, M., 1968. Resistens hos fisk mot glykol, tensider och en vanlig tensidråvara. - Vatten, 24, 430-443.

Tulkki, P., 1964. Studies on the bottom fauna of the Finnish southwestern archipelago. II. Bottom fauna of the polluted harbour area of Turku. - Arch. Soc. Vanamo, 18, 175-188.

Vallin, S., 1968. Undersökningar av salthalt och fosfatskiktning i Öresund. - Vatten, 24, 41-48.

Vasseur, E., 1966. Progress in sulfit pulp pollution abatement in Sweden. - J. Water Pollution Control Federation, 1966, 27-37.

Ventz, D. & G. Zänger, 1966. Beitrag zur biologischen Reinigung der Abwässer aus Fischereiverarbeitungsbetrieben. - Fischereiforschung, wiss. Schriftreihe, 4, 91-98.

Voipio, A., 1968. Hydrographic features of the Baltic Sea. - Information Bull., 15, Europ. Federat. Protect. Waters, 8-11.

Voipio, A., 1969. On the cycle and balance of phosphorus in the Baltic. - Suomen Kemistilehti A, 42, 38-42.

Voipio, A. & A. Salo, 1969. On the balance of 90Sr and 137Cs in the Baltic. - 5th R.I.S. Symposium, Helsinki, May 19-20, 1969.

Wase, K., 1968. Svenska förhållanden. Förordningar och åtgärder. - In the Swedish edition of R.L. Budd: Biocider och den levande naturen, Stockholm 1968.

Wallhäuser, K.H., 1967. Oil decomposing micro-organisms in nature and technique. - Helgol. wiss. Meeresunters., 16, 328-335.

Weber, E., 1965. Einwirkung von Pentachlorphenolnatrium auf Fische und Fischnährtiere. - Biol. Zentralbl., 84, 83-93.

Weichart, G., 1968. Veränderungen des Meeres durch Abfälle und die darauf basierende Einführung von fünf Gefahrenklassen für das Einbringen von Abfällen ins Meer. - Helgol. wiss. Meeresunters., 17, 398-410.

Wurster, C.F., 1968. DDT reduces photosynthesis by marine phytoplankton. - Science, 159, 1474-1475.

Other literature

A comprehensive literature list on marine pollution problems is included in the Report of the Working Group on Pollution of the North Sea (ICES Cooperative Research Report, Series A, No. 13, 1969).

Most of the Members of the present Working Group have presented more or less complete bibliographies of works on marine pollution and related subjects in the Baltic Sea. These lists are given in Appendix II, page 72.

TABLES AND FIGURES

Table I

Name of Basin or Deep	Area km^2	Volume km^3	Max. depth m	Mean depth m	Sill-depth m
Kattegat	23 000	580		25	
Belt Sea	21 000				
Baltic proper	202 000	13 600	459	67	17
1. Arkona basin (below 30 m).		70	55		17
2. Bornholm basin(below 60 m)		160	105		45
3. Central basin (below 60 m)		4 100	459		60
A. Eastern Gotland basin (below 100 m)		920	249		60
a. Gdańsk basin (below 100 m)		10	116		88
b. Gotland Deep (below 150 m)		196	249		60
c. Fårö Deep (below 150 m)		25	205		140
B. Northern Central basin (below 100 m)		558	459		115
a. Northern basin (below 100 m)		228	219		115
b. Landsort Deep (below 100 m)		270	459		138
C. Western Gotland basin (below 100 m)		101	205		100
a. Norrköping Deep			205		100
b. Karlsö Deep			112		101
4. Riga Bay	16 700	460	51	28	c.20
Gulf of Finland	29 500	1 125	100	38	
Baltic proper + Gulf of Finland (0-60 m)	249 000	9 500			17
Baltic proper + Gulf of Finland (total)	249 000	15 190	459	61	17
Åland Sea	5 200	405	301	77	
Archipelago Sea	8 300	195		23	
Bothnian Sea	66 600	4 595	293	69	40(70?)
Bothnian Bay	37 000	1 540	126	42	25
Baltic Sea (total)	366 000	21 960	459	60	17

(From Jensen, Jonnels, Olsson & Otterlind, 1969).

	No. in Sample	P.p.m. in fat ΣDDT*	DDT	PCB	P.p.m. in fresh tissue ΣDDT*	DDT	PCB	Per cent fat
Swedish West Coast								
Mussel Oct.1966,Dec.1967	17	1 (0.4-5)	0.6 (0.3-1.3)	2 (0.5-7.0)	0.02 (0.005-0.04)	0.007 (0.002-0.03)	0.084 (0.011-0.33)	1.3 (0.66-2.6)
Plaice Sept.1966	3	1 (0.9-2)	n.e.	5 (0.4-14)	0.006 (0.003-0.009)	0.004 (trace - 0,006)	0.021 (0.002-0.056)	0.5 (0.4-0.5)
Cod Sept.1967	4	1 (0.6-2)	n.e.	7.3 (1.8-16)	0.005 (0.001-0.006)	0.003 (n.d. - 0,006)	0.019 (0.006-0.030)	0.30 (0.19-0.34)
Picked Dogfish Aug.1968	7	1.5 (0.29-3.9)	0.91 (0.15-2.3)	1.5 (0.81-2.4)	0.15 (0.028-0.33)	0.091 (0.015-0.21)	0.15 (0.054-0.30)	9.6 (6.7-14)
Fish Oil Oct.1968	3	2.1 (1.5-2.6)	1.2 (0.83-1.4)	0.74 (0.54-1.0)				100
Baltic Sea proper incl. the Sound								
Mussel Oct.1966,Dec.1966,Dec. 1967,Jan.1968	40	6 (0.9-10)	1.8 (0.5-2.9)	4.3 (1.9-8.6)	0.03 (0.009-0.07)	0.02 (0.003-0.023)	0.03 (0.008-0.057)	0.92 (0.46-1.6)
Herring Apr./Sept.1966-68	18	17 (4.1-37)	9.7 (1.5-21)	6.8 (0.5-23)	0.68 (0.093-2.3)	0.40 (0.012-1.3)	0.27 (0.009-1.0)	4.4 (0.7-12)
Plaice Sept.1967	6	2.7 (1.4-7.8)	2.1 (0.6-7.2)	2.7 (1.7-4.8)	0.018 (0.006-0.036)	0.013 (0.003-0.029)	0.017 (0.010-0.032)	0.65 (0.58-0.71)
Cod Sept.1967	5	19 (12-31)	9.8 (3.5-19)	11 (3.2-20)	0.063 (0.027-0.11)	0.032 (0,008-0,068)	0.033 (0.012-0.057)	0.32 (0.23-0.44)
Salmon* Autumn 1968	11	31 (20-53)	14 (7.7-20)	2.9 (1.1-8.2)	3.4 (0.26-7.1)	1.5 (0.095-3.1)	0.30 (0.014-0.54)	11.0 (1.2-20)
Fish Oil Oct.1968	1	16	7.3	3.5				100
Seal (grey) liver	1	96	41	44	3.9	1.7	1.8	4.1
Seal (common and grey) Sept.Nov.1968	2	130 (110-150)	62 (57-66)	30 (16-43)	66 (58-74)	32 (31-32)	15 (8.5-21)	52 (48-55)
Eggs from Guillemot May 1968	9	570 (300-790)	20 (7.5-38)	250 (140-360)	40 (20-51)	1.2 (0.7-2.3)	16 (7.9-21)	7.0 (3.6-11)
The Archipelago of Stockholm								
Mussel Oct.1966,Dec.1967	15	3 (1-4.7)	1 (1-1.8)	5.2 (3.4-7.0)	0.04 (0.01-0.061)	0.02 (0.01-0.024)	0.37 (0.032-0.044)	1.1 (0.94-1.3)
Herring May 1965	4	7.7 (4.3-11)	3.9 (2.0-5.3)	5.1 (3.3-8.5)	0.23 (0.094-0.30)	0.11 (0.044-0.15)	0.17 (0.073-0.23)	2.6 (2.2-2.8)
Seal (grey)* May 1968	3	170 (97-310)	17 (11-21)	30 (16-56)	36 (35-36)	4.2 (2.4-6.6)	6.1 (5.7-6.4)	27.1 (11.5-37.5)
White tailed eagle March-June 1965-66 Pectoral muscle	4	25 000 (16 000-36 000)	n.d.	14 000 (8 400-17 000)	330 (290-400)	n.d.	190 (150-240)	1.5 (0.9-2.0)
Brain	3	1 900 (1 700-2 100)	n.d.	910 (490-1 500)	100 (99-110)	n.d.	47 (29-70)	5.4 (4.6-6.0)
Eggs from white tailed eagle May-June 1966	5	1 000 (610-1 600)	n.d.	540 (250-800)	n.e.	n.e.	n.e.	5.6 (3.4-9.1)
Heron April 1967	1	14 000	n.d.	9 400	71	n.d.	48	0.51
Gulf of Bothnia								
Herring	4	6.2 (5.2-8.1)	3.5 (2.9-4.8)	1.5 (0.93-2.0)	0.26 (0.15-0.42)	0.14 (0.091-0.21)	0.065 (0.026-0.091)	4.4 (2.1-6.8)
Seal (ringed) May-Oct.1968	2	120 (110-130)	56 (54-57)	13 (9.7-16)	63 (58-68)	30 (28-31)	6.8 (5.0-8.5)	54 (52-55)
Gulf of Finland								
Seal pup (ringed) March 1968	2	42 (41-43)	23 (22-23)	6.5 (6.0-7.0)	25 (24-26)	14 (13-14)	3.9 (3.4-4.4)	60 (56-63)
Seal milk March 1968	1	36	21	4.5	11	6.5	1.4	31

* Σ DDT stands for DDT + DDE + DDD. For salmon and seal there were respectively 41 per cent DDD in Σ DDT, the mean figure being 17 per cent.

n.e. Not estimated

n.d. Not detected

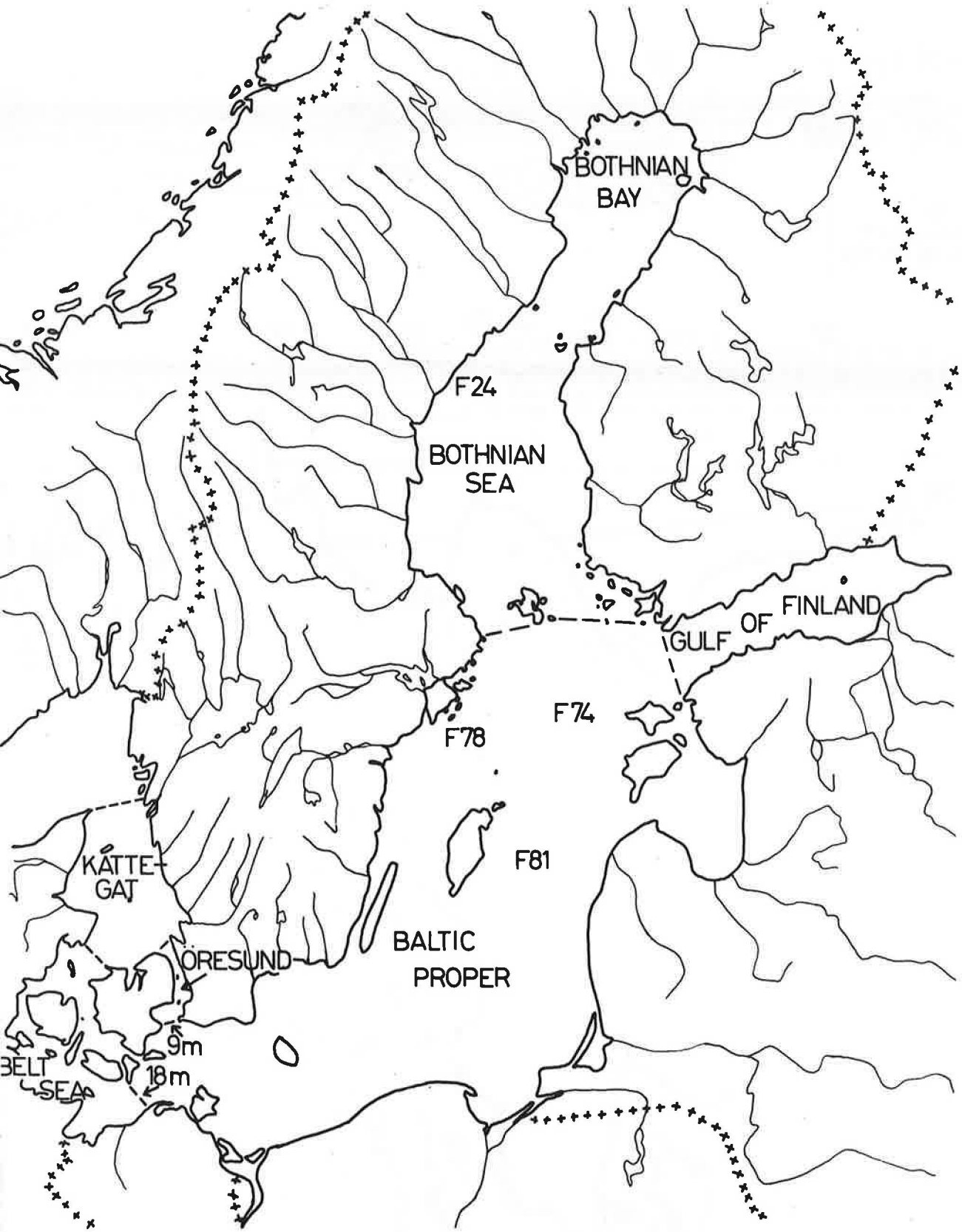
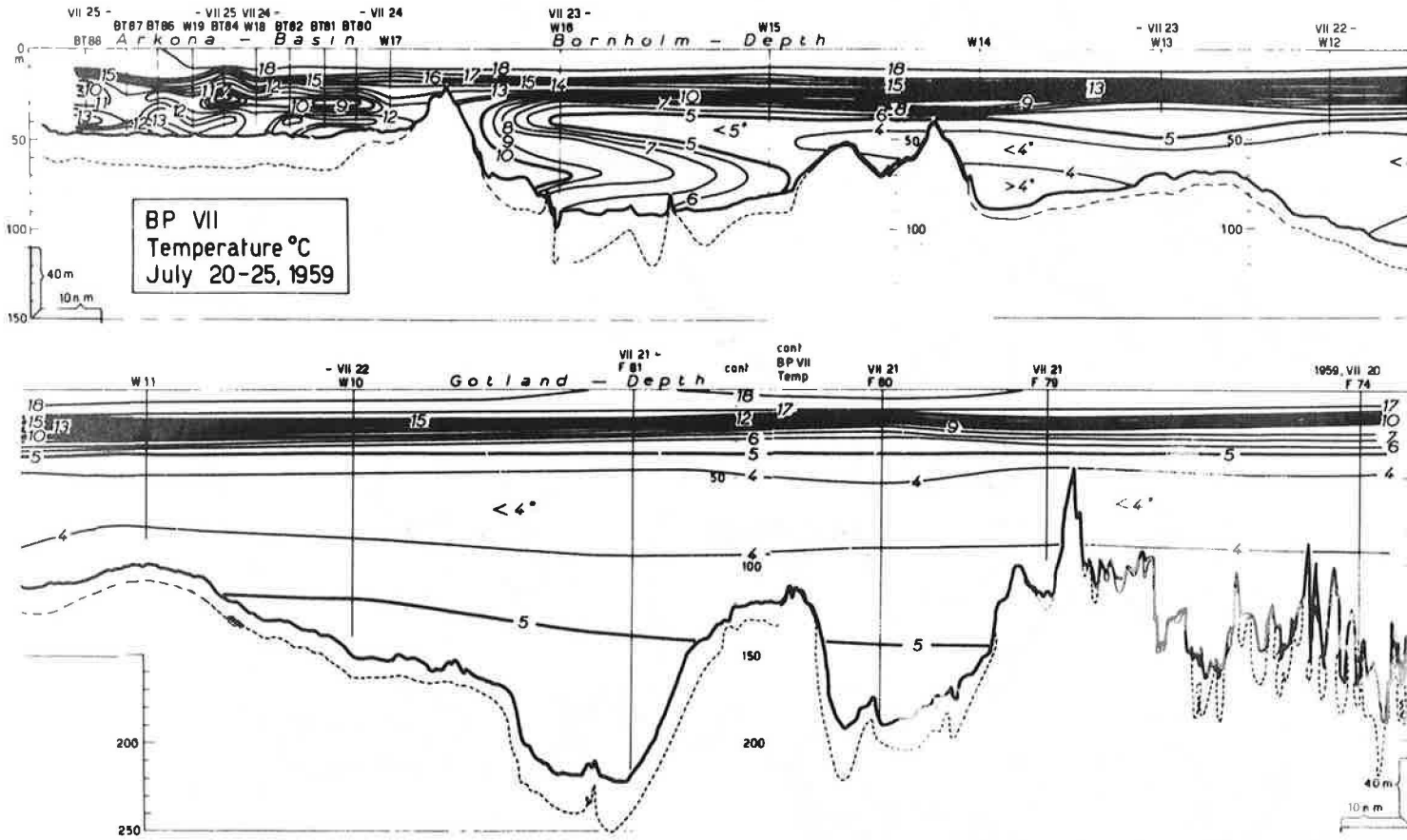

BOTHNIAN
BAY
F24
BOTHNIAN
SEA
GULF OF FINLAND
F74
F78
F81
KÄTTE-
GAT
ÖRESUND
BALTIC
PROPER
9m
18m
BELT
SEA

Fig. 1.


Arkona – Basin
Bornholm – Depth
Gotland – Depth
BP VII
Temperature °C
July 20-25, 1959
40 m
10 n m
cont
BP VII
Temp
1959, VII 20
F 74

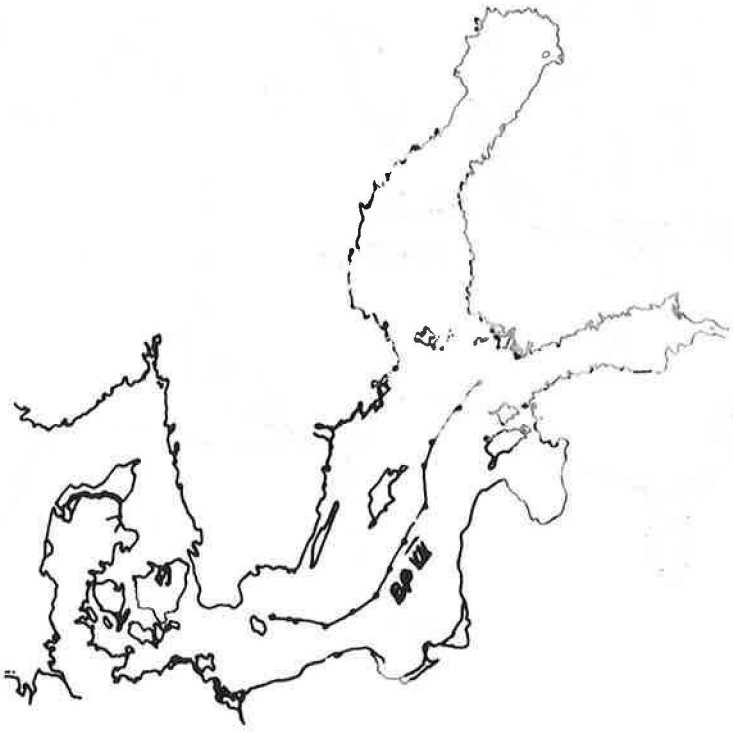
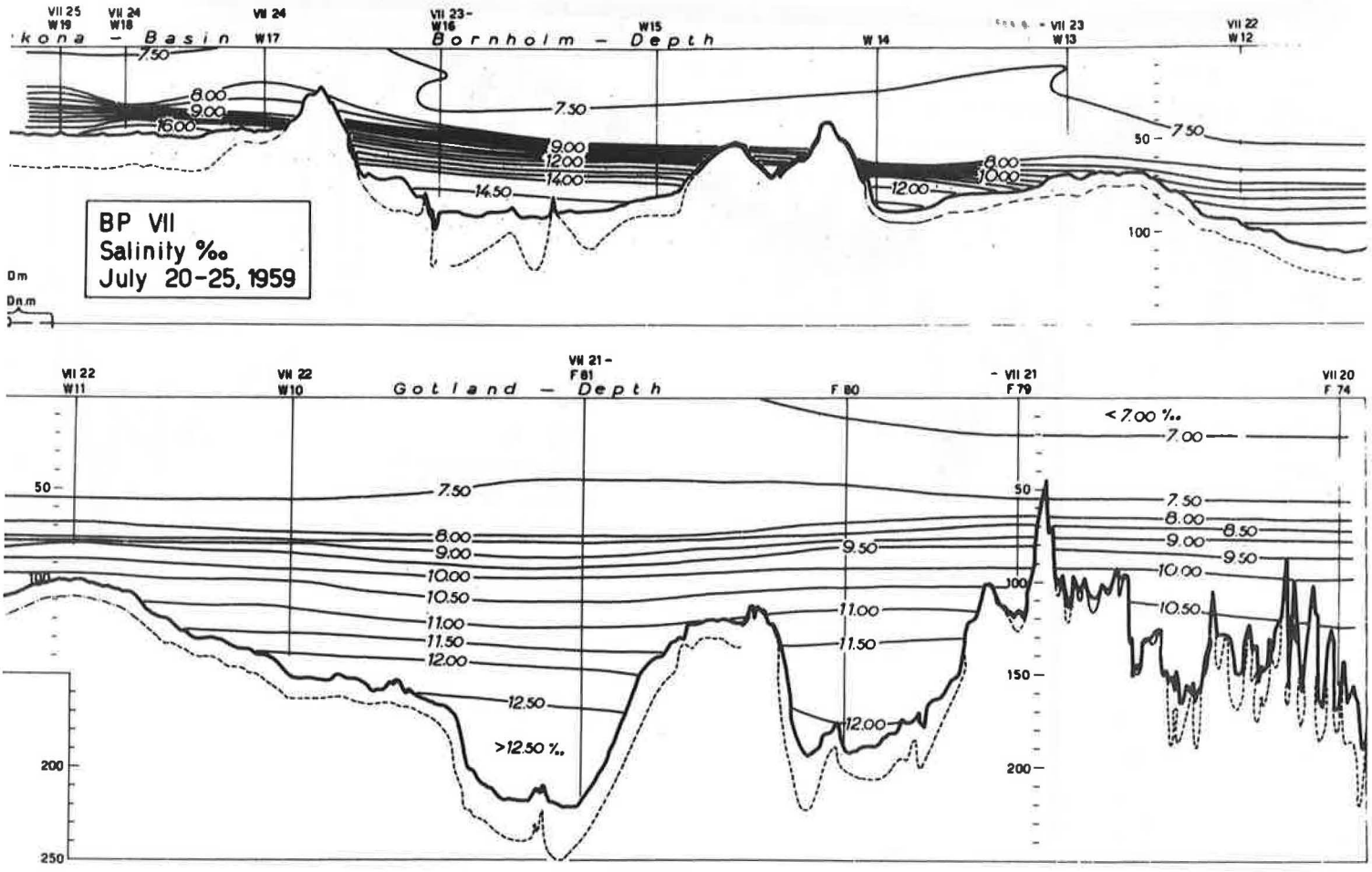
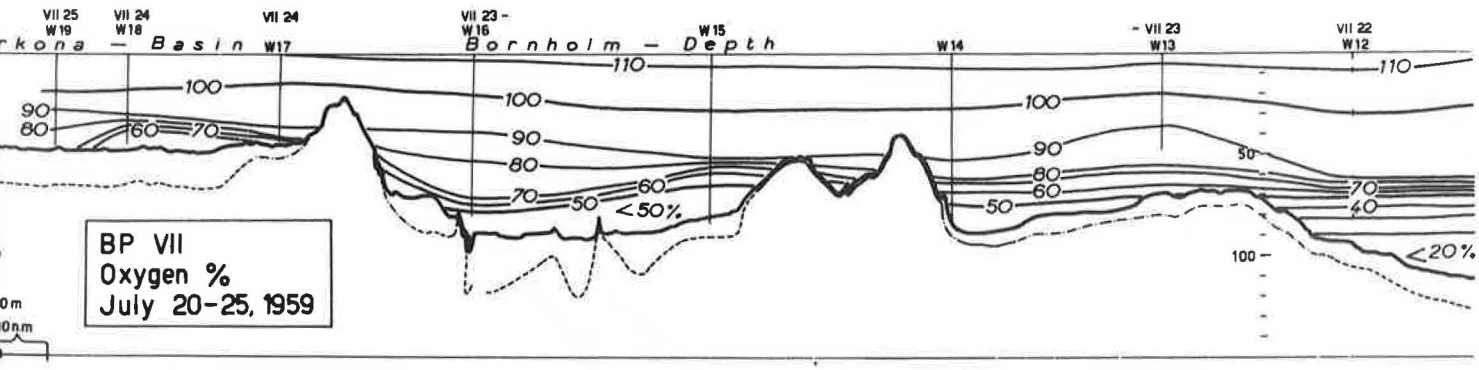

BP VII

FIG 2A


VII 25 W19
VII 24 W18
VII 24 W17
VII 23 - W16
W15
VII 23 W13
VII 22 W12
W 14
Bornholm - Depth
BP VII
Salinity ‰
July 20-25, 1959
7.50
8.00
9.00
16.00
12.00
14.00
14.50
100
50
Dm
Dnm

VII 22 W11
VII 22 W10
VII 21 - F81
F 80
VII 21 F 79
VII 20 F 74
Gotland - Depth
< 7.00 ‰
7.00
7.50
8.00
8.50
9.00
9.50
10.00
10.50
11.00
11.50
12.00
12.50
>12.50 ‰
50
100
150
200
250


VII 25 W19
VII 24 W18
VII 24 W17
VII 23 - W16
W15
W14
VII 23 W13
VII 22 W12
Bornholm - Depth
BP VII
Oxygen %
July 20-25, 1959
110
100
90
80
70
60
50
40
<50%
<20%
50
100
Dm
Dnm

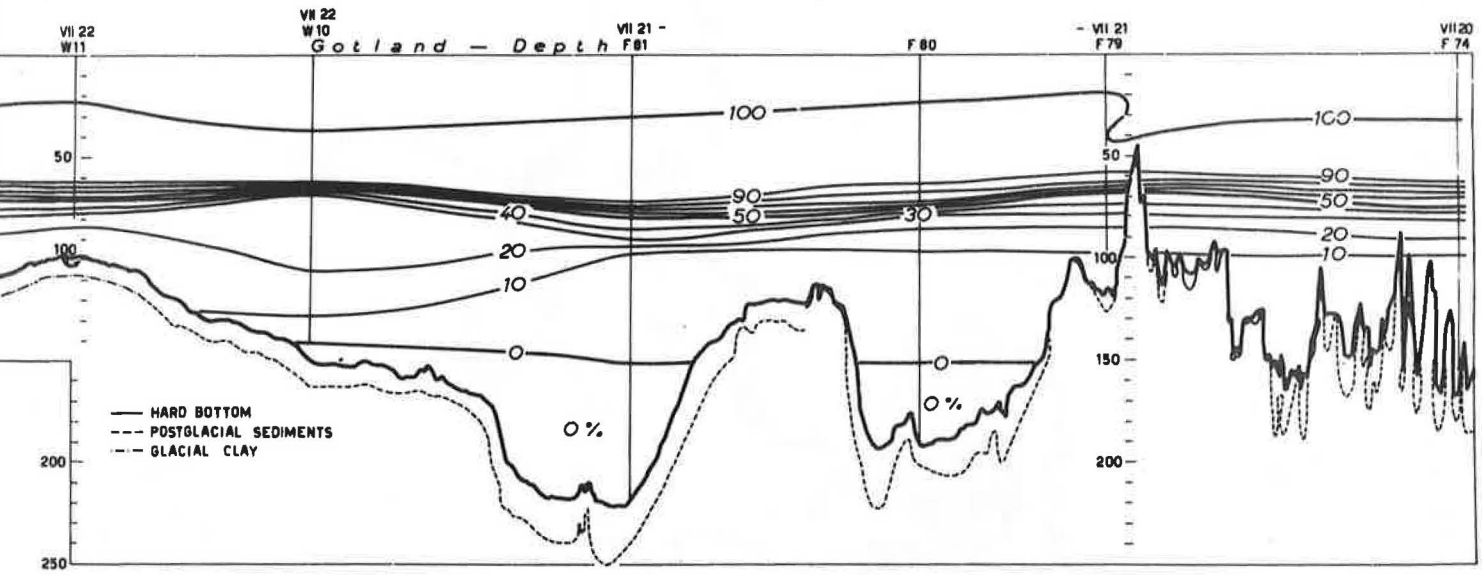
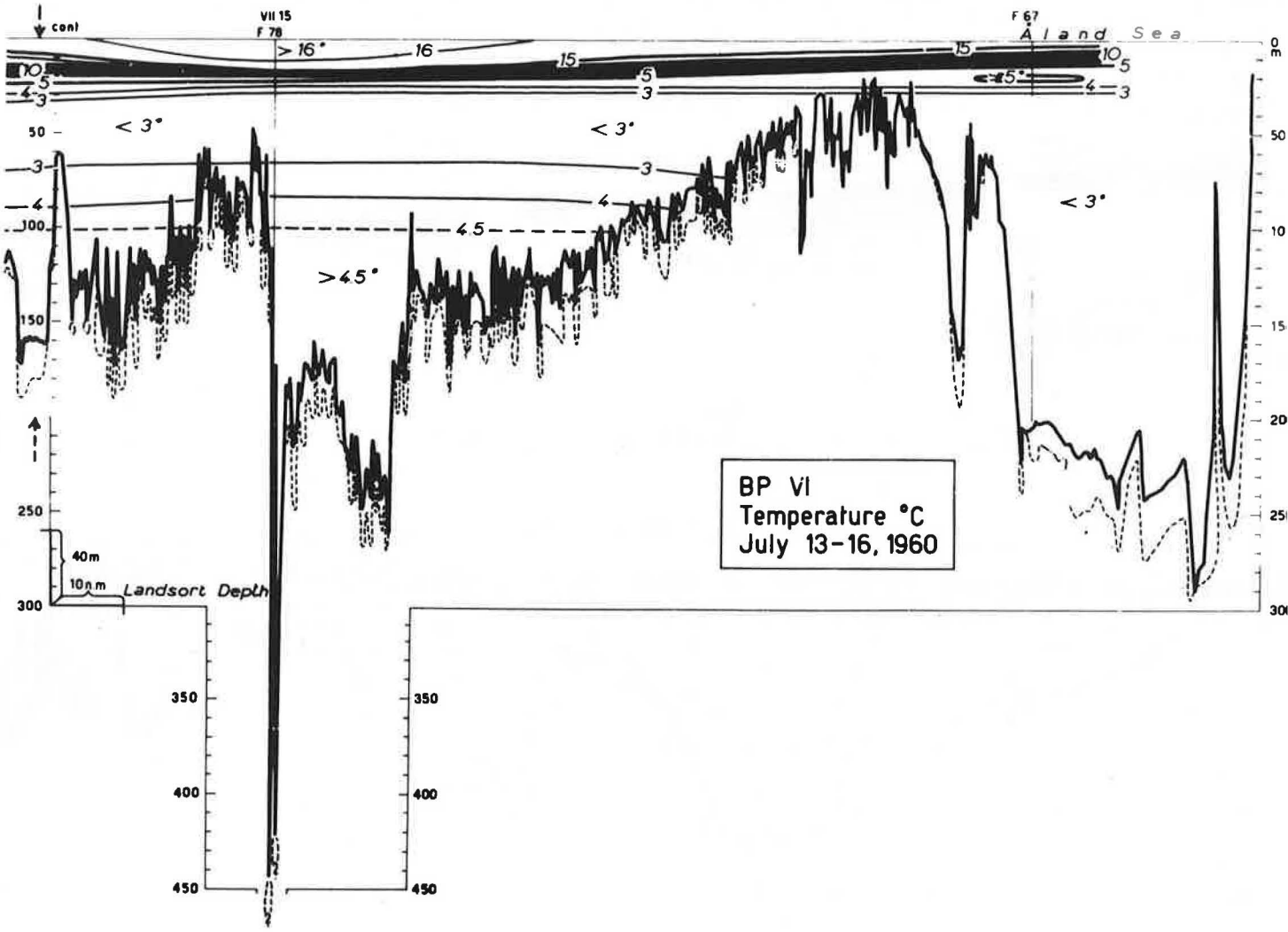

VII 22 W11
VII 22 W10
VII 21 - F81
F 80
VII 21 F 79
VII 20 F 74
Gotland - Depth
100
90
50
40
30
20
10
0
0 %
50
100
150
200
250
HARD BOTTOM
POSTGLACIAL SEDIMENTS
GLACIAL CLAY

FIG 2B


cont
VII 15
F 78
F 67
Åland Sea
> 16°
16
15
10
5
4
3
< 3°
> 45°
45
50
100
150
250
300
350
400
450
40m
10nm
Landsort Depth
BP VI
Temperature °C
July 13-16, 1960

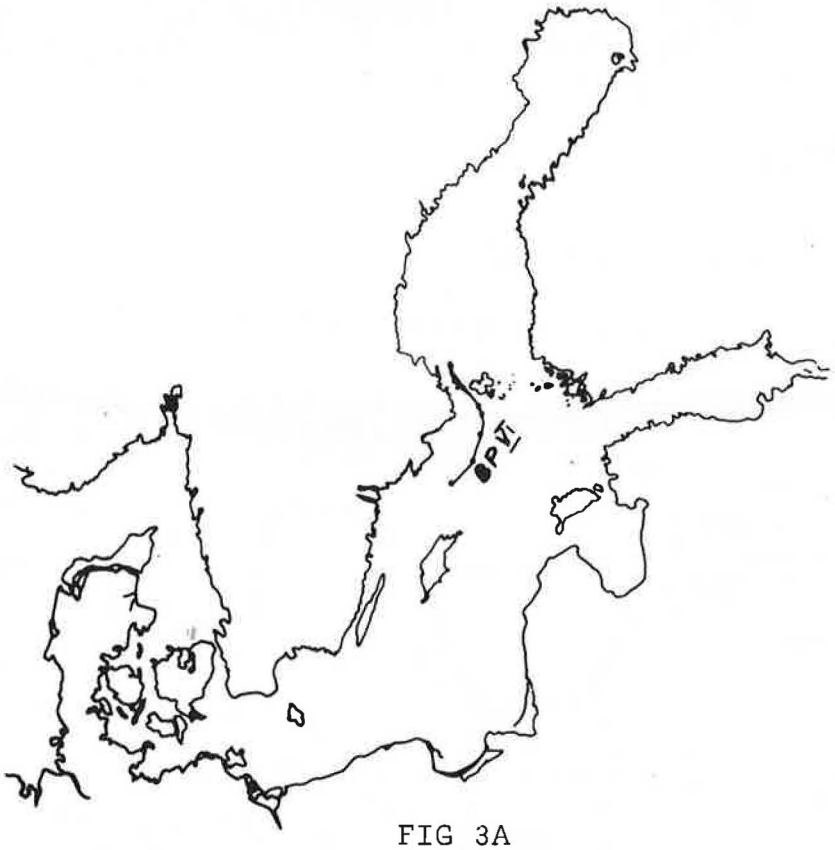
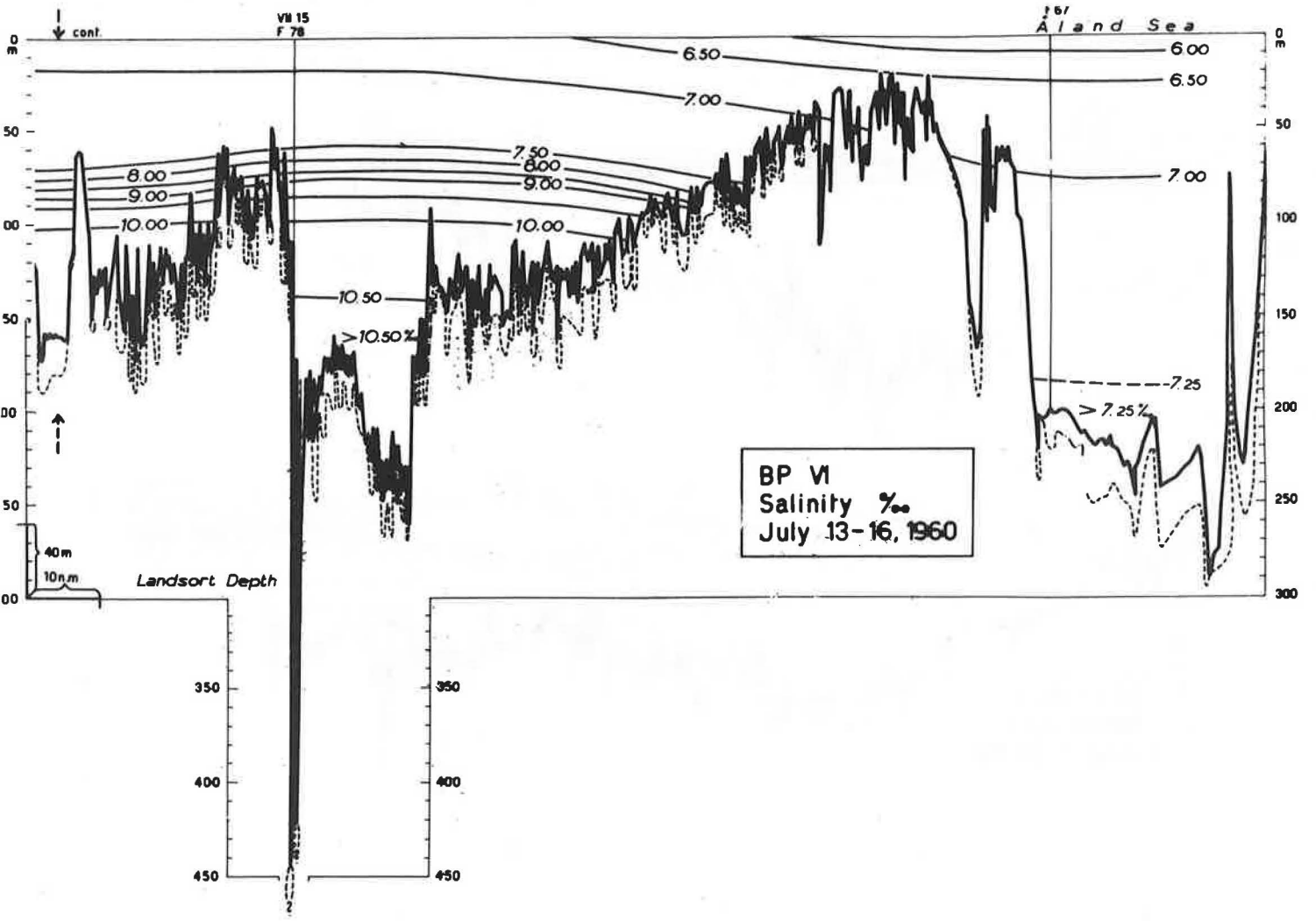

BP VI

FIG 3A


cont.
VII 15
F 78
Åland Sea
6.50
6.00
6.50
7.00
7.00
7.50
8.00
9.00
9.00
10.00
10.00
10.50
>10.50‰
7.25
>7.25‰
BP VI
Salinity ‰
July 13-16, 1960
40m
10n.m
Landsort Depth
350
400
450

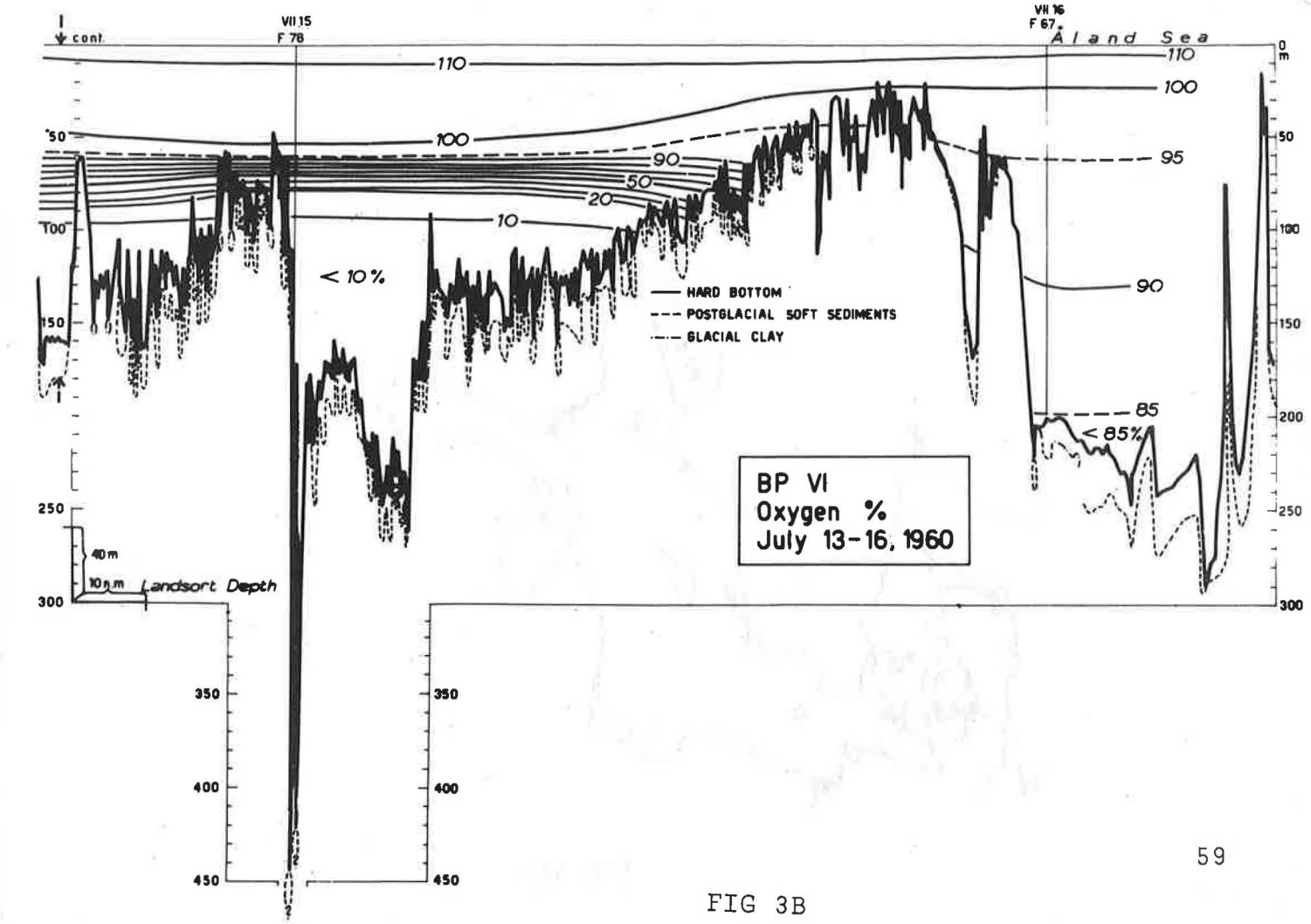
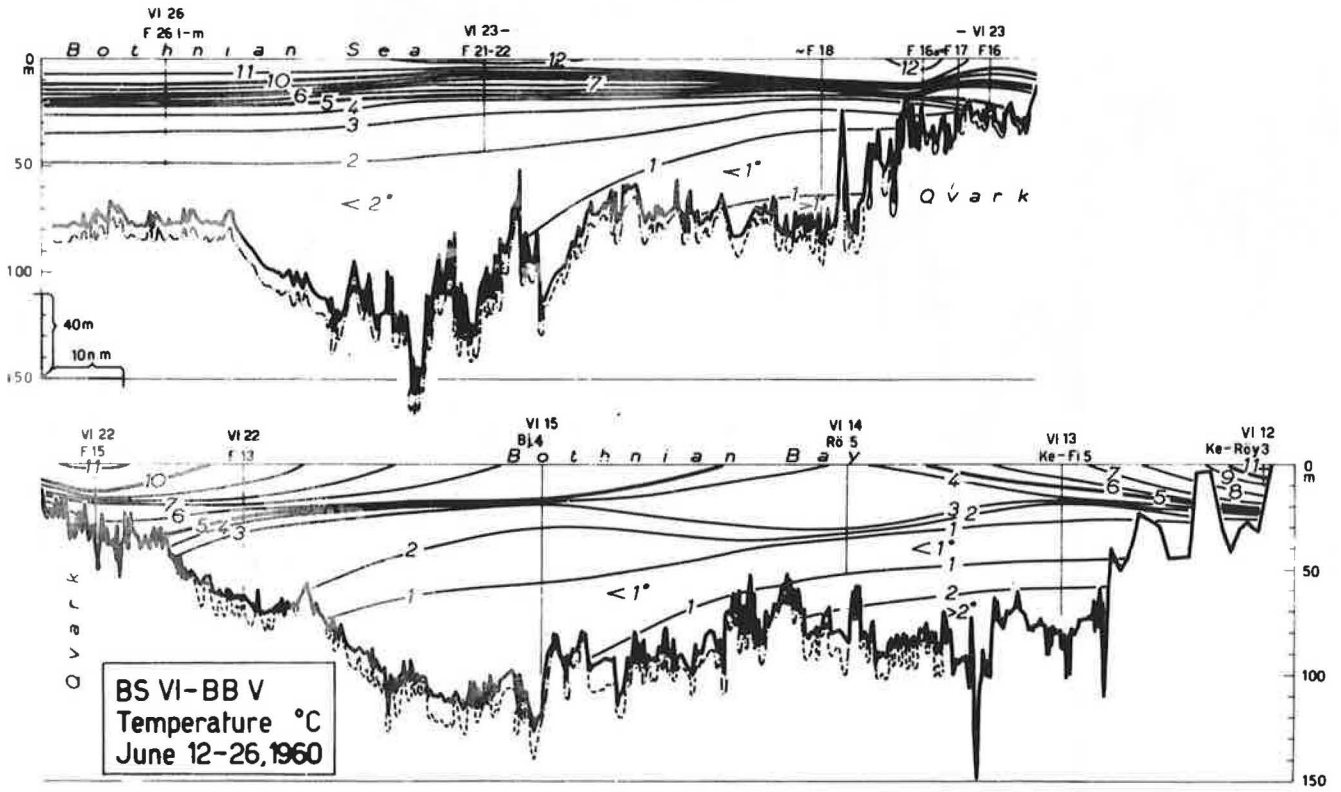

cont.
VII 15
F 78
VII 16
F 67
Åland Sea
110
110
100
100
95
90
50
20
10
<10%
90
85
<85%
HARD BOTTOM
POSTGLACIAL SOFT SEDIMENTS
GLACIAL CLAY
BP VI
Oxygen %
July 13-16, 1960
40m
10n.m
Landsort Depth
350
400
450

FIG 3B


VI 26
F 26 I-m
Bothnian Sea
VI 23-
F 21-22
~F 18
F 16
F 17
F 16
- VI 23
Qvark
40m
10n m
VI 22
F 15
VI 22
F 13
VI 15
Bj 4
Bothnian Bay
VI 14
Rö 5
VI 13
Ke-Fi 5
VI 12
Ke-Roy 3
Qvark
BS VI-BB V
Temperature °C
June 12-26, 1960

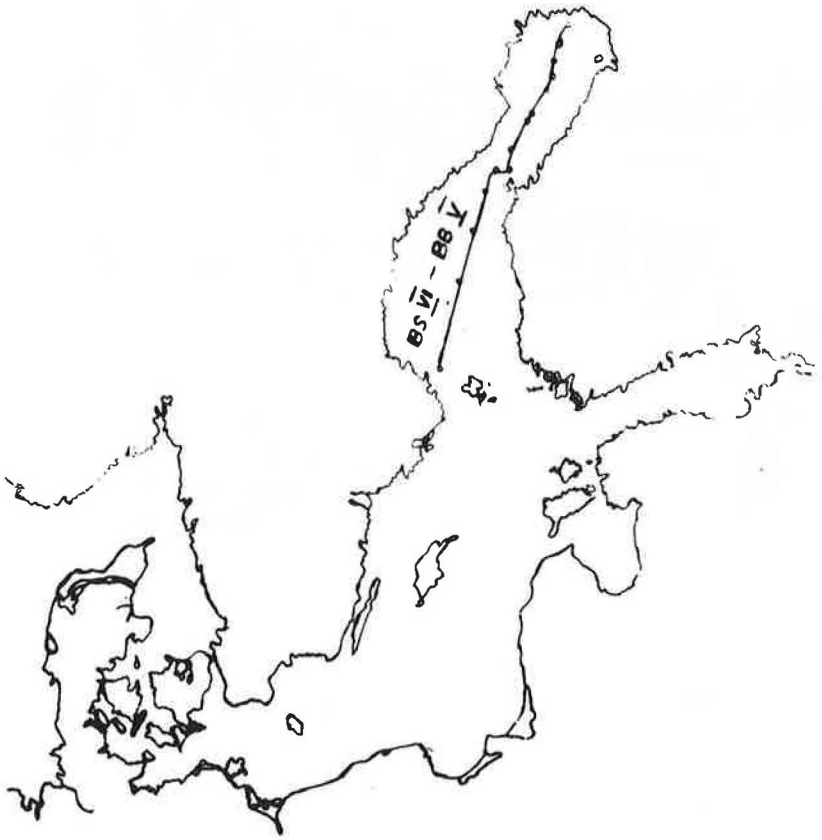
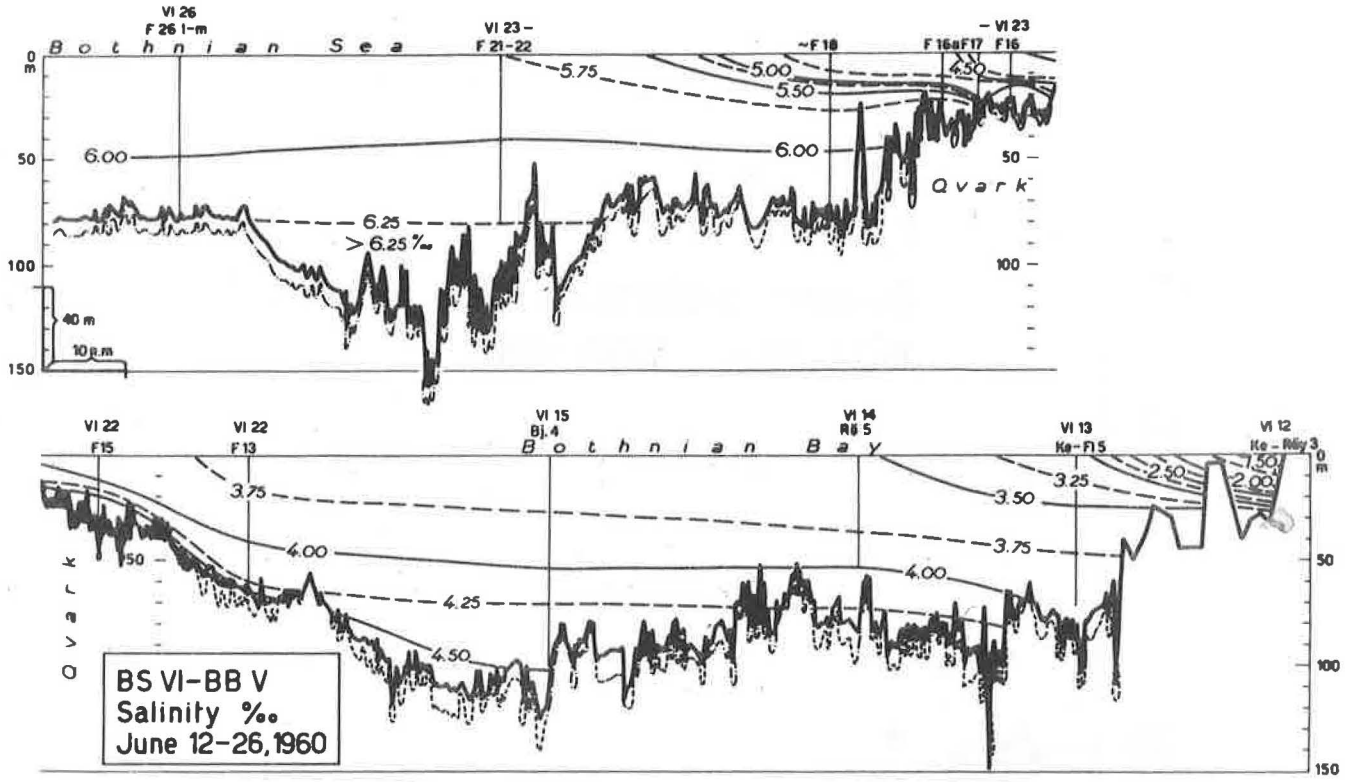

BS VI - BB V

FIG 4A


VI 26
F 26 I-m
Bothnian Sea
VI 23 -
F 21-22
~F 18
F 16aF17
VI 23
F16
5.75
5.00
5.50
4.50
6.00
6.00
6.25
>6.25 ‰
Qvark
40 m
10 n.m
VI 22
F15
VI 22
F 13
VI 15
Bj. 4
Bothnian Bay
VI 14
Rö 5
VI 13
Ke-Fi 5
VI 12
Ke-Röy 3
3.75
3.25
3.50
2.50
1.50
2.00
4.00
3.75
4.00
4.25
4.50
Qvark
BS VI-BB V
Salinity ‰
June 12-26,1960

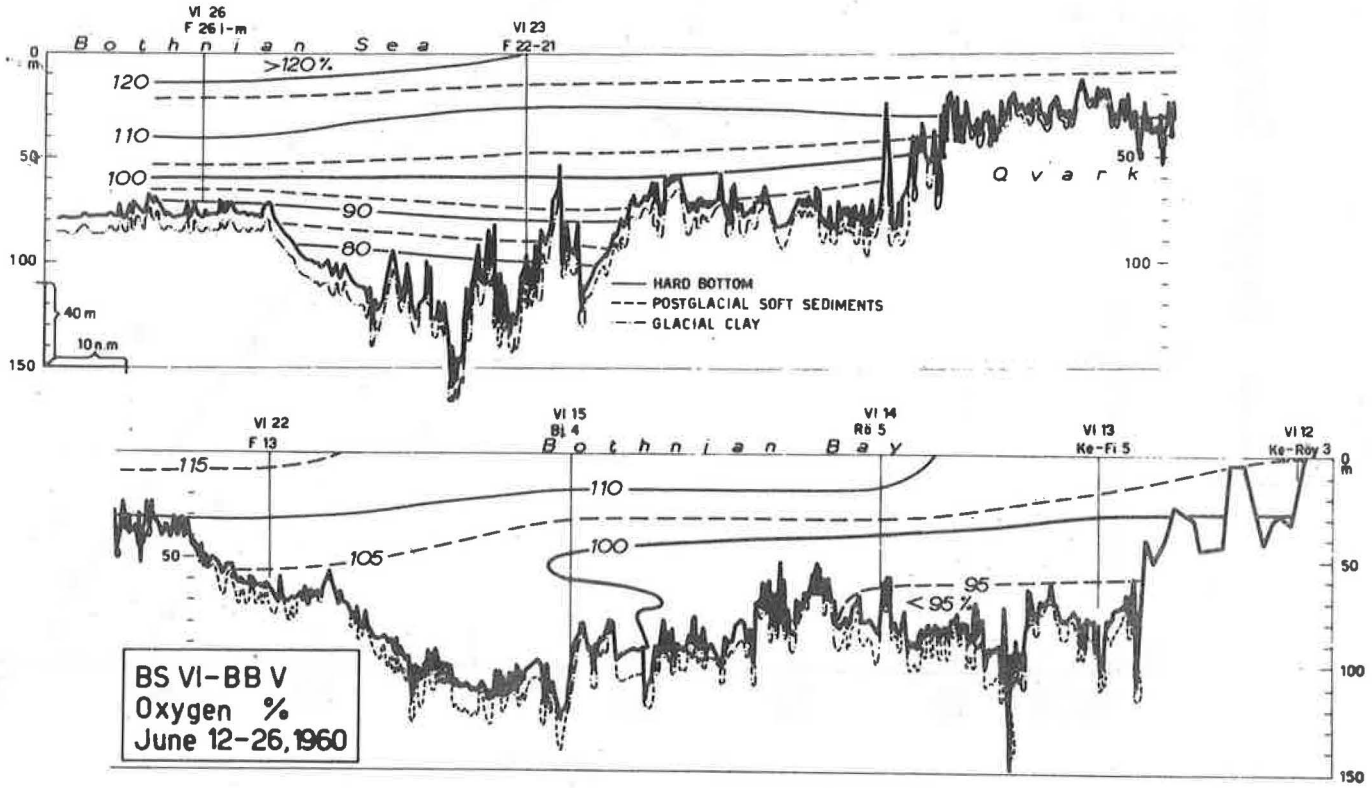

VI 26
F 26 I-m
Bothnian Sea
VI 23
F 22-21
>120%
120
110
100
90
80
Qvark
HARD BOTTOM
POSTGLACIAL SOFT SEDIMENTS
GLACIAL CLAY
40 m
10 n.m
VI 22
F 13
VI 15
Bj. 4
Bothnian Bay
VI 14
Rö 5
VI 13
Ke-Fi 5
VI 12
Ke-Röy 3
115
110
105
100
95
<95 %
BS VI-BB V
Oxygen %
June 12-26,1960

FIG 4B

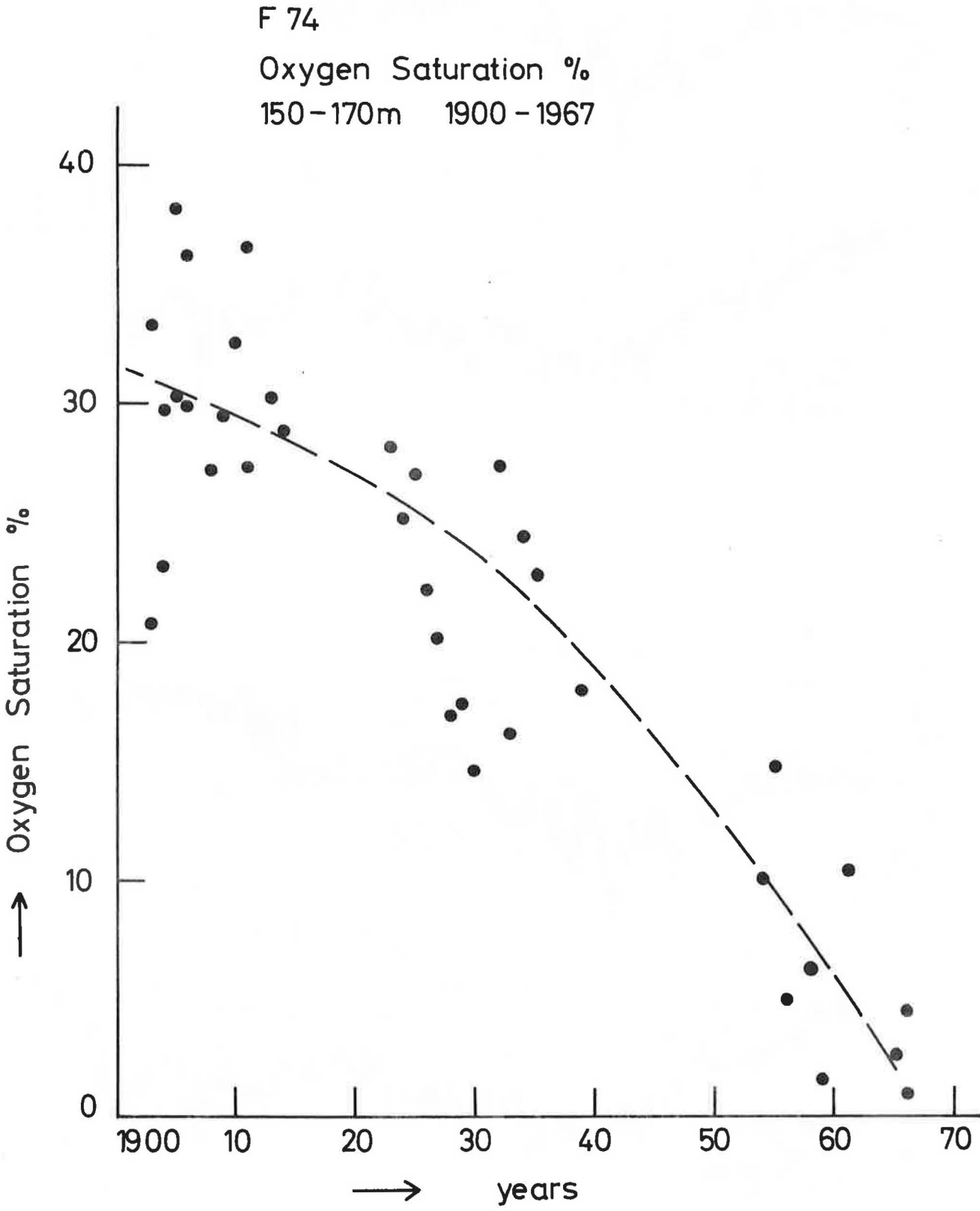

F 74
Oxygen Saturation %
150 – 170m 1900 – 1967
40
30
20
10
0
Oxygen Saturation %
1900
10
20
30
40
50
60
70
years

Fig. 5.

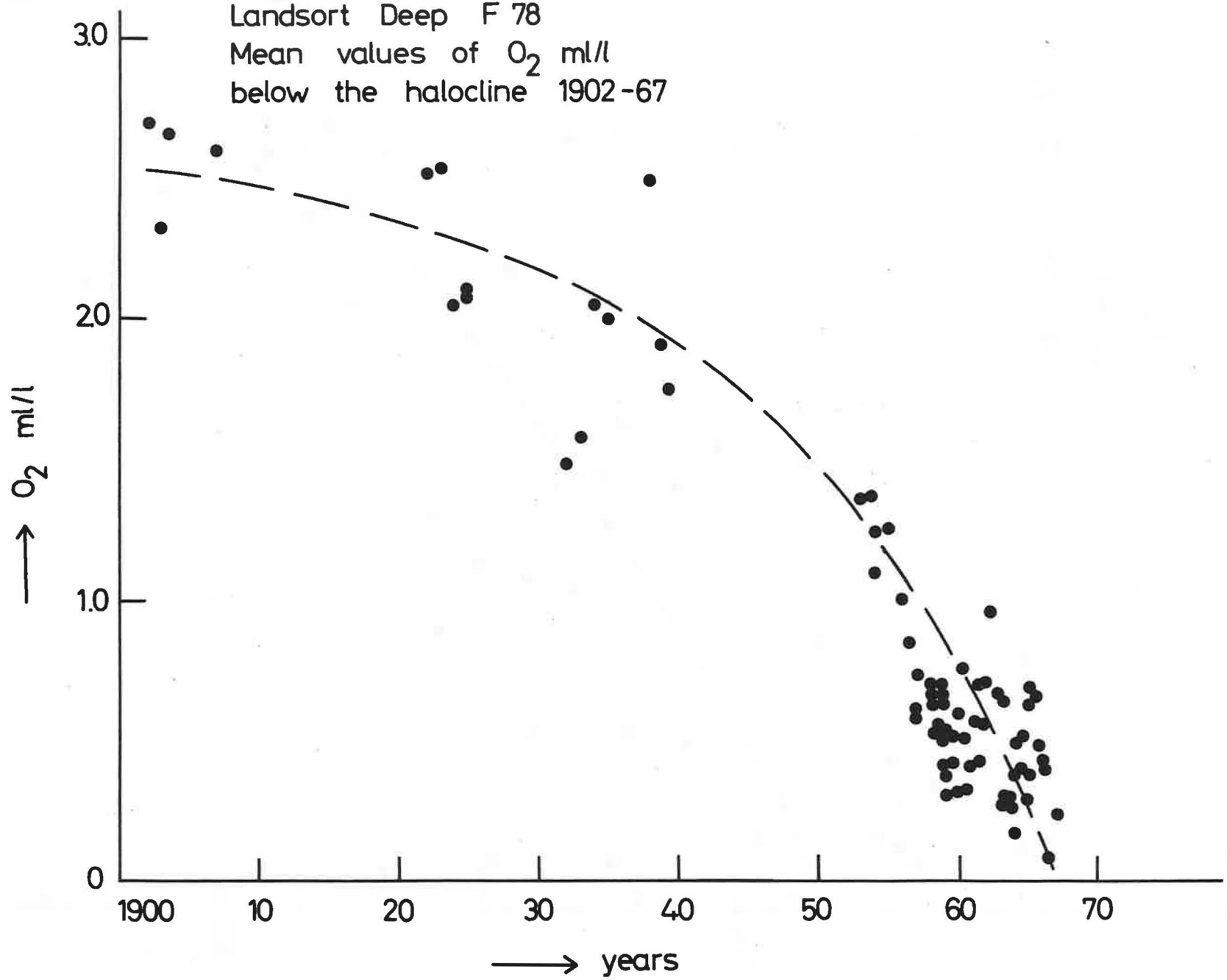

Landsort Deep F 78
Mean values of O_2 ml/l
below the halocline 1902-67
3.0
2.0
1.0
0
O_2 ml/l
1900
10
20
30
40
50
60
70
years

Fig.6.

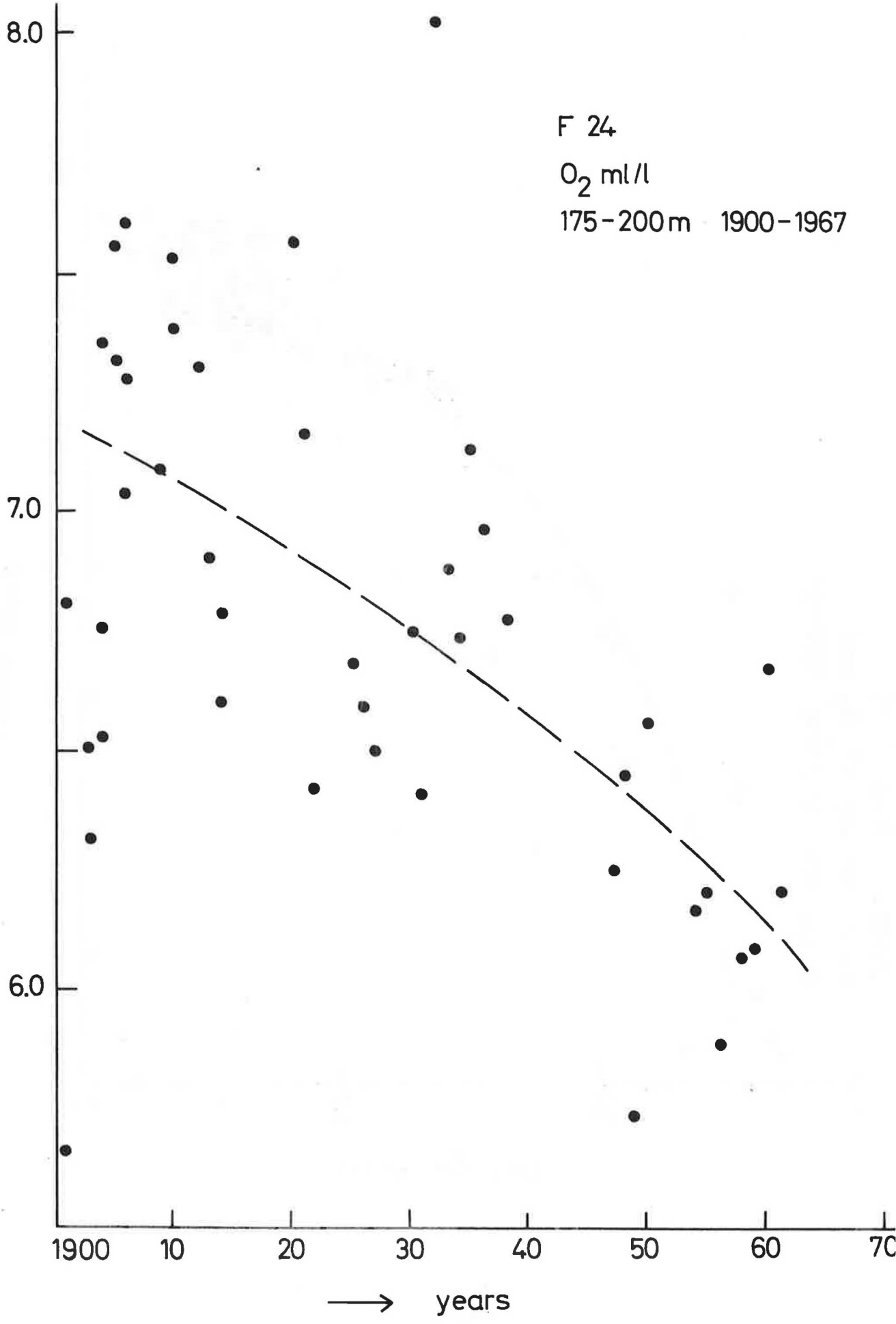
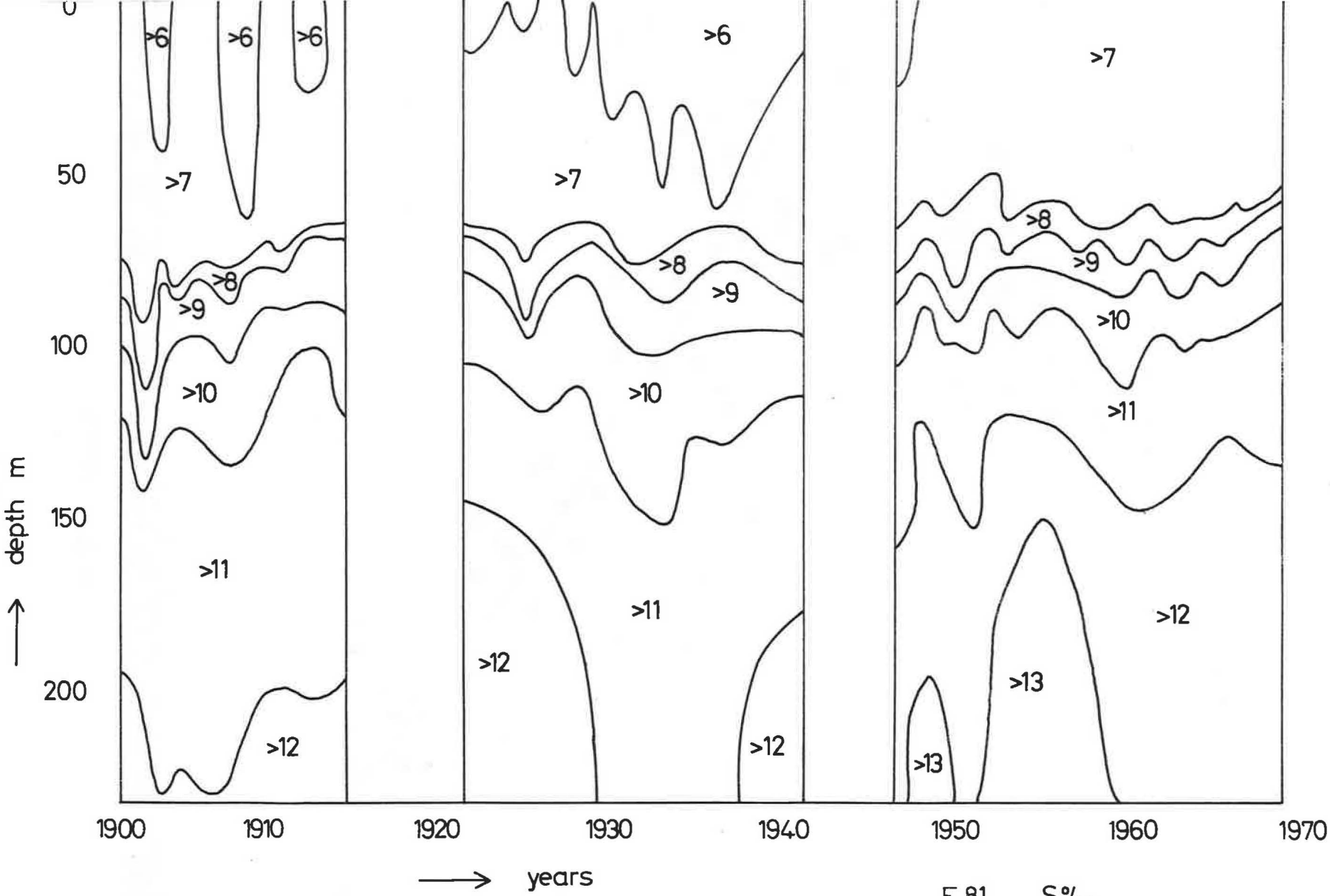

8.0
7.0
6.0
F 24
O_2 ml/l
175-200 m 1900-1967
1900
10
20
30
40
50
60
70
years

Fig. 7



F 81 S‰

Fig. 8. Yearly mean values

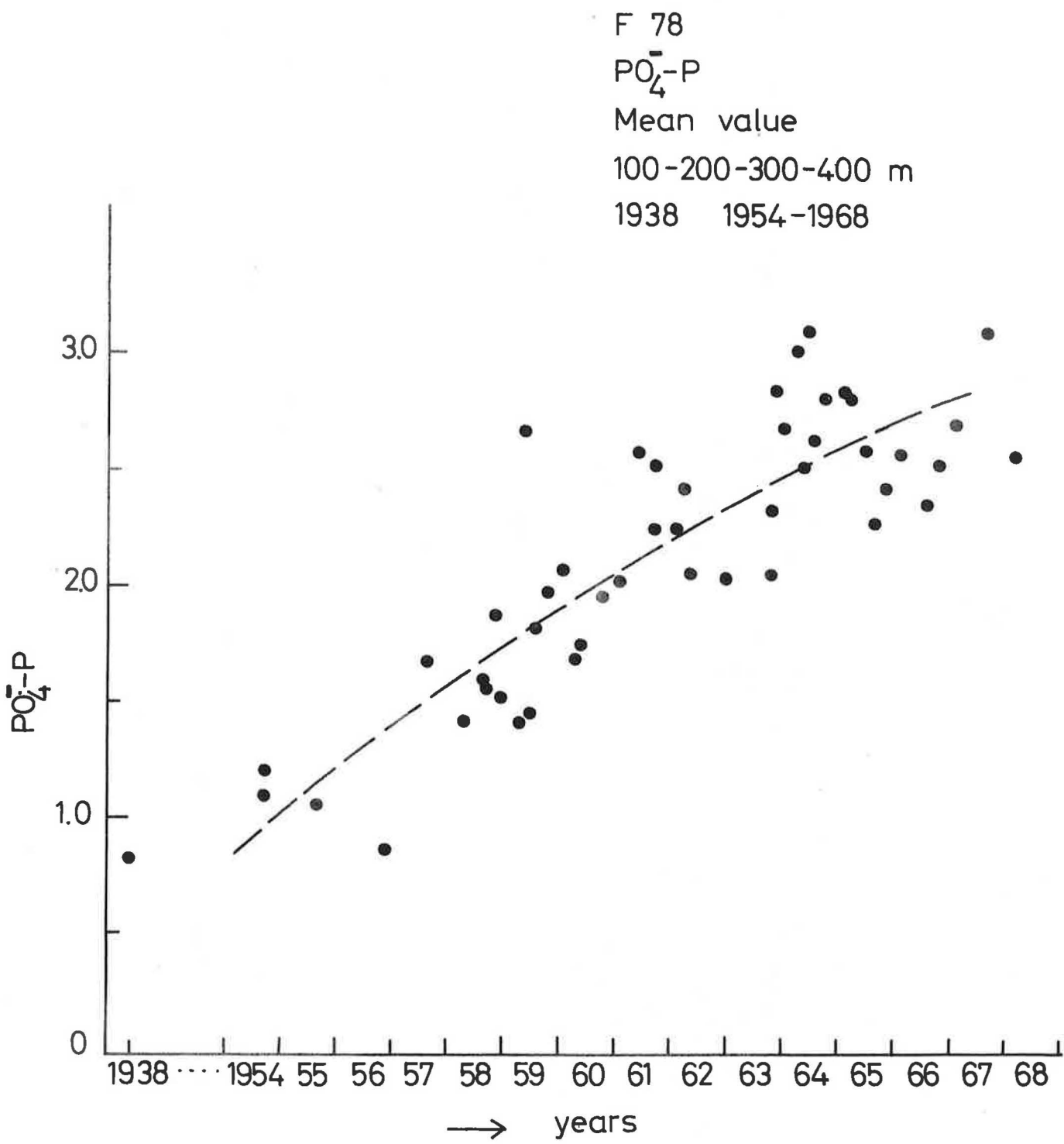

F 78
PO_4^--P
Mean value
100-200-300-400 m
1938 1954-1968
3.0
2.0
1.0
0
PO_4^--P
1938 · · · · 1954 55 56 57 58 59 60 61 62 63 64 65 66 67 68
years

Fig. 9.

APPENDIX I

Review of pollution transport and dispersion mechanisms especially in regard to Baltic conditions

By A. Aitsam

Pollutants discharged into the sea water alter the water environment and the change is accompanied by biological changes. Therefore, to avoid undesirable consequences, pollution must be kept within prescribed limits.

The individuality of organisms and the more or less random character of a pollution field caused by turbulence make it necessary to make probability analyses concerning the extension of the pollution field and the expected concentration levels (Aitsam, 1969). Consequently one must not only be interested in average values but also in extreme values, expected to be critical.

The extension of a pollution field in the marine environment is mainly caused by marine turbulence which takes its energy from the atmospheric and tidal forces, including wind influence and seiches.

Pollutants are discharged mainly in the form of sewage and other waste waters in which they are kept either as solutions, as solid particles or as films (oils). Only a limited part of the pollution is discharged into the sea without water (e.g. dumping of solid matters from industry, ships, etc.).

According to their physical and chemical properties the pollutants can be divided into stable and unstable, buoyant and submerging substances. The spreading of all kinds of polluting substances (except those in film-form) may be described according to the same general model of turbulent diffusion.

The velocities of sewage or other waste waters, at the moment when they are discharged, differ from the current velocities in the sea. The discharge velocity of pollutants influences the dispersion velocity in the vicinity of the outfall. This process can be called the initial dilution, diffusion in free turbulence, or turbulence in the region of primary velocities. The primary velocity of the waste water is small in comparison with the current velocity at some distance from the outfall and does not contribute much to the spreading of the pollution field.

Outside this initial zone the spreading is mainly influenced by the marine turbulence. This secondary process can be called diffusion in turbulent flow. The change-over between the two zones is smooth and can be estimated only conditionally.

Most investigations hitherto made to describe the spreading of pollution field parameters in the marine environment are based on averaged time studies. Only recently have some works based on probability analyses appeared in the literature (Gifford, 1959; Monin & Jaglom, 1967; Aitsam, 1968).

The diffusion process in the marine environment is usually described by means of differential equations for linear mass transfer, by making some assumptions concerning the kind of and properties of random functions describing the diffusion process, and by making use of turbulence similarity hypotheses and dispersion theories (Monin & Jaglom, 1965). Semi-empirical diffusion equations can also be derived by assuming the random function describing the diffusion process to be continous Markov functions. In the third case relations for more complicated conditions can be obtained (Monin & Jaglom, 1965; Hela & Voipio, 1960).

The characteristics of the marine velocity field must be known in order to calculate the pollution diffusion in the sea. To estimate the average time of the velocity field one can make use of mathematical model methods (Hansen, 1966; Leendertse, 1967; Tamsalu, 1967). The estimation of the probability characteristics of the marine velocity field has been discussed by Ozmidov (1958), Aitsam & Astok (1967, 1968). Determination of diffusion coefficients and their variation limits in the Baltic have been discussed by Joseph (1954), Ozmidov (1958, 1960, 1968), Okubo (1962), Bowdun (1964), Aitsam & Allpere (1967), and others.

Relations for pollution spreading under different boundary conditions and different assumptions concerning diffusion coefficients, have been presented by Aitsam (1968), Monin & Jaglom (1965, 1967), and Ozmidov (1968). The diffusion process of pollutants has been studied in nature by means of artificial tracers by several scientists, e.g. Harremoës (1964), Weidemann (1964), Voipio (1964) and van Dam (1966).

To describe the dispersal of pollutants in the region of primary dilution, simultaneous solution of differential equations describing the primary velocity field and the turbulent diffusion is used. The similarity hypothesis and dimension theories are

also used. Calculating relations for the time-averaged concentration field in the region of primary velocities are given by Abraham (1963, 1966).

The dilution of pollutants in the primary velocity field can be regulated by means of several kinds of diffusors. The purpose of obtaining a high initial dilution of pollutants is, (1) lowering of the critical concentration below a certain level at a short distance from the outfall, or (2) to intensify the decrease of the primary velocity in order to prevent the pollution plume from passing through the thermocline, that is to keep it submerged under the thermocline during the summer time.

Diffusors used to obtain a great initial dilution may cause some greater concentration values at large distances from the outfall than single and simple orifices.

In the literature are also discussed some special kinds of pollution dispersal in the marine environment, e.g. pollutants floating on the surface (oil) (Tomczak, 1964; Neumann, 1966), and in the wake of ships (Abraham & Hilberts, 1967).

References

Abraham, G., 1963. Jet diffusion in stagnant ambient fluid. - Delft Hydraulics Lab., No. 29.

--- 1966. Initiële menging. De afvoer van afvalwater naar zee. - 1. vakantiecursus in behandeling van afvalwater, 14-15 April, 1966, Delft. Moormans Period. Pers. N.V., Den Haag.

Abraham, G. & Hilberts, B., 1967. Mixing of waste acids in the wake of a propeller of a coaster. - Delft Hydraulics Lab., No. 51.

Aitsam, A.M., 1967. Discussion on the subject "Microturbulent diffusion and dispersion". - Proc. XII Congr. IAHR, 5.

--- 1968. Stohastický model vypouštěníodpadních vod do moře. Vodní Hospodářství, 6. - IV Mezinárodní konference o výzkumu znečištění vod, Praha 2-6 září 1968.

--- 1969. Ob opredelenii dopustimoĭ nagruzi zagryazneniya Finskogo zaliva. - I simp. sovet-sko - finskoĭ rabocheĭ gruppy po probleme "Okhrana vod Finskogo zaliva ot zagryazneniya", Helsinki.

Aitsam, A.M. & Allpere, A.R., 1967. Metodika opredeleniya glavnogo vertikal´nogo sostavlyayushchego tenzora koéffitsienta turbulentnoĭ diffuzii passénykh skalyarnykh veshchestv v moryakh. - Vsesoyazn. nauchn.-tekhn. konfer. po okhrane poverkhnostnykh i podzemnykh vod ot zagryazneniya, g. Tallin, 19-22 sentyabrya 1967 g. Dokl. i soobshch. po voprosam samoochishcheniya rodoemov i smeshcheniya stochnykh rod (II Vsesoyuzn. simpoz.), Tallin.

Aitsam, A.M. & Astok, V.K., 1967. Issledovanie i raschet samoochishchavushchei sposobnosti Tallinskogo zaliva. - B. sb. Morskie zalivy kak priemniki stochnykh vod. "Zinatne", Riga.

--- 1968. Nekotorye vychisleniya spektra sluchaĭnoĭ funktsiĭ s periodicheskimi sostavlyayushchimi (na primere spektra morskikh techeniĭ). - Izv. ANSSSR, Fizika atmosferch i okeana, t. Iu, No 7.

Astok, V.K. & Aitsam, A.M., 1967. Opredelenie stokhasticheskikh kharakteristik techeniĭ pri raschete samoochishcheniya. - V sb. Morskie zalivy kak priemniki stochnykh vod. "Zinatne", Riga.

Bowden, K.F., 1964. Turbulence. - Oceanography and Marine Biology, 2.

van Dam, G.C., 1966. Concentratieverdeling bij lozing in zee. De afvoer van afvalwater naar zee. - 1. vakantiecursus in behandeling van afvalwater, 14-15 April, 1966, Delft. Moormans period. Pers. N.V., Den Haag.

Gifford, F., 1959. Statistical properties of a fluctuating plume dispersion model. - Adv. Geophys., 6.

Hansen, W., 1966. Die Reproduktion der Bewegungsvorgänge im Meere mit hydrodynamisch-numerischem Verfahren. - Mitt.Inst.Meeresk. Univ. Hamburg, 5.

Harremoës, P., 1964. Prediction of pollution from planned sewage outlets. - Teknillisen Kemian Aikakanslehti, 21.

Hela, I. & Voipio, A., 1960. Tracer dyes as a mean of studying turbulent diffusion in the sea. - Ann. Acad. Scient.Fennicae, Ser. A, VI. Physica, 69.

Joseph, J., 1954. Die Sinkstoffführung von Gezeitenströme als Austauschproblem. - Arch.Met.Geophys. Bioklim., A 7.

Joseph, J. & Sendner, H., 1958. Über die horizontale Diffusion im Meere. - Dt. Hydrogr. Z., 11.

Joseph, J., Sendner, H. & Weidemann, H., 1964. Untersuchungen über die horizontale Diffusion in der Nordsee. - Dt. Hydrogr.Z., 17.

Leendertse, J.J., 1967. Aspects of a computational model for long period water-wave propagation. - Rand Corporation, Sta Monica, U.S.A.

Monin, A.S., 1968. Turbulentnaya diffuziya v moryakh. - Doklad na simpoziume KAPG, Moskva.

Monin, A.S. & Jaglom, A.M., 1965. Statisticheskaya gidrologieskiĭe. I. Izv. - "Nauka", Moskva.

--- 1967. Statisticheskaya gidrologieskiĭe. II.Izv. - "Nauka", Moskva.

Neumann, H., 1966. Die Beziehung zwischen Wind und Oberflächenströmung auf Grund von Triftkartenuntersuchungen. - Dt. Hydrogr. Z., 19.

Okubo, A., 1962. Horizontal diffusion from an instantaneous point-source due to oceanic turbulence. - Tech. Rep. Chesapeake Bay Inst., No. 32.

Ozmidov, R.V., 1958. O raschete gorisontal´noĭ turbulentnoĭ diffuzii pyatna primesi v more. - Dokl. ANSSSR, 1958, 120, No. 4.

--- 1960. Diffuziya primesi v pole odnorodnoĭ izotropnoĭ turbulentnosti. - Izv. ANSSSR, ser. geofiz., 1958, No. 2.

--- 1968. Gorizontal´naya turbulentnost´ i turbulentnyĭ obmen v okeane. - "Nauka", Moskva.

Tamsalu, R.Z., 1967. O raschete prilivny techniĭ na nelineĭnoĭ gidrologicheskiĭ modeli pri raschete samoochishcheniya morei. - Vsesoyuzn. nauchn.-tekh. konfer. po okhrane poverkhnostnykh i podzemnykh rod ot zagryazneniya, g. Tallin, 19-22 sentyabrya 1967 g. Dokl. i soobshch. po voprosam samoochishcheniya rodoemov i smeshcheniya stochnykh rod (II. Vsesoyuzn.simpozium). Tallin.

Tomczak, G., 1964. Investigations with driftcards to determine the influence of the wind on surface currents. - Studies on Oceanography, pp 129-139. Univ. Washington Press.

Voipio, A., 1964. Jäteveden johtaminen mereen. - Rakennustekniikka, 6, 1964.

APPENDIX II

Bibliographies of works on marine pollution and related subjects in the Baltic Sea

Federal Republic of Germany

Ahrens, R. & G. Rheinheimer, 1967. Über einige sternbildende Bakterien aus der Ostsee. - Kieler Meeresf., 23, 127-136.

Banse, K., 1957. Ergebnisse eines hydrographisch-produktionsbiologischen Längsschnitts durch die Ostsee im Sommer 1956. II. Die Verteilung von Sauerstoff, Phosphat und suspendierter Substanz. - Kieler Meeresf., 13, 185-201.

Bauer, K., 1961. Studies of the action of pesticides on fish and fish-food at Bundesanstalt für Land- und Forstwirtschaft. - Berlin-Dahlem, Heft 105, Verlag Paul Parey. Berlin und Hamburg.

Bock, K.J., 1960. Biologische Untersuchungen, insbesondere der Ciliatenfauna, in der durch Abwässer belasteten Schlei (westliche Ostsee). - Kieler Meeresf., 16, 57-68.

Boje, R., 1965. Die Bedeutung der Nahrungsfaktoren für das Wachstum von Mytilus edulis L. in der Kieler Förde und im Nord-Ostsee-Kanal. - Kieler Meeresf., 21, 81-100.

Dietrich, G., 1950. Die natürlichen Regionen von Nord- und Ostsee auf hydrographischer Grundlage. - Kieler Meeresf., 7, 35-69.

Friedrich, H. & H. Lüneberg, 1962. Contributions to a bibliography "Sewage in sea water". - Veröffentl. d. Inst. f. Meeresf. Bremerhaven, 8, 37-52.

Gieskes, J.M.T.M., 1968. Some hydrographical observations on salt brine pollution in the Kiel Fjord. - Helgol. wiss. Meeresunters. 17, 411-421.

Gunkel, W., 1967. Experimental ecological investigations regarding the limiting factors of microbial oil degradation in the marine environment. - Helgol.wiss.Meeresunters., 15, 210-225.

Gunkel, W. & H.H. Trekel, 1967. On the method of quantitative determination of oil decomposing bacteria in oil-polluted sediments and soils, oil-water mixtures, oils and tarry substances. - Helgol.wiss.Meeresunters., 16, 336-348.

Halsband, E. & I., 1963. On the changes in blood of fishes as a result of damage by toxins. - Arch.f.Fischereiwiss., 8, 68-85.

-"- 1966. On the behaviour of fish in an electric field when subjected to different industrial effluents. - Arch. f. Fischereiwiss., 8, 134-149.

-"- 1968. Physiological study methods in the examination of the harmfulness of some waste water discharges to fresh, brackish and salt waters. - Helgol. wiss. Meeresunters., 17, 224-246.

Hellmann, H., K. Klein & H. Knöpp, 1966. Examination of the use of emulsifiers for the removal of oil from water. - Dt.Gewässerk. Mitt., 10, 29-35.

Hellmann, H. & Knöpp, H., 1967. Further investigations on the use of emulsifiers for the removal of oil from water. - Dt. Gewässerk. Mitt., 11, 91-95.

Kändler, R., 1953. Hydrographische Untersuchungen zum Abwasserproblem in den Buchten und Förden der Ostseeküste Schleswig-Holsteins. - Kieler Meeresf., 9, 176-200.

-"- 1956. Die hydrologischen Verhältnisse in den Buchten und Förden der Ostseeküste Schleswig-Holsteins im Hinblick auf die Abwasserbelastung. - Arbeit. d. Dtsch. Fisch. Verbandes., Heft 7, 17-24.

-"- 1963. Hydrographische Untersuchungen über die Abwasserbelastung der Flensburger Förde. - Kieler Meeresf., 19, 142-157.

Kayser, H., 1969. Rearing experiments on two marine flagellates (Dinophyta) and their application to a toxicological waste water test. - Helgol.wiss.Meeresunters., 19, 21-44.

Kinne, O. & H. Rosenthal, 1967. Effects of sulphuric water pollutants on fertilization, embryonic development and larvae of the herring, Clupea harengus. - Marine Biology, 1, 65-83.

Krey, J., 1956. Die Trophie küstennaher Meeresgebiete. - Kieler Meeresf. 12, 46-64.

-"- Ergebnisse eines hydrographisch-produktionsbiologischen Längsschnitts durch die Ostsee im Sommer 1956. III. Die Verteilung des Gesamtphosphors. - Kieler Meeresf., 13, 201-211. 1957.

-"- 1961. Beobachtungen über den Gehalt an Mikrobiomasse und Detritus in der Kieler Bucht 1958-1960. - Kieler Meeresf., 17, 163-175.

Krey, J., P.H. Koske & K.H. Szekielda, 1965. Produktionsbiologische und hydrographische Untersuchungen in der Eckernförder Bucht. - Kieler Meeresf., 21, 135-143.

Krey, J. & K.H. Szekielda, 1966. Gesamtkohlenstoff und Mikrobiomasse in der Ostsee im Mai 1962. - Kieler Meeresf., 22, 64-69.

Kühl, H. & H. Mann, 1967. The toxicity of various oil-counteracting agents for sea and freshwater animals. - Helgol. wiss. Meeresunters., 16, 321-327.

Mann, H., 1965. Effects on the flavour of fishes by oils and phenols. - Symp. Monaco April 1964. Pollutions marines par les micro-organismes et les produits pétroliers, CIESM, 1964, 371-374.

-"- 1966. Tests with binding agents for the removal of oil in its operation upon fish and their food animals. - Fischwirt., 16, 153-156.

Nellen, W., 1965. Beiträge zur Brackwasserökologie der Fische im Ostseeraum. - Kieler Meeresf., 21, 192-199.

Rheinheimer, G., 1967. Verschmutzung und Selbstreinigung des Meeres. - Christiana Albertina, 3, 39-46.

Rosenthal, H. & W. Gunkel, 1967. Effects of crude oil-emulsifier mixtures on marine fish fry and their food animals. - Helgol. wiss. Meeresunters., 16, 315-320.

Schwenke, H., 1964. Vegetation und Vegetationsbedingungen in der westlichen Ostsee. - Kieler Meeresf., 20, 157-168.

Wallhäuser, K.H., 1967. Oil decomposing micro-organisms in nature and technique. - Helgol. wiss. Meeresunters., 16, 328-335.

Wattenberg, H., 1941. Über die Grenzen zwischen Nord- und Ostseewasser. - Ann. Hydr. u. marit. Met., 69.

Weber, E., 1965. Einwirkung von Pentachlorphenolnatrium auf Fische und Fischnährtiere. - Biol. Zentralbl., 84, 83-93.

Weichart, G., 1968. Veränderungen des Meeres durch Abfälle und die darauf basierende Einführung von fünf Gefahrenklassen für das Einbringen von Abfällen ins Meer. - Helgol. wiss. Meeresunters., 17, 398-410.

Wuhrmann, K., 1952. On some of the principles of fish toxicology. - Bull. du Centre Belge d'Etude et de Documentation des Eaux, 15.

Wuhrmann, K. & H. Woker, 1950. Statistical considerations of toxicity experiments with fish poisons in open waters. - Ibid., 12, 79-93.

-"- 1953. On the wastes from ammonia and cyanide undertakings, with various oxygen levels and temperatures, to fish. - Ibid., 15, 236-260.

Wüst, G., 1957. Ergebnisse eines hydrographisch-produktionsbiologischen Längsschnitts durch die Ostsee im Sommer 1956. I. Die Verteilung von Temperatur, Salzgehalt und Dichte. - Kieler Meeresf., 13, 163-185.

Finland

Pollution by sewage and hydrographic aspects of the pollution.

Bagge, P., 1969. Effects of pollution on estuarine ecosystems. II. The succession of the bottom fauna communities in polluted estuarine habitats in the Baltic-Skagerak region. - Merentutkimuslait. Julk./Havsforskningsinst. Skr., No. 228, 119-130.

Bagge, P. & A. Voipio, 1967. Disturbed bottom and hydrographic conditions in some coastal areas of Finland. Loviisa. - Merentutkimuslait. Julk./Havsforskningsinst. Skr., No. 223, 3-12.

Bergmann, K.G., 1908. Studier öfver inverkan af Helsingfors affallsvatten på vatten kring staden sommaren 1908 (Studies of the effects of sewage on the waters off Helsinki in summer 1908). - Hälsovårdsnämndens i Helsingfors Årsberättelse för år 1907 40 pp. Helsingfors 1908.

Hela, I., 1960. The hydrographic features of the Baltic Sea and the disposal of radioactive wastes. Disposal of Radioactive Wastes, IAEA, Vienna 1960, pp. 573-587.

Häyrén, E., 1921. Studier över föroreningens inflytande på strändernas vegetation och flora i Helsingfors hamnområde (Über die Einwirkung der Verunreinigung auf die Vegetation und die Flora der Ufer im Hafengebiet von Helsingfors). - Bidrag till Kännedom af Finlands Natur och Folk, H. 80, No. 3, 1-128.

-"- 1933. Förorening och strandvegetation i Helsingfors hamnområde år 1932 (Verunreinigung und Ufervegetation im Hafengebiet von Helsingfors im Jahre 1932) - Ibid., H. 84, No. 5, 1-38.

Häyrén, E., 1937. Iakttagelser rörande förorening och strandvegetation i Helsingfors hamnområde år 1936 (Beobachtungen über Verunreinigung und Ufervegetation im Hafengebiet von Helsingfors im Jahre 1936). - Ibid., H. 85, No. 6, 1-18.

-"- 1944. Studier över saprob strandvegetation och flora i några kuststäder i södra Finland (Studien über die saprobe Ufervegetation und Flora in einigen Küstenstädten in Südfinnland). - Ibid., H. 88, No. 5, 1-120.

Laakso, M., 1965. The bottom fauna in the surroundings of Helsinki. - Ann. Zool. Fenn., 2, 19-37.

-"- 1968. The bottom fauna in the surroundings of Helsinki II. Records of Naididae and Tubificidae (Oligochaeta) and Spionidae (Polychaeta). - Ann. Zool. Fenn., 5:3, 262-264.

Karimo, K., 1965. Lounaisrannikon merialueen likaantumistutkimus kesällä 1963 (Studies of pollution off the SW-coast of Finland in summer 1963). - Vesiensuojelutoimiston tiedonantoja, 19, 1-26.

Leppäkoski, E., 1968. Bedömning av föroreningsgrad på basis av bottenfaunan i Norra Östersjön. - Havsforskarmöte i Uppsala 18-19 april 1968 (mimeographed).

Lehmusluoto, P.O., 1968. Kasviplanktonin perustuotanto Helsingin edustan merialueella (Phytoplankton primary production off the coast of Helsinki). - Limnologisymposion 1967, 31-42.

Levander, K.M., 1913. Till kännedom om planktonbeskaffenhet i Helsingfors inre hamnar. - Med.Soc.F.Fl.Fenn., 39, 26-36.

Nyberg, C. & Maija Nyberg, 1933. Untersuchungen über die zur Coli-Typhus-Dysenterie-Gruppe gehörenden Bakterien im Kloakenwasser. - Acta.Soc.Medic.Fenn. "Duodecim" Ser. A, XVI:3, 1-20.

Sjöblom, V., 1966. Muuttuvat rannikkovetemme ja jätteiden purkaminen mereen (Polluted coastal waters and discharge of wastes into the sea). - Limnologisymposion 1965, 35-51.

Särkkä, J., 1967. Pohjaeläimistö likaantuneiden jokien suualueilla (Bottom animals at the mouths of some polluted rivers in Finland). - Vesitalous, 3 (1967), 17-20.

Tulkki, P., 1964. Studies on the bottom fauna of the Finnish southwestern archipelago. II. Bottom fauna of the polluted harbour area of Turku. Arch. Soc. Vanamo, 18:3, 175-188.

-"- 1967. Pohjaeläimistö rannikkovesiemme likaantumisindikaattorina (Bottom animals as indicators of pollution in brackish waters). - Limnologisymposion 1966, 28-36.

Voipio, A., 1964. Jäteveden johtaminen mereen (Disposal of the wastes into the sea). Rakennustekniikka (1964): 6, 436-441.

-"- 1968. Hydrographic features of the Baltic Sea. - European Feder. for the Protection of the Waters. Information Bulletin, No. 15:8-11.

-"- 1969. On the cycle and balance of phosphorus in the Baltic Sea. - Suomen Kemistilehti A, 42:38-42.

-"- 1969. Meren saastuminen. Saastumisongelmien tarkastelu erityisesti Itämeren kohdalta (Pollution of the sea - especially the Baltic). - Teknillinen Aikakauslehti, No. 4 (1969), 7 pp.

Witting, R., 1922. Helsinkiä ympäröivät vedet veden vaihtumista ja likaantumista silmällä pitäen (Die Meeresbuchten um Helsingfors, ihre Wasserumsetzung und Verunreinigung). - Merentutkimuslait. Julk./Havsforskningsinst. Skr. 11,

-"- 1933. Utlåtande om huru i havet utanför Helsingfors eventuellt utledd större spillvattenmängd där skulle sig förhålla. Helsingfors 1933.

Välikangas, I., 1926. Planktologische Untersuchungen im Hafengebiet von Helsingfors I. Über das Plankton insbesondere das Netz-zooplankton des Sommerhalbjahres. Acta Zool. Fenn. 1, 298 pp.

Pollution by oil

Lemmetyinen, R., 1966. Jäteöljyn vesilinnuille aiheuttamista tuhoista Itämeren alueella (Damage to waterfowl in the Baltic area caused by waste oil). - Suomen Riista 19, 63-71.

Industrial pollution

Sjöblom, V., 1968. Kalojen elohopeapitoisuus (Mercury content in fish). - Limnologisymposion (1967), 80-92.

Häsänen, E. & V. Sjöblom, 1968. Kalojen elohopeapitoisuus Suomessa vuonna 1967. (Mercury content of fish in Finland in 1967) - Suomen Kalatalous 36, 1-24.

Eastern Germany

Arndt, E.A., H. Pankow & V. Kell, 1966. Über das Phytoplankton der Wismar Bucht. - Int. Revue d. ges. Hydrobiol., 51, 127-146.

Bauer, W., 1963. Fischsterben im Küstengebiet der DDR in den Jahren 1951-1961. - Deutsche Fischereizeitg., 10, 59-63.

-"- 1963. Hydrographische Beobachtungen im Kleinen Haff und seinen Nebengewässern in den Jahren 1958-1960. - Z. f. Fischerei., 11, 563-570.

Brosin, H.-J., 1965. Hydrographie und Wasserhaushalt in der Boddenkette südlich des Darss und des Zingst. - Veröff. d. Geophys. Inst. d. Karl-Marx-Univ. Leipzig, 2.Ser., 18 (3).

Hübel, H., 1966. Die Phytoplanktonproduktion der Nord-Rügenschen Boddengewässer. - Wiss. Z. d. Univ. Rostock, Math.-Nat. Reihe., 15, 611-613.

Keil, R., 1966. Zum Thema Bakterienbefunde in Hafengewässern. - Gesundheitswesen u. Desinfektion. 4.

-"- 1967. Zur Rest-Beta-Aktivität in Oberflächengewässern. Z.f. ges. Hygiene u. ihre Grenzgebiete, 13, 322-326.

Keil, R. & M. Mewes, 1967. Zur Beurteilung der Wirksamkeit einer Anlage für mechanische Abwasserreinigung. - Arch. f. Hygiene u. Bakteriologie, 151, 231-242.

Keil, R. & F. Randow, 1962. Chemische und bakteriologische Befunde im Abwasser des Fikos Rostock. - Wasserwirtschaft-Wassertechnik, 12, 391-393.

Lindner, W., 1966. Gütemässiger Zustand der Vorfluter im Grosseinzugsgebiet der Wasserwirtschaftsdirektion Küste-Warnow-Peene.- Wiss.Z.d.Univ. Rostock, Math.-Nat. Reihe, 15, 587-589.

Miehlke, O., 1968. Die Küstenforschung in der Deutschen Demokratischen Republik. - Wasserwirtschaft-Wassertechnik, 18, 293-295.

Nehring, D., S. Schulz & K.-H. Rohde, 1969. Untersuchungen über die Produktivität der Ostsee. - Beitr. z. Meereskunde, 23, 5-36.

Rohde, K.-H., 1967. Untersuchungen über die Calcium-Chlor und Magnesium-Chlor-Relationen in Flussmündungen und Bodden der westlichen Ostsee. - Beitr. z. Meereskunde, 20, 34-42.

Roy, H. & W. Bauer, 1959. Phenolhaltige Abwässer in den Küstengebieten der DDR. - Deutsche Fisherei-Zeitg., 6, 230-232.

Roy, H. & L. Rübenberg, 1957. Beiträge zu Fragen der Abwassereinflüsse im Küstengebiet der DDR. - Z. f. Fischerei, 6, 259-272.

Roy, H., W. Bauer & J. Waldmann, 1963. Hydrographische und biologische Veränderungen in der Unterwarnow. - Z. f. Fischerei, 11, 709-714.

Schnese, W., 1968. Produktionsbiologische Untersuchungen im Greifswalder Bodden. - Habilitationsschrift. Univ. Greifswald.

Schulz, S., 1968. Rückgang des Benthos in der Lübecker Bucht. - Monatsb. d. Dtsch. Akad. d. Wiss. zu Berlin, 10, 748-754.

Ventz, D. & Zenger, G., 1966. Beitrag zur biologischen Reinigung der Abwässer aus Fischbearbeitungsbetrieben. - Fischereiforschung, Wiss. Schriftreihe, 4, 91-98.

Voigt, G., 1962. Probleme der Wasserversorgung und Abwasserbeseitigung in der Faserplattenindustrie. - Wasserwirtschaft-Wassertechnik, 12, 96-101.

Poland

Most of the papers listed below in English are written in Polish

Anon., 1968. Establishing of kinetics of selfpurification of the Gulf of Puck as a recipient of wastes. - Water Economics Research Institute, 101.

Biernacka, I., 1967. Overgrowing of concrete reinforcing rods in the polluted waters of the port of Władysławowo in the years 1961-1964. - Rozprawy Hydrotechniczne, 20, 127-143.

Bojanowski, R., 1968. On the strontium content in the southern Baltic waters. - Acta Geophysica Polonica, 4.

Bojanowski, R. & S. Ostrowski, 1964. Biogenic substances variations in the sea water in the Sopot area. - Rozprawy Hydrotechniczne, Section 3, GTN.

Buczowska, Z., 1958. Determination of Salmonella bacteria in water. - Bull. Inst. Marine Medicine, Gdańsk, 9.

-"- 1959. Research on the bacteriological pollution of coastal waters in Poland. - Ibid., 10.

Buczowska, Z., 1968. The state of research of coastal water pollution in Poland. - Rocz. Pom. Akad. Med., 14, Suppl. 2, 293-297.

Buczowska, Z. & B. Nowicka, 1960. Locating Salmonella infection sources of river and bathing beaches by means of sewage examination. - Bull. Inst. Marine Medicine, Gdańsk, 11.

Buczowska, Z., B. Nowicka & Z. Kubanek, 1961. Evaluation of enterococci as indicator of coastal water pollution. - Ibid., 12.

Demel, K. & W. Mańkowski, 1951. Quantitative investigations on the bottom in the southern Baltic. - Rep. Sea Fisheries Inst., 6, 57-82.

Demel, K. & Z. Mikucki, 1954. Quantitative investigations on the biological productivity of the South Baltic. - Ibid., 7, 75-126.

Demel, K. & Z. Mulicki, 1958. The zoobenthic biomass in the southern Baltic. - J. Cons. Int. Explor. Mer., 24.

Dera, J., 1965. Miektóre właściwości optyczne wód Zatoki Gdańskiej jako wskaźniki struktury jej mas wodnych. - Acta Geophys. Polonica, 13.

-"- 1967. The measurements of optical quantities characterising the conditions of photosynthesis in the Gulf of Gdańsk. - Ibid., 15.

Dera, J. & Bojanowski, R., 1966. Preliminary studies into conditions of photosynthesis in the Gulf of Gdańsk. - Ibid., 14.

Dera, J., B. Szczeblewski & B. Łokuczewski, 1962. Radioactive contamination of the sea waters in the northern Europe region in 1959-1961. - Ibid., 2.

Filarski, J., 1955. Hydrographical conditions of the southern Baltic for the period from April 1952 to May 1953. - Rep. Sea Fisheries Inst., 8, 255-282.

-"- 1956. Badania hydrograficzne Bałtyku poludniowego w roku 1953-1955. - Ibid., 9.

-"- 1959. Polish observations in the southern Baltic during 1956-1957. - Annls. Biol., Cons. Int. Explor. Mer., 14.

-"- 1960. Polish observations in the southern Baltic March 1958-February 1959. - Ibid., 15.

Głowińska, A., 1950. Hydrographical observations off the Polish coasts in 1947 and 1948. - Ibid., 5.

-"- 1955. Hydrologic research in the southern Baltic in 1951. - Rep. Sea Fisheries Inst., 8, 159-190.

-"- 1960. Report on the phosphate investigations in the southern Baltic for 1947-1960. - ICES C.M. 1960/No. 72, Hydr. Comm. (mimeographed).

-"- 1963. Fosforany Bałtyku południowego w latach 1947-1960. - Rep. Sea Fisheries Inst., 12A.

-"- 1964. Polish hydrographical observations in the southern Baltic Sea in 1964. - Annls.Biol.,Cons.Int.Explor.Mer., 21.

-"- 1964. Hydrographical conditions (T,S,O_2 and P) in the southern Baltic. May 1963-May 1964. - ICES C.M. 1964/No 67, Baltic-Belt Seas Comm. (mimeographed).

Greissereir, K. & J. Makowski, 1965. Harmful effects or radioactive wastes discharged into the sea. - Arch. Hydrotechn., 12, 131-135.

Kijowski, S., 1937. Nieco danych o składzie chemicznym wód Zatoki Gdańskiej. - Biuletyn Stacji Morskiej w Helu, 1.

Kornaś, J., 1957. Roślinność denna polskiego Bałtyku, stan badań i postulaty ich przyszłego rozwoju. - Wiadomości botaniczne, 1.

Kornaś, J. & A. Medwecka-Kornaś, 1948. Podwodne zespoły roślinne Zatoki Gdańskiej. - Rozprawy Wydzialu Matematyczno-Przyrodniczego PAU, 73, dz. B, No. 3.

Kowalik, Z., 1963. Internal waves of the Baltic Sea. - Acta Geophys. Polonica, 11.

-"- 1966. Effect of stratification of water masses on the dynamic processes of the Baltic. - Ibid., 14.

-"- Wind-driven circulation in a shallow sea with application to the Baltic Sea. - Ibid., in press.

Kowalik, Z. & S. Taranowska, 1967. Horizontal large-scale turbulence in the Baltic Sea. - Cahiers Océanogr., 4.

Łomniewski, K., 1960. Hydrographic problems at the Polish Baltic coast. - Przegl. Geograf., 32, Suppl.

Makowski, J., 1960. The metods of rendering harmless of radioactive contamination before its discharge into the stream. - Gospodarka Wodna, 12, 525-531.

Mańkowski, W., 1959. Hydrological conditions in the southern Baltic in 1946-1956. - Acta Geophys. Polonica, 5, 176-191.

-"- 1961. Polish macroplankton observations in 1959. - Annls. Biol., Cons. Int. Explor. Mer., 16.

Młodzińska, Z., 1963. Wptyv wód Wisły na sklad chemiczny wody Zatoki Gdańskiej. - Przegląd Geofiz., 1963.

Morzycka, M., 1952. Badania nad sezonowymi wahaniami zanieczyszczenia wody morskiej Zatoki Gdańskiej. - Biuletyn IMM i T, 4.

Netzel, J., 1967. Investigations on codling quantities and dispersal in the western area of the Gulf of Gdańsk in the years 1961-1964. - Rep. Sea Fisheries Inst., 14 A.

Ostrowski, S., 1962. O zawartości krzemu w wodach Zatoki Gdańskiej. - Acta Geophys. Polonica, 10.

Ostrowski, S. & Z. Bojanowska, 1964. Yearly variations of biogenic substances in the sea water of the Sopot area. - Scient. Soc. Gdańsk Rozprawy, Sect. 3.

Piechura, J., 1960. Equilibre vertical des couches d'eau dans la Baltique Méridionale. - Referat na 12 posiedzenie IUGG, Helsinki.

-"- 1961. Mieszanie sie wód południowego Bałtyku. - Referat na V Zjazd Hydrobiologów Polskich w Gdańsku w 1961.

Piatek, W., 1959. Barwa i przezroczystość wody morskiej w pobliżu Gdyni w 1954 r. - Rep. Sea Fisheries Inst., 10 A.

-"- 1962. Wstępne opracowanie fosforanów Baltyku południowego za okres 1948-1954. - Ibid., 11 A.

Raźniewski, J., 1961. Damage in fishery in the Szczecin Holm caused by pollution. - Gospod. Rybna, 3.

-"- 1966. Szczecin Holm water pollution by phenols and damage to fishery economy. - Gospod. Rybna, 1.

Ringer, Z., 1962. Southern Baltic phytoplankton in 1956. - ICES C.M. 1962/No. 29, Plankton Comm. (mimeographed).

Rumek, A., 1948. Lista gatunków fitoplanktonu powierzchniowego Zatoki Gdańskiej. - Biuletyn MIR, 4.

-"- 1950. Sezonowe występowanie gatunków w fitoplanktonie Zatoki Gdańskiej. - Biuletyn MIR, 5.

Rybiński, J. & R. Zeidler, 1968. Dissipation of industrial wastes and domestic sewage in the sea. - Technika i Gospod. Morska, 18.

Rybiński, J., E. Zelazny & R. Zeidler, 1969. Dissipation of wastes from Gdynia in the sea and kinetics of the Gulf of Puck selfpurification. - Ibid., 19.

Siudziński, K., 1964. Macro- and ichtyoplankton of the southern Baltic in 1956-1959. - Annls. Biol., Cons. Int. Explor. Mer., 21.

Taranowska, S., 1967. Transparency and colour of sea water in the Sopot-Mole area in 1958-1960. - Rozp. Wydz. 3 GTN, 4,5-12.

Tomczak, J., 1960. Pomiary skażeń radioaktywnych powietrza, opadów i wód w rejonie Zatoki Gdańskiej. - Przegl. Geofiz., 5, 229-239.

Wiktor, K., 1959. Zooplankton in the Pomeranian Bay. - Referat wygłoszony na Sekcji Planktonologicznej ICES, C.M. 1959.

Zmudziński, L., 1967. Zoobenthos of the Gulf of Gdańsk. Rep. Sea Fisheries Inst., 14 A.

-"- 1968. Variability of the bottom fauna in the southern Baltic in view of the hydrographic changes during the last centuary. - Zeszyty Naukowe SGGW, Zootechnika 7, Rybactwo 3.

Sweden

Ackefors, H. & Fonselius, S.H., 1969. Preliminary investigations on the effect of sand suction work on the bottom in the Öresund. - ICES C.M. 1969/E:13 (Fish.Impr.Comm.),(mimeographed).

Ackefors, H., G. Löfroth & C.-G. Rosén. A survey of the mercury pollution problem in Sweden with special reference to fish. - Oceanography and Marine Biology, 7. (in press).

Agnedahl, P.O., 1966. Calcium and strontium in Swedish waters and fish and accumulation of 90Sr. - Proc. Int. Symp. Radioecological Conf., Stockholm, April 1966, 879-896.

-"- 1966. Recipient capacity of Tvären, a Baltic bay. - Int.Atomic Energy Agency, Vienna: Disposal of Radioactive Wastes into Seas, Oceans and Surface Waters, 753-767.

Anon., 1966. The mercury problem. Symposium concerning mercury in the environment held at Wenner-Gren Center, Stockholm, January 1966. - Oikos Supplementum, 9 (1967).

Anon., 1967. Miljövårdsforskning. Betänkande avgivet av 1964 års naturresursutredning. I. Forskningsområdet. (Research on the protection of the natural environment. Report by the Natural Resources Conservation Committee of 1964). - Statens offentliga utredningar, 1967 (43), 1-239.

Bonde, G.J. (ed.), 1967. Øresundvandkomiteens undersøgelser 1959-1964. (Report on the investigations of the Swedo-Danish Committee on Pollution of the Sound in 1959-1964. Administration, hydrography, biology, bacteriology and fishery). - København 1967. 1-309.

Cederwall, K., 1968. Hydraulics of marine waste water disposal. - Hydraulic Division, Chalmer's Institute of Technology, Göteborg. Report No. 42. 1-273.

Corin, C., S.H. Fonselius & A. Svansson, 1969. On the oxygen and phosphate conditions in the Kattegat and the Öresund. - Meddel. Havsfiskelaboratoriet, Lysekil, No. 32.

Cronholm, M., 1965. Föroreningsförhållandena i Stockholms Skärgård. (Pollution conditions in the archipelago of Stockholm). - Vattenhygien., 21, 34-46.

Cronström, A., 1968. Avloppsrening contra tunnlar. Avledning genom tunnlar. (Treatment contra discharge through pipelines). - Vatten., 24, 84-92.

Dackman, T., 1968. Föroreningsförhållandena vid den svenska Öresundskusten. (Pollution conditions at the Swedish Öresund coast). - Vatten., 24, 4-9.

Ehlin, U., 1966. Hydrologiska kustvattenundersökningar i samband med utsläpp av avlopps- och kylvatten. (Hydrological investigations in coastal waters with regard to discharge of waste and cooling waters). - Vattenhygien., 22, 33-40.

Falkenmark, M. & T. Milanov, 1969. Om kylvattenutsläpp i recipienter. (On discharge of cooling water). - Vatten., 25, 2-15.

Fonselius, S.H., 1969. Hydrography of the Baltic deep basins III. - Fishery Bd. Sweden, Ser. Hydrography., No. 23, 1-97.

Gudmundsson, S., 1964. Malmö och Öresund; avloppsproblemet. (Waste water problem of Malmö and the Sound). - Vattenhygien., 20, 11-18.

Hannerz, L., 1966. Fall out ^{137}Cs in fish and plankton from Lake Mälaren and the Baltic. - Proc. 1st Nordic Radiation Protection Conference, Stockholm, February 1966. - Acta Radiologica, Suppl. 254, 22-28.

-"- 1968. Experimental investigations on the accumulation of mercury in water organisms. - Inst. Freshw. Res., Drottningholm, 48, 120-176.

-"- 1968. Varmvatten - en förorening med ökande betydelse. (Cooling water, an increasing problem). - Vatten., 24, 324-328.

Hasselroth, T., 1964. Investigations with caged fish as an indication of pollution from craft pulp mills. - Vattenhygien., 20, 74-82.

-"- 1968. Report on current field investigations concerning the mercury content in fish, bottom sediments and water. - Inst. Freshw. Res., Drottningholm, 48, 102-111.

Henriksson, R., 1968. The bottom fauna in polluted areas of the Sound. - Oikos, 19, 111-125.

Höglund, L.B., 1961. The reactions of fish in concentration gradients. A comparative study on fluviarium experiments with special reference to oxygen, acidity, carbon dioxide and sulphite waste liquor (SWL). - Inst. Freshw. Res., Drottningholm, 43, 1-147.

Jensen, S., 1968. Miljögiftproblematik. (Environmental toxicity problems). - Flora och Fauna 1968 (5), 190-195.

Jensen, S., M. Olsson, A. Johnels & G. Otterlind, 1969. Contamination from DDT and PCB in certain organisms in Swedish marine waters. - ICES C.M. 1969/E:14 (Fish. Impr. Comm.) (mimeographed).

Johnels, A., M. Olsson & T. Westermark, 1967. Kvicksilver i fisk. (Mercury in fish). - Vår Föda 1967 (7), 65-103.

Johnels, A., T. Westermark, W. Berg, P.I. Persson & B. Sjöstrand, 1967. Pike (Esox lucius) and some other aquatic organisms as indicators of mercury contamination in the environment. - Oikos, 18, 323-333.

Kallings, L.O., 1961. Adenovirusinfektioner. Möjligheter för vattenburen smitta illustrerade av Nackaepidemien 1959. (Adenovirus. Possibilities of infection by water-borne virus, as illustrated by the epidemic at Nacka in 1959). - Vattenhygien., 17, 7 pp.

Lindgren, P.E., 1965. Coastal algae off Göteborg in relation to gradients in salinity and pollution. - Acta Phytogeogr. Suecica., 50.

Löfquist, L., 1966. Avloppsvattnet som skadefaktor för havet. (Waste waters as a damaging factor to the sea). - Hygienisk Revy, 1966 (2), 323-325.

Löfroth, G., 1969. Methylmercury. A review of health hazards and side effects associated with the emission of mercury compounds into natural systems. - Swedish Natural Science Research Council. Ecological Research Committee. Bull. No 4, 1-29.

Otterlind, G., 1964. Östersjön som tippningsområde för gifter, skrotbilar m.m. (The Baltic as a dumping area for toxic matters, old cars etc.). Ostkusten, 36. Oct. 1964, 10-12.

Rahm, L. & Cederwall, K., 1965. Submarine disposal of sewage. - Hydraulic Division, Chalmer's Institute of Technology, Göteborg. Report No. 23.

Rennerfelt, J., 1963. Studium av skogsindustriella avloppsvatten. I. Avloppsvattnens sammansättning och deras behandling på biologisk väg, en litteraturöversikt. (Cellulose industry wastes and their biological treatment, a literature survey). - Svensk Papperstidning, 66, 967-977.

Rosén, B., (ed.), 1969. Fartygens och fritidsbåtarnas förorening av farvattnen med fast och flytande avfall. (Pollution of the waters by ships and small boats). - Vatten., 25, 21-66.

Swedmark, B., 1966. Bottenfaunans förändringar i Göta Älvs mynning under 1900-talet.(Changes of the bottom fauna in the Göta River Estuary during the last decades). - Vattenhygien., 22, 41-44.

Swedmark, M., 1968. Resistens hos fisk mot glykol, tensider och en vanlig tensidråvara. (Resistance in fish to glycol and some phenol compounds). - Vatten., 24, 430-443.

Vallin, S., 1968. Undersökningar av salthalt och fosfatskiktning i Öresund. (Investigations on salinity and phosphate in the Öresund). - Vatten., 24, 41-48.

-"- 1968. Inverkan på fisk och fisket i Öresund genom utsläpp av gips från superfosfatfabriker. (Effect of calcium-sulphate on fish and fishery in the Öresund). - Vatten., 24, 49-50.

-"- 1968. Giftverkan av fluor på fisk. (Toxicity of fluor to fish). - Vatten., 24, 51-52.

Vasseur, E., 1966. Progress in sulfite pulp pollution abatement in Sweden. - J. Water Pollution Control Federation, 1966, 27-37.

Water Authorities of Göteborg, 1968. Undersökningar för havsutsläpp år 1966-1967. (Meteorology, hydrography, geology, marine biology of the polluted waters in the archipelago of Göteborg). - Göteborg 1968, 1-210.

-"- 1969. Recipientundersökningar år 1967-1968. (Recipient investigations in the Göteborg archipelago 1967-1968). - Göteborg 1969, 1-134.

Westöö, G. & Noren, K., 1967. Kvicksilver och metylkvicksilver i fisk. (Mercury and methylmercury in fish). - Vår Föda 1967 (10), 135-178.

U.S.S.R.

Adrov, M.M. Gidrologicheskiĭ rezhim v vostochnoĭ chasti Dat-skogo proliva vesnoĭ 1955 g-"Tr.Polyarn. n.-i. in-ta morsk. rybn. kh-va i okeanogr." 1969, vyp.II.

Aitsam, A.M. Matematicheskaya model' regulirovaniya kachestva vody vodoemov.-"Vsesoyuznaya nauchno-tekhn. konferentsiya po okhrane poverkhnostnykh i podzemnykh vod ot zagryazneniya, Tallin, 19-22 sentyabrya 1967 g. Doklady i soobshcheniya po voprosam samoochishcheniya vodoemov i smesheniya stochnykh vod", Tallin, 1967.

Aitsam, A.M. Raschet samoochishcheniya morskikh bukht. - Ibid., 1967.

Aitsam, A.M., Vel'ner Kh.A. & Paal' L.L. Ob opredelenii raschetnykh nagruzok zagryazneniĭ pri raschete samoochishcheniya vodoemov. - "Nauchnye dokl. po voprosam samoochishcheniya vodoemov i smesheniya stochnykh vod (I. Vsesoyuznyĭ simpozium 7-10.VI. 1965)", Tallin, 1965.

Aitsam, A.M. Ob opredelenii dopustimoĭ nagruzki zagryazneniĭ Finskogo zaliva.-I.simpozium sovet-sko-finskoĭ rabocheĭ gruppy po probleme "Okhrany vod Finskogo zaliva ot zagryazneniya", Helsinki, 1969.

Aleksandrovskaya, N.B. Nekotorye osobennosti i raspredeleniya biogennykh elementov v Baltiĭskom more.-Sb."Khim.protsessy v moryakh i okeanakh", Moskva, "Nauka", 1966.

Andrushaĭtis, G.P. Pribrezhnaya zona Finskogo zaliva kak priemnik stochnykh vod.-V sb. "Morskie zalivy kak priemniki stochnykh vod", "Zinatne", Riga, 1967.

Antonov, A.E. Nekotorye osobennosti gidrologicheskikh uslovii yuzhnoi Baltiki v 1947-1958 gg.-"Tr. Baltiisk. n.i. in-ta morsk. rybn. khoz-va i okeanogr.", vyp. 1960, vyp. 6.

Astok, V.K. Techeniya Finskogo zaliva na osnove obrabotki gidrologicheskikh nablyudenii dinamicheskim metodom. - "Okeanologiya 1965, Nr. 5.

Betin, V.V. Techeniya v Tallinskom zalive po materialam aerofotos'emki 1966 g.-"Sb. rabot Leningrad. gidrometeor. observ." 1967, vyp.4.

Betin, V.V. & Panteleev, P.V. Postoyannye techeniya Finskogo i Rizhskogo zalivov. - Ibid., 1966, vyp. 3.

Borishanskii, L.S. Raschet raspredeleniya solenosti vody v predust'evom prostranstve morya dlya reki s shirokim ust'em na primere ust'ya Nevy.- Tr. gos. okeanogr. in-ta, 1964, vyp.72.

Chernovskaya, E.N. Nekotorye osobennosti raspredeleniya i rezhima fosfatov v Baltiiskom more. - Ibid., 1961, vyp. 59.

Fedosov, M.V.& Zaitsev, T.N. Vodnyı balans i khimicheskii rezhim Baltiiskogo morya i ego zalivov.-"Tr. vsesoyuzn. nauchno-issl. in-ta morsk. rybn. khoz-va i okeanogr." 1960, Nr. 42.

Fedosov, M.V. & Zaitsev,T.N. Osobennosti vodnykh mass Baltiiskogo morya. - Ibid., 1962, 46.

Gazdzyauskaite, I.B. Vliyanie zagryazneniya na pribrezhnyi nektobentos r. Neman.-Tezisy dokladov na vsesoyuznoi nauchnoi konferentsii po voprosam vodnoi toksikologii, 30 yanvarya - 2 fevralya 1968 g., "Nauka", Moskva, 1968.

Gorshkova, T.I. Organicheskoe veshchestvo donnykh otlozhenii Baltiiskogo morya.-Sb. "Khim. protsessy v moryakh i okeanakh", Moskva, "Nauka", 1966.

Gusev, A.G. Metodicheskaya skhema kompleksnykh issledovanii vliyaniya stochnykh vod i ikh komponentov na vodnye organizmy i rybokhozyaistvennye vodoemy i ustanovlenii v nikh PDK vrednykh veshchestv.-Simpozium po vodnoi toksikologii. Tezisy dokladov. Leningrad, 1969.

Izhevskii, G.K. Okeanologicheskie osnovy formirovaniya promyslovoi produktivnosti v Baltiiskom more.-V sb. "Vopr. promysl. produktivnosti morei". Moskva, 1960.

Leder, I.Z. Gidrometeorologicheskie obzory dlya Baltiiskogo morya. -"Tr. gos. okeanogr. in-ta", 1961, vyp.65.

Lubyanov, I.P. K voprosu o vliyanii DDT i neksaklorana na vodnye organizmy.-Tezisy dokladov na vsesoyuznoi nauchnoi konferentsii po voprosam vodnoi toksikologii, 30 yanvarya - 2 fevralya 1968, "Nauka", Moskva, 1968.

Lundberg, O.R. Opredelenie koeffitsienta vertikal'noi temperaturoprovodnosti po izmeneniyam temperatury vody v Baltii-skom more. -"Tr. gos. okeanogr. in-ta", 1964, vyp. 81.

Mikhailov, Yu.D. Kharakter kolebanii urovnei poverkhnosti Finskogo zaliva i ikh svyas' s kolebaniyami poverkhnosti vsego Baltiiskogo morya. - Ibid., 1960, vyp. 56.

Mikhailov, Yu.D. Ekspeditsionnye issledovaniya kolebanii urovnya i techenii v Finskom zalive. - Ibid., 1962, vyp. 69.

Mikhailov, Yu.D. & Kabanina M.A. Issledovanie svyazi mezhdu polem atmosfernogo davleniya i techeniyami v Finskom zalive. - Ibid., 1965, vyp. 87.

Monin, A.S. Poluempiricheskaya teoriya turbulentnoĭ diffuzii.-Tr. geofizicheskogo instituta, Nr. 33.

Monin, A.S. Uravnenie turbulentnoĭ diffuzii.-"Dokl. AN SSSR", 1955 t.105, Nr. 2.

Morozov, A.P. Gidrologiya Baltiĭskogo morya (tr. gos. okeanogr. in-ta, vyp. 65).-Leningrad, GIMIZ, 1961.

Ozmidov, R.V. O raschete gorisontal'noĭ turbulentnoĭ diffuzii pyatna primesi v more.-"Dokl. AN SSSR", 1958, t.120, Nr. 4.

Ozmidov, R.V. O roli turbulentnykh vikhreĭ raznykh masshtabov v protsesse diffuzii.-Izv. AN SSSR, ser. geofiz., 1958, Nr. 2.

Ozmidov, R.V. Diffuziya primesi v pole adnorodnoĭ izotropnoĭ turbulentnosti. - Ibid., 1960, Nr. 1.

Ozmidov, R.V. O skorosti dissipatsii turbulentnoĭ energii v morskikh techeniyakh i o bezrazmernoĭ universal' noĭ postoyannoĭ v "zakone 4/3". - Ibid., 1960, Nr. 8.

Ozmidov, R.V. Gorizontal'naya turbulentnost' i turbulentnyĭ obmen v okeane.-Moskva, "Nauka", 1968.

Pastukhova, N.M. Gidrokhimicheskie kharakteristiki kak pokazatel' postupleniya serveromorskikh vod v Baltiĭskoe more v 1950-1955 gg.-"Tr. gos. okeanogr. in-ta", 1961, vyp. 65.

Pomeranets, K.S. Opyt rascheta koeffitsienta vertikal'noĭ temperaturo-provodnosti v Finskom zalive v teploe vremya goda.-"Vestn. Leningr. in-ta". 1962, Nr. 12.

Pomeranets, K.S. Teplovoĭ balans Baltiĭskogo morya.-"Tr. gos. okeanogr. in-ta", 1964, vyp. 82.

Prival'skiĭ, V.E. O vynuzhdennykh kolebaniyakh urovnya Baltiĭskogo morya. "Okeanologiya", 1968, 8, Nr. 2.

Ryabikov, O.G. Nekotorye dannye o kislorodnom rezhime vo vpadinakh tsentral'noĭ i yuzhnoĭ Baltiki v 1951-1956 gg.-"Tr. Baltiĭsk. nauchno-issl. in-ta morsk. rybn. kh-va i okeanogr.", 1959, vyp. 3.

Ryabikov, O.G. Ob izmeneniyakh kislorodnogo rezhima vod v Baltiĭskom more v raĭone Gotlandskoĭ vpadiny.-"Tr. vsesoyuzn. nauchno-issl. in-ta rybn. khoz-va i okeanogr.", 1960, 42.

Skopintsev, B.A.& Timofeeva S.P. Soderzhanie organicheskogo ugleroda v vodakh Baltiĭskogo i Severnogo moreĭ, v subtropicheskoĭ i tropicheskoĭ oblastyakh severnoĭ chasti Atlanticheskogo okeana.-"Tr. morsk. gidrofiz. in-ta AN SSSR", 1965, 25.

Simonov, A.I. Osnovnye faktory formirovaniya rezhima kisloroda v poverkhnostnykh sloyakh pribrezhnykh vod.-"Tr. gos. okean. in-ta", vyp. 83, 1965.

Simson, O., Lutsoa Kh., Ilmoja K. & Ditrikh M. O zagryaznennosti vneshneĭ sredy ostatkami pestitsidov za 1964-1967 gg. v Estonskoĭ SSR.-Tezisy dokl. VI. nauchn. konf. Pribaltiĭskikh respublik po zashchite rasteniĭ. Tartu, 1968, I.

Soskin, I.M. Gidrologicheskie fronty v dat-skikh prolivakh v Kattegate, ikh peremeshchenie i vliyanie na gidrologicheskie usloviya Baltiĭskogo morya.-"Tr. gos. okeanogr. in-ta", 1961, vyp. 65.

Soskin, I.M. Mnogoletnie izmeneniya gidrologicheskikh kharakteristik Baltiĭskogo morya, Gidrometeoizdat, 1963.

Vel'ner, Kh.A. Nekotorye voprosy issledovaniya zagryazneniya morskikh bukht ESSR.-"Tezisy dokl. vsesoyuzn. soveshchaniya po zagryazneniyu morya", Batumi, 1963.

Yarvekyulg, A. Nekotorye voprosy detal'nogo issledovaniya donnoĭ fauny v pribrezhnoĭ zone morya.-"Izv. AN ESSR", ser. biol. 12, Nr. 3, 1963.

Zykov, I.R.& Pomerantsev K.S. Spektry techeniĭ tsentral'noĭ chasti Baltiĭskogo morya.-"Izv. AN SSSR, Fiz. atmosfery i okeana", 1967, 3, Nr. 10.