COMPLEXITY OF RECENT MARINE POLLUTION IN JAPANESE WATERS

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I. Warning of marine pollution

Since World War II fields of marine studies dealing with nearshore oceanography, estuarine oceanography and marine culture have progressed in Japan. Artificial culture is now widely applied to various kinds of marine organisms, *i.e.*, pearl oyster, edible oyster, abalone, scallop, mussel, clam, laver, kelp, Tengusa (*Gelidium*), young yellowtail, seabream, puffer, eel, squid, octopus, spiny lobster, prawn, edible crab and so on, and the culture of some of these have reached the scale of commercial enterprise (Ogasawara 1970). However, there have arisen serious problems of marine pollution induced by the rapid development of industries, the marine culture on the coasts undergoing drastic damaging effects (Uda 1972).

Recent marine pollution involves very complex sources, *i.e.*, (a) autopollution (degradation of marine farms due to over-densely culturerd organisms on the rafts excreting large amounts of organic substances) (Ogasawara 1970), (b) eutrophication or over fertilization due to a large amount of discharge of inorganic and organic nutrients from industrial factories and city wastes, resulting in frequent occurrence of harmful red tide (Murakami 1972, Nishimura 1973), (c) oil-pollution mainly due to bilge water and sludge disposed from tankers (Kurashima 1972), outflow of oil from a wreck having extensive serious effects (Nishimura 1972), (d) thermal pollution caused by oil power and atomic power electricity plants (Ochiai 1973), (e) radioactive pollution due to accidental discharge (Ichikawa 1970), (f) pollution by inflow of heavy metals (Hg, Cd, Pb, Cu, As, Ni, Al, Mo, Cr, etc.), strong alkali or acid, cyanic acid, PCB (Isono and Fujiwara 1972), PCT, pesticides (DDT, DDE BHC, etc.) (Fujitani 1970), solid wastes such as nylon, vinyl, plastic, rubber, etc. and (g) also deterioration of environment caused by marine engineering such as embayment, mining, dredging, channel digging, canal costruction, dam construction, harbor construction and so forth.

Engineering techniques for improving culture conditions which have been developed since about 1962 have certainly contributed to improving the conditions of marine farms. The task is achieved by model experiments and involves (a) sets of artificial fish banks and reefs, (b) construction of a fence, jetty or set of tetrapots to reduce the wave action at farm sites, (c) construction of a water way or channel to assist the exchange of water by changing circulation patterns, (d) installation of an air curtain by means of bubbling to assist in the aeration of the

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太平洋海洋資源の増殖　第一回太平洋の水産増殖に関する日ソ合同シンポジウム論文集（1972年12月東京・清水）103～111 頁（1973）東海大学

water and at the same time make a barrier for swimming animals, (e) construction of facilities for convection making, thermocline breaking, turbulence making, etc. (f) ploughing, dredging, digging, depositing of new sediments, etc. to remodel the sea floor, (g) various devices such as oil fences, sea cleaning, removal of fouling organisms, and so on. Despite application of such techniques, marine pollution around Japan has increased rapidly in proportion to industrial development since about 1965, and environmental deterioration is extending to many bays and the inland sea of Japan. Habitats of marine life in many places are now progressively turning into azoic zones.

II. Spread of marine pollution indicated by decreasing transparency and other parameters

In about the last fifteen years water pollution and other environmental deterioration has become remarkable in Tokyo Bay, Sagami Bay, Suruga Bay, and Ise Bay on the coast of the Pacific Ocean, in the eastern and western parts of the Seto Inland Sea, and Toyama Bay on the coast of the Japan Sea. This has caused serious damage to the marine culture and coastal fisheries (Figs. 1-6).

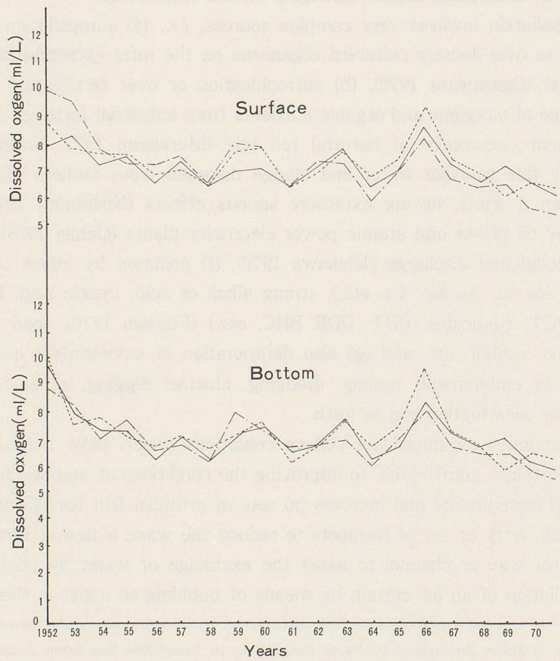

Fig. 1. Secular variation of dissolved oxygen in Tokyo Bay in January 1952-70

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· · · · Central part of the bay
····· Southern entrance of the bay

Oxygen content of the water has progressively declined in Tokyo Bay during recent yeears as a result of increasing contamination of the water (Fig. 1). The water has become greatly turbid as seen in lowering of the transparency. The transparency (by Secchi disc reading) in the spring of 1965 (solid line) is compared with that in 1931 (dotted line) ; there is a great change between these years, transparency decreasing from the northern part of the bay toward the south (Fig. 2a). Fig 2b shows the change in seasonal pattern of clear water inflow in summer in recent

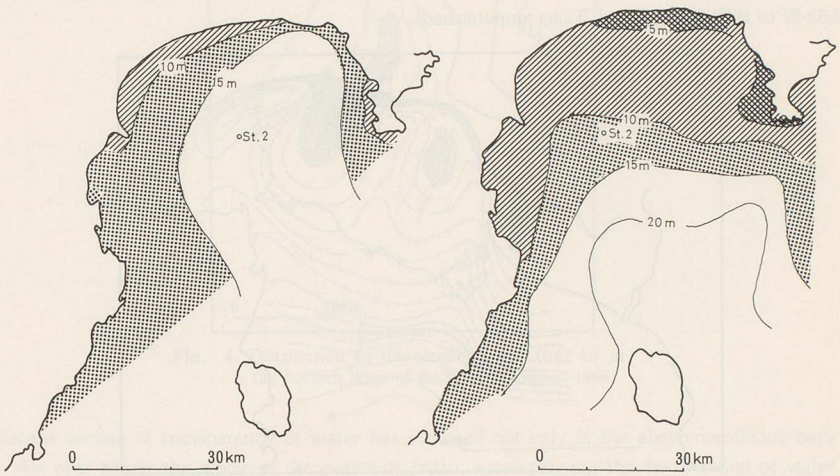


Fig. 2a. Distribution of transparency (Secchi disc reading) in Sagami Bay in Spring, 1931 (left) and 1965 (right)

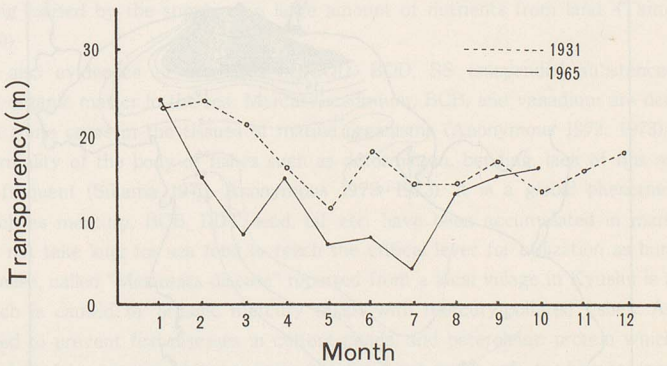


Fig. 2b. Seasonal variation of transparency at St. 2 (see Fig. 2a) in the central Sagami Bay, 1931 and 1965

years. In Suruga Bay heavily turbid and polluted pulp-mill effluent is found at the innermost part of the bay (Fig. 3a,b). Fig. 4a shows the distribution of dissolved oxygen in summer of summer of 1968 on the bottom of Ise Bay, the central basin being an almost zero-oxygen area. Fig. 5a,b is illustrated to show the change of distribution of transparency in the eastern part of the Seto Inland Sea from the summer of 1965 to the summer of 1972. The turbid area has apparently expanded in 1972 (Nishimura 1972). In Fig. 6a,b it is seen that the transparency of water in the coastal area of Toyama Bay has decreased during the period from 1953-57 to 1963-67 (UDA and TAIRA unpublished).

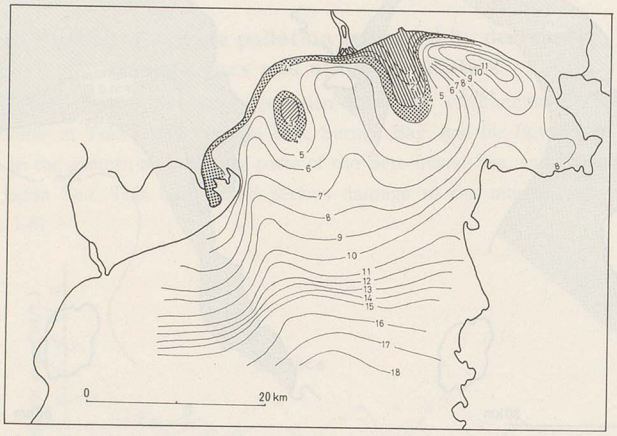


Fig. 3a. Distribution of transparency in the northern part of Suruga Bay in autumn (Oct. 29---Nov. 18, 1972)

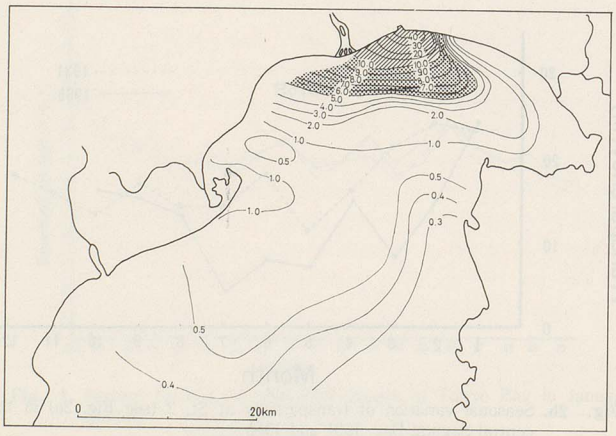


Fig. 3b. Distribution of CDO in ppm at the surface of Suruga Bay in autumn (Oct. 29-Nov. 18, 1972)

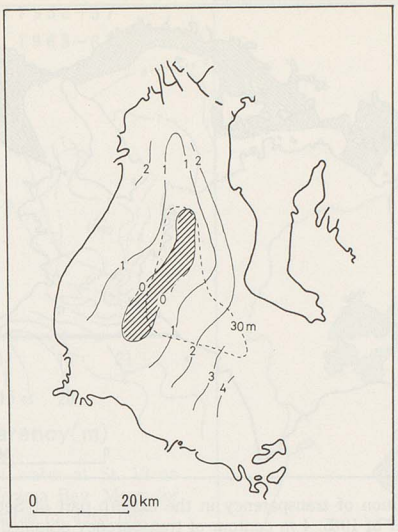


Fig. 4. Distribution of dissolved oxygen (ml/ L) in the bottom layer of Ise Bay in August 1968

Recent decline of transparency of water has occurred not only in the above-mentioned bays but also over nearly the whole of the coasts of Japan, accompanying the discoloration of water to yellowish or brownish color (more than 8 in Forel-Ule's scale). The area of oxygen depletion on the bottom has extended in contrast to the super-saturation of dissolved oxygen in the surface layer (in summer). Depletion of oxygen in the subsurface zone is due to the degradation of a large amount of organic material while the super-saturation at the surface is due to the floral blooming caused by the supply of a large amount of nutrients from land. (Tamura 1970, Kitamori 1970).

There are also evidences of increases of COD, BOD, SS (suspended substances), toxic inorganic and organic matter in the sea. Mercury, cadmium, BCB, and vanadium are detected in abundance in some cases in the tissues of marine organisms (Anonymous 1972, 1973). Occurrence of abnormality of the body of fishes such as deformation, bending, lack of fins and so on has become frequent (Sikama 1970, Anonymous 1972, 1973). It is a global phenomenon that pollutants such as mercury, BCB, DDT, lead, oil, etc. have been accumulated in marine organisms. It will not take long for sea food to reach the critical lever for utilization as human diet. A serious disease, called "Minamata disease" reported from a local village in Kyushu is a terrible example which is caused by organic mercury taken with mercury-polluted fishes. Antibiotics which are used to prevent fish diseases in culture ponds, and peteroleum protein which is used as an artifical food in culturing fish are now considered not to be safe for human consumption of the fish cultured with these substances.

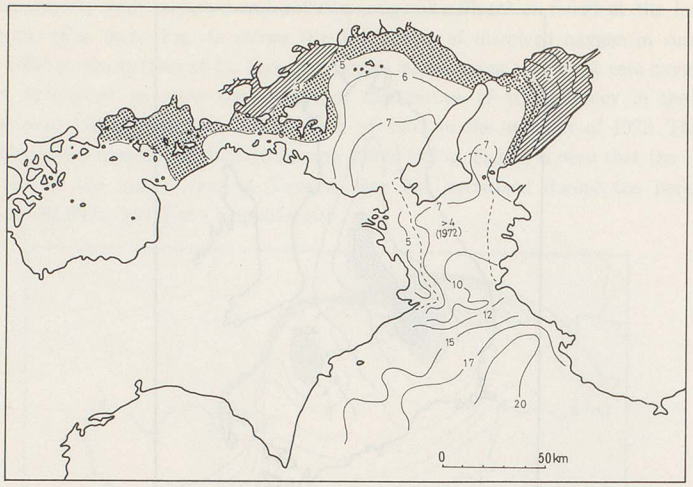


Fig. 5a. Distribution of transparency in the eastern part of Seto Inland Sea in summer of 1965. 4 m contour of transparency obtained in May 1972 is drawn by dotted lines for comparison.

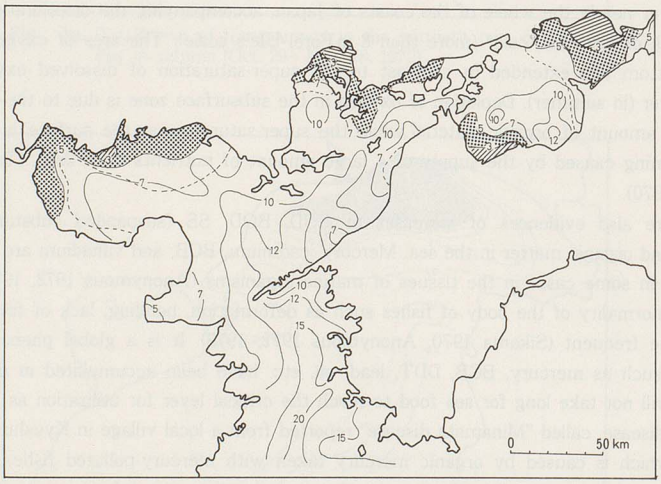
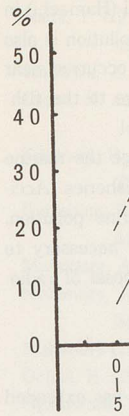


Fig. 5b. Distribution of transparency in the estern and central parts of Seto Inland Sea in summer of 1967. 4 m contour of transparency obtained in May 1972 is drawn by dotted lines for comparison. (Nishimura 1972, P. 623)



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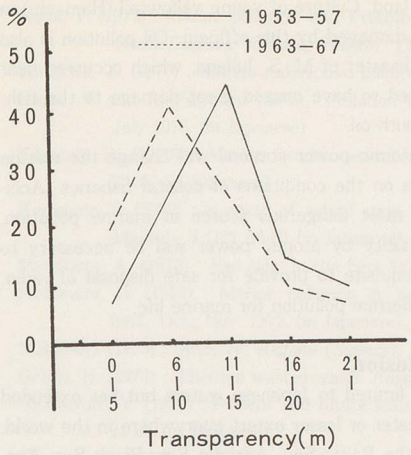

Fig. 6a. Transparency of water at St. 13 on the coast of Toyama Bay. Mean for 1953-1957 and mean for 1963-1967.

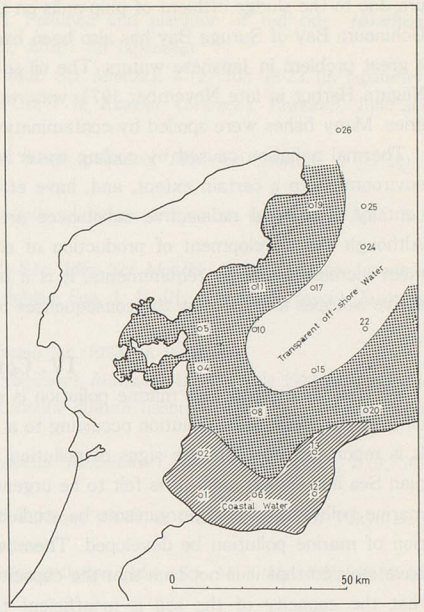

Fig. 6b. Distribution of transparent and turbid waters in Toyama Bay

III. Harmful effects on fisheries

It is a great menace to fish culture on the coast that the red tides frequently occurring since 1963 are very harmful to fish. Mass mortality of cultured young yellowtail (Hamachi, *Seriola quinquiradiata*) has been caused by harmful red tides. Nearly 16 million Hamachi were killed in the middle part of Seto Inland Sea by a densely concentrated red tide in early August 1972 which occurred after a typhoon and stationary front (Baiu-front) had passed. In addition, the thermocline wolud cause depletion of the oxygen in the water where the culture netting of Hamachi was located.

A new type of red tide organism, *Hemieutreptia antiqua* Hada of the Euglenoida, was found in the red tide of the Seto Inland Sea for the first time (HADA, 1972). This species is extermely harmful for cultured fish. A polychaete, *Hydroides norvegica,* has appeared in abnormal abundance in the Seto Inland Sea with progressing pollution, and damaged the cultured oyster in Hiroshima Bay (Arakawa 1971). Areas of sea grass on the coast, known as Moba in Japanese, are very important places for marine production as nursery grounds of many kinds of fishes and invertebrates. Such areas on the coasts of Japan have been widely destroyed by marine pollution. Poliution of estuaries will also be a great problem for the reason that juveniles of salmon stay awhile there after they have migrated down from rivers. Fisheries of *Sergestes lucens,* "Sakuraebi," are a large enterprise in Suruga Bay, but it has declined near the port of Tagono-

ura due to the sludge effluent of pulp-mills on the land. Culture of young yellowtail (Hamachi) in Uchinoura Bay of Suruga Bay has also been badly damaged by this effluent. Oil pollution is also a great problem in Japanese waters. The oil spill disaster of M. S. Juliana, which occurred near Niigata Harbor in late November 1971, was reported to have caused great damage to the fisheries. Many fishes were spoiled by contamination with oil.

Thermal pollution caused by cooling water of atomic power stations will change the marine environment to a certain extent, and, have effects on the conditions of coastal fisheries. Accidentally discharged radioactive substances are a most dangerous source of marine pollution. Although the development of production of electricity by atomic power will be necessary to meet increasing energy requirements, it is a prerequisite to provide for safe disposal of radioactive isotopes and to know the consequences of thermal pollution for marine life.

IV. Conclusion

we now understand that marine pollution is not limited to Japanese waters but has extended all over the world seas, pollution occurring to a greater or lesser extert everywhere in the world. It is reported that there are signs of pollution in the Baltic Sea, Adriatic Sea, Black Sea, Kaspian Sea and Baikal Lake. It is felt to be urgently necessary that the effects of various kinds of marine pollution on living organisms be studied precisely and monitoring techniques of estimation of marine pollution be developed. Then proper counter-measures could be developed. We have realized that it is not true that the capacity of the sea and air is unlimited. We have learnt that the capacity of the sea is insufficient to fade out the pollutants by natural diffusion. Further, the toxicity of recent pollutants hinders the bacterial activity of decomposition, and so self-purification of water is no longer going on. The problems should be tackled not only by marine scientists but also by all concerned with industries and politics. It is felt that such a global task cannot be solved without international cooperation.

Acknowledgement

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意見　環境破壊に対してはあらゆる自然科学の分野の協力を必要とすると思う。(小泉)

回答　然り。日本海洋学会でも「海をまもる」運動について具体的に考えようということになった。協力を御願いしたい。(宇田)

質疑　生物学的影響に対する具体的調査，対象魚種の病状の確認など日本で行なっていることを教示されたい。ソ連では石油汚染の影響として生活機能の停止などを調べている。(Ayushin)

回答　化学汚染による漁の病的変化像についての事実は種々知らされて来た。例えば有機水銀によってスズキその他の海水魚が神経系特に脳に顕著な退行性変化の病変を起していることを熊本医大が報告している。その他六価クローム，CN, Abs, 腐植酸の影響と思われるもので，未詳ながら，マハゼなどに良性或は悪性の腫瘍をおこすことが知られた。(四竈)

意見　カキの害敵フジツボは栄養分の多い水の流れのある内湾の杭などに繁殖する。本年的矢湾(マトヤ)では水道部カキ養殖場では多数のフジツボの着生によって，3/4 位のカキが害をうけた。広島湾では本年カキが海水汚染によって 1/3 に減少し，その 2/3 はフジツボの着生によって斃死したと報告されている。海の過栄養化によってふえた附着生物により，養殖カキの被害は大きな問題になって来た。(佐藤忠)

意見　静岡，神奈川，千葉三県でカツオ，マグロ用生餌のイワシを生で蓄養し全国のカツオ，マグロ漁船に供給しているが，最近餌用のイワシが減少したのみならず，生簀内で死滅するものが多くなった。之皆海水汚染のためと思われる。太平洋で操業する漁船は折角カツオ漁群を発見しても生餌不足のため操業できないで帰港することが，しばしばある。海洋汚染防止のため研究の結果が国家の施策に反映するようにして戴きたい。(小高)