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I. Recent Advances in Fisheries Oceanography of Japan from 1970 to 1973

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1. General

The First Joint Oceanographic Assembly (1970. 9, 13-25, Tokyo), "The Ocean World", including a Symposium G8 (Environmental Data and Forecasting for Fisheries) was held successfully. Its Proceedings edited by M. UDA *et al* (pp.562, photos. 14pp.) was published in 1971 by Japan Society for the Promotion of Science, Tokyo. The Collected Papers for CSK Symposium (Sept. 28-Oct. 1, 1970, Tokyo) called "The Kuroshio II" edited by K. SUGAWARA was published in 1972. "The Kuroshio" edited by J. C. MARR for CSK Symposium at Honolulu (1968) was already published in 1970. Similar bibliography entitled "Kuroshio"—Its Physical Aspects, edited by H. STOMMEL and K. YOSHIDA, published by University of Tokyo Press (1972) is a comprehensive one (pp.517).

Publication of "Basic Series of Marine Sciences" (Vol. 1-13, Tokai University Press, 1970-'73 and following another publication, "Series of Oceanography" (Vol. 1-14, University of Tokyo Press, 1972-'73) presented the advance of modern oceanography (both written in Japanese). "Biological Oceanography of the Northern North Pacific Ocean" edited by Y. TAKENOUTI *et al* (pp. 672, 1972, Tokyo) is a notable recent contribution in commemoration of retired Prof. S. MOTODA.

Concerning the Progress of Fisheries Oceanography in Japan, the following literatures are mainly referred to the present paper;

The Bulletin of Japanese Society of Fisheries Oceanography, No. 16 (Mar., 1970) -No. 22 (Mar., 1973). (B.J.S.F.O.)

Journal of the Oceanographical Society of Japan, 30th Anniversary Volume. (1971, Dec. Vol. 27, No. 6, pp. 233-320).

Report of Deep Sea Animals (published by Faculty of Fisheries, Kyoto University, 1973).

M. UDA (1972), Compiled historical development of fisheries oceanography in Japan. (Proc. Royal Soc. Edinburgh. (B). 73. 37, pp. 391-398).

2. New Exploitation of Trawl Fishing Grounds

i) On the Sea-Mounts in the North Pacific Ocean

S. CHIKUNI (1971) reported on the ground fishes such as "Kusakaritsubodai" (pelagic armorhead or percoid fish, *Pentaceros richardsoni*) and "Kinmedai" (betrycoid fish, *Beryx splendens*) on the Milwaukee Seamounts in the Mid-Pacific. Those fishes are very tasty. They live in the North Pacific Current System as the Extension of the Kuroshio Current.

(a) "Kusakaritsubodai" .... eggs and larvae are pelagic in the subsurface and intermediate layers, growing up to 25-30 cm (4-5 ages). They live in the waters of water temperature 5°-20°C (optimum 8°-15°C) in the zone of 45°-50°N. (In summer it was found in the surface layer less than 100 m. depth.)

(b) "Kinmedai" ... It distributes on seamounts mainly in the zone of 25°-40°N. in the Kuroshio Extension, having optimum temperature 16°-18°C, body length 16-44 cm (ages 1-5), pelagic eggs and larvae, and spawning season in August-October.

(c) "Gindara" Sable fish (*Anoplopoma fimbria*) was found on the Patton Seamount and Cobb Seamount, locating in the Alaskan Gyre, with the mixed catch of Rat-tail (*Caryphaenoididae*). The body length of sable fish is 53-72 cm.

(d) "Kuromenuke" (Black rock-fish, *Sebastes melanopsis*) ... In 1970 a Japanese trawler caught a plenty of them on the Cobb Seamount at the depths of 80-180 m.

ii) Trawl Fishing Ground off Sarawaku, Northwest Coast of Borneo

In Nov.-Dec., 1970 "Oshoro Maru" of Hokkaido University surveyed this area by V.D. Otter Trawl. N. Masuda, T. Fujii *et al* (1973) reported the results with catch of snappers, hairtail, croakers, grouper, horse mackerel, etc. K. Ozawa and I. Kotake (1972) reported the results of new trawling ground surveys by "Umitaka Maru" (Oct.-Nov. 1968, Nov. 1969) in the southern part of the South China Sea.

iii) New Zealand Trawl Investigations

(a) F. Kudo (1971) on board of Taiyo Maru No. 61 (1497 tons, 1800 HP, stern trawler), basing on the hauls during Sept. 5-Dec. 10, 1970, reported red cod concentration in the southeast offing of Bank Peninsula, South Island and silver-fish concentration on the Reserve Bank of Chatham Rise.

(b) H.Suzuki (1972) on board of No. 61 Taiyo Maru reported the results trawling surveys during 1971 (Sept.-Nov.) and 1972 (Jan.-Feb.) in the eastern and southeastern waters of New Zealand (including Chatham Rise and Cambell Plateau). Favourable fishing grounds (catch per haul more than 1 ton, including good catch of 2.6-6.4 tons/haul) were found in the 9 areas, such as West Entrance of Foveaux Strait and on Chatham Rise (Mernoo, Reserve and Matheson Banks). Main fishes caught are .... Barracouta (*Thyrsites atun*), Trevalley (*Caranx lutescens*), "Tarakihi" (*Cheilodactylus macropterus*), "Warehou" (*Seriollela brama*), Silver-fish (*Seriollela punctata*), Southern cod (*Mictomesistius australis*) and squid. K. Nasu (1972a) reported marine environmental conditions around New Zealand concerning demersal fishing grounds.

iv) **Surveys along the Coasts of Peru and Chile**

(a) T. DOI (1970) recorded the results of Emerald Expedition on board of Kaiyo Maru (Japan Fisheries Agency) in the Peru-Chilean waters during Oct. 1968-Mar. '69. The catch in the Peruvian waters was 48.187 tons (catch/haul 1,661 kg) and that in the Chilean waters 43.527 tons (catch/haul 1,319 kg). *Merluccius gayi* distributes to the north of 42°S and densely in the north-offing of Chiloe Is. *Macruronus magellanicus* and *Merluccius gayi* were found densely around Isla Grafo. Although demersal fish-stocks are rich in the offing of southern Chile, steep and rocky coast seems to reduce its availability.

v) **Northwest Atlantic Trawling Survey**

(a) H. HATANAKA (1971) reported the results of survey (Oct. 1969-Mar. 1970) on board of Zaoo Maru (2,500 tons) in the waters from east-offing of Newfound Land to Georges Bank with the catch of *Argentina silus*, Red-fish, Butter fish, squid etc.

700 hauls (1000 hours) with the catch of 3 tons/hr. at the depths of 125-300 m. (bottom temperature 5°-15°C) were recorded.

(b) R/S Kaiyo Maru (Japan Fisheries Agency) recorded the catch of New Zealand hake (*Merluccius australis*) in the Patagonian Shelf Waters in 1969/70 and also investigated southern cod (*Micromesistius australis*) in the New Zealand waters in 1970/71.

vi) **Trawling Survey in the Southeastern Waters of Africa**

(a) T. KOYAMA (1971) investigated lobster (*Palinurus vulgaris*) fishing grounds during June 1970-Mar. 1971 in the areas of 25°-34°S, 20°-35°E within the Mozambique Current. In the offing of Mozambique—Lourenço Marques in summer (July-Sept.) dense concentration of lobsters was found with the records of average size 22 cm, 317 gm (age 2, 3) and bottom temperature 9°-11.5°C, particularly in mid-August dense concentration of cast-off-skin lobster caught 25 tons in 3 days.

During June-Aug. in the offing of Durban egg-bearing lobsters were caught in concentration at the depths of 150-160 m. (bottom temperature 13°-14°C) with the catch of 10 tons in 2 days and its size record (average 22 cm. 318 gm, age 2-3).

Total catch during 61 days (late Jun.-early Sept.) from Laurenço Marques-Durban was 88 tons. Besides lobster catch, catch of snapper called "Kizimadai" 44 tons, hake 10 tons and horse mackerel 80 tons was recorded in June around Agulhas Bank at the depths of 80-120 m. with bottom temperature 8.5°-13°C.

3. Bering Sea Trawl Fishery

i) Alaska Pollack (*Theragra chalcogramma*, PALLAS) Fishery

T. Maeda (1971) studied sub-populations of Alaska Pollack and distinguished Bristol population distributing on the continental shelf in the eastern Bering Sea near around the Pribilof Is. east to 170°W and another subpopulation inhabiting in the area west 170°W. Grounds of wintering (Oct.-Mar.), spawning (Apr.-May) and feeding (June-Sept.) fluctuate year by year in subject to the movement of bottom cold watermass. In cold years the spawning grounds move to south and in warmer years they move to north-east. The central zone is formed in the frontal zone of warm water affected by the inflowing oceanic water. The migration pattern of adult Alaska pollack depends on the concentration of food organisms (northern red prawn, pollack youngs, copepods, amphipods, euphausiids, bivalves etc.). K. WAKABAYASHI (1970) remarked some subarctic important demersal fishes such as Alaska pollack (–0.5–+4.5°C water), halibut and "Rosukegarei" (flat fish) indicate higher rate of survival (greater year-class strength) in the warmer years.

According to Y. TAKAHASHI (1971) larger size group (%) of Alaska pollack is decreasing, notwithstanding the increase of C.P.U.E. in recent years. There appears the invasion of arctic cod in the waters north to Anadyr Bay.

In summer in the western Bering Sea abundant pelagic Alaska pollack is discovered in the surface layer of salmon driftnet fishing area with the echo traces in night.

ii) Halibut Fishery and Alaska Stream Extension

K. KIHARA (1971) reported the negative correlation between the integrated prevalent wind-force at Unimak Is. during Feb.-Jul. and the spreading of Alaska Stream Extension (r= –0.91). He remarked also negative correlation (r= –0.72) between the amount of halibut catch and the volume of the Alaska Stream water in the halibut fishing areas in the eastern Bering Sea.

The years of weakening southerly wind (e.g. 1963, 1968) indicate stronger northwest-going current and conspicuous spreading of Alaska Stream Extension water.

4. Subarctic Salmon Fisheries in the Pacific

i) Life History of Chum Salmon

S. NAKAMURA (1970) remarked rich and poor years of adult chums (mainly 4 years age) of 4 years cycle in the waters south to 48°N (i.e. poor years 1957, '61, '65, '69 and rich years intermediate such as 1963, '67).

T. KOBAYASHI (1970) found that young chums soon after coming down the river in Hokkaido stay in the estuary zone near very shallow surf-zone of 1-2 m. depths as transitional habitat and then with their growth to the size of 50-100 mm in mid-May to late June they are caught in the coastal set-net within 1-3 km distance abundantly. T. KUBO (1970) concluded the life span of young chums in the surf-zone period above mentioned as the critical period, attaining their rate of mortality to the maximum, apt to lose the equilibrium between exterior and internal conditions of fish, in correspondence to the pattern of scale and size of fish in pond culture life period. In the estuarine life we can notice the adaptation to the rapid change of salinity in the environment, osmosis regulation and hormone reaction, etc.

ii) Environments of Salmon

K. Ohtani (1971a) computed the transports of subarctic circulation and constructed schematical map in the Bering Sea and Aleutian waters with geographical distribution of salinity structure. He (1970) and K. Kitano (1971) studied the fluctuation and termination of the Alaska Stream.

K. Nasu (1972b) noted also the stronger extension of the Alaska Current in the salmon fishing season of 1969 to the west near 172°E (in 1970, termination at 175°W) and the location of Subarctic Boundary northerly shifted year by year from 1967 to 1969 (at 160°E, from 42.5°N to 44°50′ N), however again back to 42°N in 1970. S. Machidori (1972) proved the distribution of silver-salmon before the season in June of 1966-'67 in the region of 42°-45°N, 170°-180°E (water temperature 6°-13.5°C). T. Nishiyama (1972) pointed out that water temperature causes to change rate of growth and metabolism of red-salmon in Bristol Bay.

K. Hasunuma (1970) studied surface waters in winter of the northern North Pacific Ocean using data of "Argo" Survey (Jan.-Apr., 1966).

K. Kitani (1973) studied dichothermal and transitional layers in the Okhotsk Sea as the basis of fisheries prediction.

5. World Tuna Fisheries and Oceanography

Since high sea tuna fisheries by long-line increased its fishing intensity in the years of 1963 (boats 36×10^4 tons) and 1964 (48×10^4 tons) by 3 nations (Japan, Korea and Taiwan), it was felt to regulate tuna fisheries as proposed by A. Suda (1969). S. Hayashi (1970) emphasized the urgent needs of international control for tuna fisheries resources.

S. Ueyanagi (1970) noted unutilized fish resources through world-wide tuna studies. Except famed skipjack and bonito, *Gasterochisma melampus* ("Urokomaguro") distributed in the waters of southern bluefin tuna fishery and slender tuna ("Hosokatsuwo") were recommended to be expoited. *Stolephorus buccaneeri* ("Taiwan-ainoko"), *Vinciquerria* spp., *Exocoetus volitans* ("Idatentobiuo"), *Coryphaena equiselis* ("Ebisu-siira"), *Elagatis bipinnulatus* ("Tsumuburi"), sauries (*Cololabis saira, C. adocetus, Scomberesox saurus*) were promising species to be exploited in future.

M. Inoue (1970) stressed the possibility of marine culture of tunas and is continuing the experiments in Suruga Bay. H. Yamanaka (1970) reported the fluctuation of bluefin-tuna resource in relation to the change of oceanic climate. He concluded that in the Pacific Ocean the amount of bluefin catch is abundant in warmer years and less in colder years, and remarked that a conspicuous change in the population structure of bluefin-tuna in response to the great oceanic change in the years of 1958-'59 (Japan side cold, American side warm in abnormal degree). I. Yamanaka (1970) studied the relationship between the population size of yellowfin-tuna and oceanic climate represented by the location of 29°C-line in the Equatorial western Pacific Ocean (1955, '61 northern, 1958, '66 southern extrema located).

M. Inoue and Y. Iwasaki (1971) pointed out the importance of the geomorphological situaton of ridges and seamountains in the Equatorial and

Tropical Pacific Ocean in relation to skipjack fishing grounds for new exploitation.

Searching studies of livebaits for southern skipjack near and around New Guinea, New Britain and Bougainville Is. were reported by S. KIKAWA (1971). Clupeid coral fishes were sampled by drive-in net with fish-lamp in the periods of Northwest (Nov.-Mar.) and Southwest (May-Oct.) Monsoons.

E. HANAMOTO (1971) confirmed the close relationship between the fishing grounds of southern bluefin (1964-'69) and submarine topography in the east offing of Australia and waters around New Zealand, in which the main grounds locate in the offing of Tasmania (Mar.-May), Sidney (June-Nov.) and around Chatham Rise, back eddies and near Subtropical Convergence. M. INOUE and Y. IWASAKI (1971) noted the importance of heat equator and water temperature 29°-31°C for skipjack fishing areas in the Indian and Pacific Oceans.

J. NAKAGOME (1973) reported the results of marking experiment of tunas carried out by Kanagawa Prefectural Fisheries Experimental Station since 1954 (released tunas in pacific 2383, Indian Ocean 1240, Atlantic Ocean 102, total 3725 individuals until 1972). Recaptured fish are only two; (i) Tagged swordfish (fork-length 120 cm) liberated at 6°00′N, 177°50′W on Aug. 10, 1955 and recovered tag from the stomach of a shark caught at 6°02′N, 170°14′W on Aug. 13, 1955. (ii) Tagged southern bluefin tuna at 37°51′S, 150°47′E on July 7, 1967 and recaptured at 37°20′S, 153°00′E on Aug. 3, 1967. Too low rate of recovery may due to the larger size of long-line tunas, possibly immediate death after release of long hours hooked fish, and liberated small number compared to broad fishing area, etc. The tags used are tube type and dart types. The experiments will be continued by improved methods and tags.

I. YAMANAKA & H. YAMANAKA (1972) reported on the variation of current pattern in the equatorial western Pacific Ocean and its relationship with the yellowfin-tuna stock.

M. UDA (1972) remarked the meridional Kamchatka Current Extension at about 160°-170°E, 50°-30°N, forming fishing areas of tunas (albacore etc.) and others (saury, salmon, whales).

6. Development of Squid Fisheries in the Sea of Japan

The offshore squid fisheries in Japan Sea developed rapidly in recent several years since 1967 (mainly in summer along the Polar Front running through the Central Sea of Japan and its center locating around Yamato-Tai Bank with the catch more than 0.1 million tons). The most abundant species of squid, "Surume-ika" (*Ommastrephes sloani pacificus*) distributes in the Sea of Japan, East China Sea, Okhotsk Sea and northern Pacific Ocean.

H. ARAYA (1972) reported squid fishing grounds (June . . . 38°-41° N, east to 134.5°E, July-Sept. . . . 42°-49°N, east to 134°E) and considerable fluctuation of entering fish schools year by year in the northern Sea of Japan. Dense concentration of squid is found in the warm water lying at the north of Yamato-Tai Bank extended from the Polar Front in summer, and autumn. H. ARAYA (1969) reported "Autumn-born Subpopulation" (spawning grounds lying in the zone from southern East China Sea near continental margin to western Japan Sea near Korean side in Sept.-Dec., its larvae found in Oct.-Dec. along near the shelf-edge of East China Sea- western waters of Kyushu-offiing of Yamaguchi Pref.) in addition to principal winter-born Subpopulation and less abundant summer-born Subpopulation. Maturity-index method and sex-ratio analysis were used as their basis. Accumulation of north migrating squids in the sea-region north to 46°N in late summer and Sept. might be due to the loop-sack-like topographical feature.

The evaluated northern offshore population size in summer is the key-note to predict the following autumnal fisheries condition in the fishing area west to Yamato-Tai Bank.

According to S. Kasahara (1972), during the years 1961-'69 from June to October squids distribute along the meandering Polar Front (in the zone of water temperature at 50 m. depth 5°-10°C) in the sea-region of 36°-44°N, east to 131°E, and appear in the offing of North Korea in the season of late April-May, from May to October in the offing of North Korea- Maritime Province, USSR (farthest north in July-August, approaches of USSR). They are found in summer rather warm water side of the Polar Frontal Zone and in fall season rather in its cold water side.

Spawning grounds of winter-born Subpopulation (Dec.-March) lie in the zone of southwestern sea-region of the Sea of Japan west to Toyama Bay—northwestern waters of Kyushu—continental shelf-edge areas in the middle and northern part of the East China Sea.

S. Itoh (1972) noted summer-born population (May-August) distributed in the waters adjacent to Honshu and Kyushu and the cycle of squid catch around Hokkaido and Pacific side about 9 years. The fisheries condition of squid in Hokkaido changed since after 1955 (before 1955 in the waters west to Hokkaido, and since after 1955 higher per cent along the eastern coasts of Hokkaido, and after 1964 CPUE dropped rapidly against to the expansion of fishing intensity).

Concerning squid fishery around Oki Is. J. Adachi (1972) reported that in the long years when (Nov.-Mar.) southward migration route of winter-born squid approaches to the Islands good catch, early beginning of fishing season and longer duration are obtained in the back-eddies area with 4 years cycle (1955-'56, 1959-'60, 1963-'64, 1968-'69).

Y. Hayashi (1972) presented a linear empirical prediction formula of beginning day of squid fishing season in terms of the preceding maturity of female squid with high inverse correlation $r=-0.968$. T. Nazumi (1972) remarked vertical distribution of squids (echo traces proved by angling) in the zone intercepted between isopycnals σ_t, 25.50 and 26.65.

In 1971 (Aug. 18-Sept. 10) special survey of Hakuho Maru (ORI., Univ. Tokyo) was carried out in order to study the production (squids and others) structure in relation to oceanographic conditions (upwelling, etc.) around Yamato-Tai Bank. Stationary complex eddies on and near the Bank located and existence of inertia current were found.

(M. Okazaki, 1973, reported the current measured at the bottom of 320 m depth of speed 6-70 cm/sec in about 200° direction, and period of nearly 19-20 hours).

Z. Nakai *et al* (1973) reported food organisms for squid, mainly *Parathemisto japonica* on and around Yamato-Tai Bank.

7. Whaling Oceanography

In 1970 in the North Pacific Ocean large sized sperm whale became very abundant as in 1965 due to unknown reasons, such as the average length in the following: 46.1 fts (1965), 43.8 ('66), 43.5 ('67), 42.9 ('68), 42.0 ('69), 45.3 ('70).

On the other hand sei whale increased against the decrease of fin whale. The size of sei whale was bigger in 1970 as it was in 1963, probably due to plenty food plankton (euphausiids and along Aleutian Is. calanus with fishes). Large sized sei whale in Alaskan Bay appeared bigger with increase of latitudes.

A. Kawamura (1971) pointed out the importance of food organisms *Sergestes similis* ("Kitanosakuraebi") for sei whales in the North Pacific Ocean feeding actively in May and June and increasing year by year since 1967. There are two areas of dense distribution, one . . . south of Aleutian Is. 41°-49°N, 156°-174°W, another . . . . Alaskan Bay, 45°-49°N, 136°-143°W, and both lying along the Polar Front in the North Pacific Ocean (6°-14°C). In 1971 "Nitarikuzira" (warmer water species of sei whale) 109 in number was caught in the whaling area 40°-45°N, 170°-180°E (water temperature 17°-20°C in summer) by Japanese whalers. Stronger Oyashio Cold Current hindered the northward migration of sperm whales this year. Thick sea fog prevented whaling and reduced operational days to 30% of normal. Abundance of sei and sperm whales decreased greatly in number, particularly sei became ⅓ of the preceding year catch in 1971. Alaska stream was weaker in 1971.

S. Machida (1972, 1973) reported the formation of whaling grounds (especially sei whales) along the Northwest Pacific Ridge (the Emperor Seamountain) around 170°E near the southern boundary of the East Kamchatka Current Extension.

In recent years in general the whaling grounds of sei extended to west and south. In 1972 favourable sei whaling grounds were found in the area 35°-36°N, 177°E (water temperature 15°-19°C).

8. Coastal Fisheries Oceanography

i) Set Net Fisheries

General decline of coastal fisheries in Japan in recent years is notable. However, some times rapid influx of oceanic (Kuroshio) waters in the bays with unusual big catch (K. Otsuka, 1972). Y. Nakamura (1972) also measured stronger circulation in the Suruga Bay seasonally. On February 5-6, 1971 in Sagami Bay a big catch of 30,000 yellow-tail was reported with abrupt rise of water temperature from 13°C (Feb. 2nd) to 15°C (Feb. 5th) due to the intrusion of stormy current.

M. Ishino and K. Otsuka (1973) reported the examples of such rapid offshore water influx in the Tateyama Bay: Aug. 15, 1966, and July 1 and 26, 1972 in detail.

I. Mori (1972) noted the yellow-tail set-net fishery in Arikawa Bay, Goto Is. from the records of 1955-'68. Size of yellowtail varies from 8-10 kg (Dec.-mid-Mar.), late Mar.-May 6-7 kg, so-called "Higan-buri" occupying 90% of the total catch, about 6 kg in mid and late May.

ii) "Maaji" (Horse mackerel, *Trachurus japonicus*) Fishery

(a) According to S. Hattori (1971), the total catch of horse mackerel in Japan (mainly caught in the Tsushima Current area, from East China Sea to Southern part of the Sea of Japan), 0.41 million tons (1959), 0.55 ('60) peak catch, 0.50 ('61-66), 0.33 ('67), 0.31 ('68), 0.28 ('69) and 60-80 thousands tons along Pacific coast (Kyushu, Shikoku-Bôsô) was supplied mainly from the spawning grounds locating in the central part of East China Sea (28°-30°N, 126°-127.5°E) along the Kuroshio Stream and continental shelf-edge (spawning season Jan.-Mar.). The East China Sea-born larval fishes are transported by Kuroshio and its branches. The success or failure of reproduction depends on the changing route of the stream (approaching to the coast in 1969 and contrarily offshore farthering in 1970). The youngs are distributed along the stream and its branches in the seasons from February to September in the waters of 17°-27°C.

T. Tsujita (1971) summarized the life history of horse mackerel in the following table:

	Stage	Habitat	Period of inhabitation	Water temp.	Food
i)	Eggs & larvae	Tsushima Curr. (drifting)	1 month	17-19°C	Copepoda Phyllosoma
ii)	Young	Coastal waters	8-18	18-28	Engraulis Shirasu Micronektons
iii)	Adult	Offshore waters	7-12 or more	15-25	Micronektons Sardine Shirasu Jackmackerel

*Predator; Mackerel, Jackmackerel and othes for i)
Yellowtail and dolphin for ii)
Dolphin for iii)

9. Marine Culture and Marine Pollution

i) Frequent occurrence of red-tides since the year 1963 caused recent mass-mortality of cultured fishes (e.g. "Hamachi", young yellowtail *Seliola quinquiradiata,* T. & S.); particularly in the early August of 1972 in the middle Inland Sea of Japan nearly 16 million individuals of "Hamachi" were killed by heavy red-tide which appeared after the typhoon passage and heavy rain due to Bai-U stationary front. The background overload of eutrophication due to hitherto careless discharge of industrial and domestic wastes is mainly responsible, in addition to worst meteorological conditions of continued heavy rain and following intense insolation (upper higher water temperature, forming sharp thermocline or pycnocline) with the consequence of hindrance to aeration. The resulted shortage of dissolved oxygen was detrimental to marine animals "Hamachi" in live-cars, floating on the sea.

Hitherto unseen rare organisms, as the indicator of pollution harmful to marine culture, e.g. "Midori-mushi" (a kind of *Euglena*), and "Kasane-kanzashi" (a kind of polychaeta) with heavy water pollution appeared abnormally abundant in the Inland Sea and damaged oyster-culture in the Hiroshima Bay and other bays.

A. MURAKAMI (1971) reported marine pollution in the Inland Sea (Tokuyama Bay, Hiroshima Bay and Hiuti Nada) such as the frequent occurrence of red-tide (due to protozoa) since 1961. In summer of 1969 red tide covered broadly the Inland Sea (in the offing of Yamaguchi, Hiroshima, Okayama and Oita Pref.) and in Aug.-Sept. red-tide due to *Euglena* occurred explosively. The excess of nutrients (nitrogen compound and phosphate) flowed in, stagnation of water with stimulating substances (Fe, Mo, Cd, Vitamin-B etc.) were responsible to red-tide. During the advance of pollution the yield of valuable species (seabream, prawn, yellow-tail, flat-fishes etc.) decreased against the increase of lower cost species (anchovy, sand lance, etc.), decrease or disappearance of sea-grass-grown nursery grounds called "Moba" for larval and immature fishes, decrease of benthic animal species and the proportional increase of polychaeta (particularly *Capittella*) are seen successively, and finally ending in azoic state.

ii) Tokyo Bay

A. EBIHARA (1972) reported the water pollution in the northeastern coasts of Tokyo Bay, where organic turbidity due to domestic and industrial wastes increased since 1962, with the rapid increase of ammonia-nitrogen attaining 0.5 ppm, and also rapid increase of COD since 1959. As their consequences occurrence of red tide became habitually frequent. Yield of cultured laver ("Nori") declined since after the peak year 1960 (rich harvest of 1.18 billion sheets), very bad crop of 0.107 billion sheets in 1963 and it became ⅓ of 1960 in 1969. Clams are killed in summer by the shortage (almost null) of dissolved oxygen. The yield of squid, octopus, prawns and crabs all declined.

iii) Red tide in Omura Bay

H. IRIE, S. IIZUKA and others (1972) reported the red-tide in Omura Bay. Dominant red-tide plankton is *Gymnodinium* sp. "July Red Tide" occurs in rainy season. "September Red Tide" occurs in relation to the disappearance of dissolved oxygen in the bottom layer. In mid-summer stable weather develops thermocline or pycnocline, producing favourable circumstance for the violent multiplication of red-tide plankton. There occurs zero oxygen area at the bottom of the central Omura Bay in correspondence to the abundance of red-tide plankton *Gymnodinium*.

iv) Marine culture along the coasts of Japan Sea side is peculiar one, because tidal range is very small (about 0.2-0.3 m) and heavy waves aroused by severe winter monsoon in addition to the existence of sand beaches to be exploited. It needs special studies and technological development of fisheries engineering (T. OGATA, 1973). S. KIYONO (1973) reported the ecological investigation for flat-fishes culture. M. UEKITA (1973) remarked larval or young prawns and shrimps assemble in the area of eddies formed by tidal current where food (organisms and edible seston) is plenty, applicable by fisheries engineering.

v) Mariculture in northern Japan

Efforts of artificial marine culture for the decline of Hokkaido herring fishery were conducted by Hokkaido Fisheries Experimental Station, by means of annual artificial hatching of 20-40 billions eggs and release since 1941 until 1951. In 1952 hatch-out stranded eggs called "Yoriko" of about 700 billions were returned back to the seas. In spite of such efforts the decline of herring fishery has fallen to desperately poor minimum since 1955. A. Iizuka (1972) inferred that the timing of the blooming food organisms (*Acartia clausi* herring eggs and nauplius etc.) did not coincided well to the critical period of abundant herring larvae, which might be due to the change of environmental conditions.

The Pacific side Hokkaido (Akkeshi) herring fishery (most prosperous in 1959 and turned to poor in 1969) proved that herring larvae until the body length of 30 mm during 50 days after hatching need some protection.

Concerning the oceanographic enrichment structure of shallow waters around Hokkaido the prevalent influence of Oyashio waters is noted by S. Komaki (1972). Scallop fishery in Saroma-Ko lake and shallow Mutsu Bay is successful in recent years. T. Yusa (1972) reported the ecological and oceanographical features of flat-fishes (spawning season in March) in Mutsu Bay with the circulation pattern in counter-clock-wise.

vi) Pollution by chemicals and others

M. Shimizu & R. Doi (1973) reported the accumulation of Hg in tunas. N. Isono *et al* (1972) reported "Pollution by PCB".

H. Nishimura (1972, 1973) studied marine pollution in the Inland Sea of Japan in detail in relation to fisheries.

T. Hirano (1971) discussed the spreading of thermal pollution in semi-enclosed seas theoretically.

H. Ochiai (1973) summarized the researches of "Thermal discharged water" with many ART pictures and maps.

vii) Ise Bay

R. Kitamori *et al* (1970) reported sediments and benthos in Ise Bay and Mikawa Bay and evaluated the regions of heavy pollution in the Bays. R. Adachi (1970) reviewed red-tide plankton in Ise Bay and adjacent waters.

10. Long-term Fluctuation of Fisheries and Prediction

i) Trend of Fluctuation of Pelagic Fisheries Resources

H. Mitani (1970) studied the fluctuation of the main plankton-feeder species (sardine and anchovy, mackerels, horse-mackerel and saury) living in the warm waters around Japan.

One peak exists in the year 1936 (total catch 4.33 million tons, fishes only 3.40 million tons), in which sardine occupied 1.63 million tons (actually

2,62 million tons with 0.99 million ton of Korean waters in Japanese circle at that time).

The trough of catch curve in 1945 (terminating year of the World War II) corresponds to the minimum of the fishing effort in Japan. Another peak appeared after 1955 with almost equilibrium total catch of those plankton-feeders above mentioned of about 2 millions tons catch. Mitani (1970) considered 2-2.5 million tons as yield limit. In Japanese Kuroshio waters the total plankton-feeder catch amounts to nearly 9.8 million ton in average, which includes stable catch of anchovy 0.2 million ton and very low level catch of sardine continued, so that apparently the catch of saury and mackerel alternates.

In the waters of Tsushima Warm Current sardine fishery since the year 1950 (peak) declined almost linearly to the lowest level in recent years, and on the other hand horse mackerel catch increased year by year until 1960 and afterward nearly stable level of 0.4 million ton. Mitani (1970) postulates also alternative or reciprocal fluctuation of sardine and horse-mackerel catches in the Tsushima Current area as shown in the Kuroshio waters. He attributed the cause to the reduction potential of fishes. The reason remains still hypothetical.

Z. Nakai (1970) discussed also the alternating resources of important coastal commercial fishes around Japan.

Table 1. Secular fluctuation of catch indices for important coastal water fishes. (Standard 100 in 1931-'40)

Year	Sardine	Anchovy	Saury	Horse mackerel	Mackerels
1931-'40	100	100	100	(100)	100
1941-'45	30	160	50	(160)	91
1946-'50	14	170	260	(120)	195
1951-'55	16	400	1,250	(610)	210
1956-'60	7	500	1,940	1,040	240
1961-'65	3	460	1,600	1,470	410
1966	1	540	1,090	1,410	530
1967	1	490	1,000	970	590

Note: ( ) includes scad.

As shown in Table 1 above, except the case of heavily declined sardine, catch indices of other fishes increased rapidly since the years of 1956-'60, such as saury attaining to peak (1940) in 1950-'60 with afterward gradual decrease and horse-mackerel attaining to peak (1470) in 1961-'65 with decreasing trend after.

In the case of anchovy it keeps rather stable index of nearly 500 and for mackerels it increased continuously and attained to 590 in 1967. Such rapid increase of the amount of catch except sardine after the World War II responsible to natural increase of population size or to man's activity (fishing efforts, gears improvement and fishing exploitation, etc.) is questionable.

Basing on the results of larval net sampling, Nakai (1970) inclined to disagree the rapid increase of above-mentioned fishes after the War and also the alternation of prevalent fish-stocks due to the competition of food organisms as MITANI (1970) presumed.

T. ASAMI (1970) studied the alternating phenomena of fish-communities (stable period-changing period) in the southern sea-region adjacent to Japan. He remarked that after the growing stage of anchovy fishery in the area, in recent years Pacific mackerel, sardine, etc. fond of cooler waters in this area are increasing. Further, percent of yellowfin tuna more or less dropped against the increase of those for big-eyed and albacore-tunas (cooler species) among the long-line coastal catches. The abundance of sardine spawners and eggs in this sea-region increased clearly after the abnormal cold winter year 1963. The main spawning grounds locate in the offing of Kii to Tosa Bay during the years of 1964-'70 with the gradual improvement of reproduction potential. Also, it is notable that migration of Pacific mackerel increased rapidly following after the abnormal cold year 1964. There appears remarkable recruitment of zero-age groups in the surface layer of Kuroshio in its growing period, such as spotted-mackerel in the years of 1954 and 1956, and horse-mackerel in 1953, '57, '63. Stable and changing periods of life cycle pattern seems to alternate in the interval of 3-5 years. (T. ASAMI, 1970).

ii) Fluctuation of Fishery Oceanographical Conditions, Particularly for Saury and Mackerel Fisheries

(a) S. SUZUKI (1971) reported that after the prevalence of severe north-westerly monsoon in winter (abundant snow-fall as an indicator) there occurs the approach and upwelling of cold under-current and enriches the Sanriku coasts with lowering of water temperature and consequently increases primary, secondary and tertiary productions successively.

With the turn of oceanographic conditions from warm water type (skipjack, tunas) to cold water type (dog fish) through transitional stage (mackerel, saury, yellowtail, and sardine fishing areas move to southward. In warm water type period trend of northerly migration for yellow-tail was observed.

(b) K. KAWASAKI (1971) remarked the oceanographic change during 1950's to 1960's favourable to mackerel stock and unfavourable to saury stock affecting on feeding and reproduction.

The southerly retreat of Kuroshio Front and the northerly and off-shore retreat of Oyashio Front caused the broadening of mixing or transitional zone and after cold intrusion of 1963 the cut-off and northerly shift of large warm eddies with the growing and northerly extending mackerel population as well as the decline of saury population and its offshore-escaping distribution.

(c) Concerning Pacific mackerel oceanography M. UDA (1970c) stressed the remarkable enrichment in the Kuroshio waters south to Japan through the cold water intrusion of 1963 resulted to the success of mackerel reproduction. Notwithstanding the delay of spawning season and southerly shift of spawning grounds to the area of Oshima-Zenizu Banks tremendous increase of spawned eggs and its survival with the recovery of oceanic climate since 1965 (Mar.-Apr.) brought the prosperity of mackerel fishery.

(d) Concerning the failure of Pacific saury fishery S. FUKUSHIMA (1970) postulated the effect of environmental change, particularly the deflection of weakened Oyashio to the east-offing with the offshore displacement of main migration route of saury and dispersal in the offing (resulting to worse reproduction).

(e) Y. OGAWA (1971) studied the correlation between Pacific coastal fisheries (catch of horse mackerel, mackerel, anchovy and round herring) and the path of the Kuroshio in the waters south to Japan. Very high correlation coefficients were computed for the total catch of horse mackerel, mackerel and clupeids in the south offing of Shionomisaki (Wakayama Pref.) r = −0.94 and in the southeast-offing of Toizaki (Miyazaki Pref.).

(f) Abnormal high tide (+ 15-50 cm) along the south coasts of Japan in early September, 1971. S. UEHARA (1972) reported the information with abnormal related oceanographic and fisheries conditions. The abnormal rise of tide occurred after the passage of Typhoon No. 23 from Kyushu to the east of Japan along the south coasts of Japan. K. YOSHIDA, D. SHOJI, J. MASUZAWA, (1972) during late Aug. to early Sept. reported the approach of Kuroshio responsible to the anomalous rise of tide in addition to the spring equinoxial tide mainly due to the prevalent easterlies over the Kuroshio. The approach of Kuroshio intruded the warmer, salty and transparent water with catches of immature bluefin-tunas, bonitos, skipjack, mackerel, sardine, dolphin etc. to the coasts.

11. Miscellaneous Papers of Fisheries Oceanography

H. KAWAI (1970) studied survey planning for the kinematic movement of cold area in synoptic broad scale.

S. KURASHINA (1970) investigated the drift and diffusion of spilled oil on the seas adjacent to Japan.

T. NAKAHARA, Y. OGAWA and Y. FUJII (1972) reported the distribution, recruitment and dispersal pattern of pelagic fish-schools adjacent to Yamaguchi Pref. as basis of prediction.

S. USAMI (1970) studied behaviour of Pacific mackerel throughout the life history and its population change.

M. UDA (1970c) stated Pacific mackerel oceanography in Kuroshio waters. He outlined also the rôle of oceanography for the maintenance of tuna longline fisheries (M. UDA, 1970a).

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