# I. Recent Advances in Fisheries Oceanography of Japan from 1967 to 1969

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## 1. General

i) In 1968 at the occasion of Honolulu Symposium for the Co-operative Study of Kuroshio and Adjacent Regions (29 Apr.-4 May) the existence of the Pacific Subtropical Countercurrent (eastward current zone along 20°-25°N. latitudes) was reported by M. Uda, K. Yoshida, J. Masuzawa, Muromtsev et al.

M. Uda & K. Hasunuma (1969) from descriptive oceanographical point of view studied it in coincidence with the theoretical prediction of K. Yoshida & T. Kidokoro (1967). Uda mentioned particularly that the fishing grounds of saury, skipjack etc. in CSK area in relation to the frontal zones and associated eddy-systems for Kurile Front, Oyashio Front, Kuroshio Front, Sub-Tropical Convergence, Equatorial Fronts and China Continental Fronts, etc.

ii) The Report by the Japanese Council of Marine Science and Technology (Chairman: Shoichiro Hayami was presented to the Government on 4th July, 1969, in which a) The comprehensive basic surveys over the sea-beds of continental shelf adjacent to Japan, b) Investigations in the marine environments and control of oceanographic informations, c) Technological development by means of Marine Culture Experimental Fisheries Grounds d) Techniques concerning Deep-Sea Drilling (Remote Controlled), e) Precedential techniques and instrumentation needed for the Exploitation of Marine Resources were included. The above 5 years Programme was already approved by the Japanese Government. In order to accomplish them we must consider water pollution problem seriously in national and international aspects, because the recent rapidly increasing or growing water pollution threats all living resources in the seas and oceans for our indispensable food (protein) resources in future.

The Acts concerning for Marine Resources Development, the Technological Institution for the Exploitation of Marine Resources and the Scientific Foundation for the Exploitation of Marine Resources were also proposed to the Government.

The Deep Submersible *"Shinkai"* was newly built and launched in 1969, 16.5 m×5.5 m×5 m, displacement 90 tons, 4 crew, underwater normal speed 1.5 knot, equipped 10 hours durable oil-immersed lead battery, capable dive down to 600 m depth.

Her test cruise off Kannoura was reported with successful underwater photography of deep crustacea at 360 m depth.

iii) a) Japan-Australia Joint Investigation of Great Barrier Reef and adjacent waters by means of Deep Submersible *"Yomiuri-go"* was carried out from December, 1968 to June, 1969. Scientists from Japan participated are M. Uda, Yasuo Suehiro, Genki Eguchi, Hiroshi Niino cooperated with many Australian scientists for the exploitative survey of sea-bed (sampling of mineral resources and marine livings with underwater marine environments, and also counterplan against the coral damage by abundant "thorne star fishes".

b) During the period from September to November in 1967 *"Yomiuri"-go"* took the surveys for the Investigation of Sea-bed Resources in the adjacent waters of Ryukyu Islands (Okinawa-Miyako Is.-Ishigaki Zima-Iriomote Zima) with 21 dives. The results were already published in the Report (229 pages with many color photo) from the Fisheries Agency of Ryukyu Government as the basis of fisheries development.

iv) Surveys by *"Hakuho-maru"* (Ocean Research Institute, University of Tokyo)

The survey cruise of *Hakuho-maru* (GT. 3226) started in the summer of 1967 over the western and mid-Pacific, mainly for geological and geophysical studies.

In the period from 18 Nov. 1968 to March 1969 "Southern Cross" Expedition cruise was carried out along the meridian 170°E from Sub-arctic to Antarctic Continent, mainly for the chemical task (analysis of deuterium, nutrient salts, dissolved oxygen and salinity etc.) (Leader scientist, S. Horibe).

*"Tokai Daigaku-maru"*-II has carried out a sampling survey of Japanese eel larvae (Leptocephalus) in the southern sea of Japan down to 23°N including Ryukyu Islands area in May 15-29, 1969. Zinziro Nakai of Tokai University is the leading scientist.

The second survey of the spawning ground of Japanese eel by this boat will be undertaken in October and November, 1970 again.

v) R/s *Tansei-maru* (Ocean Research Institute) has made surveys in Sagami Bay, Suruga Bay and Kuroshio waters. Vertical distribution of phyto-plankton, zoo-plankton and micro-nekton was studied.

Particularly the life history, distribution, production, migration and ecology of Sergestes shrimp were illustrated by M. Omori (1969).

Microbiological studies for organic decomposition were made by H. Seki (1970) in the same area.

In September, 1969 the tracking of the Kuroshio Stream-axis was followed. In February and March special survey of Subtropical Countercurrent was also undertaken by *Hakuho-maru.*

vi) Trawling surveys in the South China Sea were carried out by *Nagasaki-maru* (Nagasaki University) in the west offing of Borneo, Sarawaku in July, 1967, '68, '69 three years. (S. Abe, 1969).

A new submarine canyon (120-100 m. depth engraved in the flat shelf of

50-30 m. depths) embraces upwelled (?) cold water mass which formed favourable demersal fishing grounds around it (sea-bream and others caught).

R/s *Umitaka-maru* (Tokyo University of Fisheries) has surveyed between Borneo and Malay Peninsula along 5°N. in October and November, 1968. Trawling experiments were made 6 hauls in the northwestern sea-region of Groot Natuna Island at the depth of 70-83 m. (muddy and sandy bottom) with catch of sea-breams, squids, trevally, bullseys, flutemouths, threadfin bream, pumfret and so on. (K. Ozawa and K. Kihara, 1969).

*Oshoro-maru* (Hokkaido University) has surveyed Arafura Sea and Gulf of Carpentaria in December, 1968 with trawlings (catch of shrimps and prawns) and reported by T. Tsujita (1969).

vii) Fishery oceangraphic works in CSK.

Manual of Fisheries Oceanography for CSK was preprinted in the reports of CSK Fisheries Aspects in Japan. (1967, '68, 69, '70).

## 2. New Exploitation of Fishing Grounds

i) *Kaiyo-maru* Expedition (Research boat, 3200 GT, Japan Fish. Ag.) 1968, June-July. East offing and south offing of South Island of New Zealand. Trawling 22 times with the total catch 76 tons, half of them barracuda, hoki (demersal cod), silver fish, whip-tail, sea-perch down to 400-500 m plenty. The commercially valuable sea-perch and silver fish inhabit on the ridge west to Chatum Is.

Along the East Coast of South America *Kaiyo-maru* took survey on the on the continental shelf with trawling and biological sampling from November, 1968 to February, 1969. From 2°S to 11°S off the coasts of Equador and northern Peru favourable fishing grounds of grouper, snapper and younger hake (7°S-10°S) were found. In the upper layer off Paita abundant mackerel was caught. From 11°-33°S the sea bottom is almost barren due to poor oxygen with $H_2S$ smell of mud in contrast to the abundance of pelagic fishes such as mackerel, horse mackerel and anchovy in the upper layer, similar to the Benguella Current region along the west coast of Africa.

Along the west coast of southern Chile again prolific world of marine livings such as hake, barracuda, crab, whale etc. was found.

ii) Trawling survey in the Northwest Atlantic by *Shirane-maru* (2528 GT, belonging to Nihon Suisan Co. Ltd.)

In the period of June, 1968-March, 1969 (storm season . . . . November-April) catch from Greeland waters and Labrador coast extending to Grand Bank mainly consisted of red-fish and cod.

In the region of New York offing—Grand Bank fishes ("Shizu", squid, "Nigisu") were harvested.

Purse-seining investigation in the South China Sea off Hongkong No. 1 *Taiho-maru* and other boats were used in the area east to 114°E along the continental shelf-edge in 1968. Total 11 cruises and 268 boat days, 116°-118°E, 21°-22°N the fishing area, from May- to next January with the harvest of 220 tons (horse mackerel, mackerel, etc.) were undertaken.

Tuna long-line fishing survey in the Southeast Pacific. In 1968 (July-September) a new bigeyed tuna ground was found in the area of 20°-25°S, 85°-95°W as profitable one in future.

iii) Development of unutilized fisheries resources is to be approached on the oceanographic knowledge of frontal zones in the equatorial and higher latitudes, especially in the coastal water regions such as the marginal zone of upwelling areas; offings of the California Current, Peru Current, Canary Current, Benguella Current, Somali Current and Arabian Sea etc. Submarine topography associated with sea-mounts, bank, reef, and ridges or sea valley and submarine canyon form also singular fishing areas. Estuarine areas are prospective as fishing grounds such as crustacean livings.

Eddy system along the frontal zones is generally presumed as the favourable fishing grounds.

Plenty concentration of food organisms such as plankton biomass, micronekton, benthic communities, DSL and even suspended organic matters are the guide-post of fishing grounds.

Development of mid-water trawl, vertical longline and other specially invented gears for the deep sea fishing, particularly to exploit the continental slope down to 1500 m depths and over the coarse, rocky sea bottom hitherto unexploidted should be our targets in near future. Electric fishing device as shown for prawn in the Gulf of Mexico shall become useful in future.

## 3. Mariculture and Nearshore Oceanography

Notwithstanding of great hope to the future development of marine food resources through mariculture and coastal fisheries, a serious threat of marine pollution from careless industrization and urbanization extended daily the area of environmental disruption.

Japan is famed by its developed mariculture technology for fish farming (young yellowtail called *"Hamachi"*, prawn and shrimp, eels, sea-bream, puffer-fish etc.), shellfish (oyster, pearl-oyster, clams, etc.), seaweed (laver called *"Nori"*, laminarian kelps etc.). Salmon and trout, abalone and scallop, lobster, flatfishes should be added to the culturing species. Water pollution and coastal engineering as well as overfishing or overcrowded culture affect seriously on the marine living resources. Our survival in the coming century is conditioned by such environmental control to get necessary protein food and drinking water from land water and desalinated sea water. Open space on and in the sea might be utilized more and more for the future civilized world. Speedy and bulky oceanic transportation on and through the sea might be developed more and more. However, water pollution harmful to human living must be strictly prohibited.

Exploitation of oil, gas and many precious mineral resources on and in the sea bottom as well as the chemical utilization of sea salts should be harmonized to the fisheries development. Of course, marine exploitation is for the welfare and happiness of human being. We need food and water at first and at least. The conservation of marine living resources environment for maximum sustainable catch (crop) is equally an urgent demand for our future survival. Oil pollution was demonstrated to be detrimental to all marine life and through food-web ultimately detrimental cancer producing agent to us.

The emerging atomic power industry accompanies also dreadful radioactive wastes as byproducts. If we fail in its management or treatment and disposal, our future life may fall in critical stage. Present permissible level of its amount is not trustworthy because of biological concentration factor and streaky pattern of spacial distribution. Accompanied thermal polluted water should be converted to the profitable warm water farming of useful marine livings and land crops. Life-esteemed exploitation and pollutionless clean environment are our final aims. Marine scientists and technologists should make more efforts to get pollutionless energy development such as wave energy, tidal energy, electric power from thermal difference, solar radiation, wind force, terrestial heat (steam) etc.

Marine engineering and technology must be developed for the sake of comprehensive human welfare. Cross fertilization, transplantation, hybridation, sea1bottom ploughing, artificial reef-making, dam-building, digging and so on should be applied wisely. Diffusion, advection, wave-reducing pile, stagnation breaking device, thermocline destroyer, rocky, sandy-, muddy-bottom clearner etc. might be developed for marine production in estuarine and coastal waters.

In case of *"Hamachi"* (young yellowtail) culture, security of seed baby fish (*"Mojako"*) quantity which depends on the approach of *Kuroshio* stream at present, bait to be fed, clearance and circulation of live car or live pond etc. and marketing are the outstanding problems.

In case of *"Nori"* culture, refrigerating seed-net preservation, floating drift-laver net are recent two revolutionary inventions.

Unfavourable climate (warm winter), decline of water quality, too dense concentration of nets causes bad crop of "Nori" due to diseases.

In the case of pearl oyster, F. Ueno (1969) studied the farm deterioration, K. Wada (1969) reported its growth and luster related to water temperature.

### 4. Marine Instrumentation for Fisheries

H. Yamanaka (1968) reviewed the results of tuna investigations from ecological point of view by means of supersonic fish-finder. M. Nishimura and K. Shibata (1967) has represented the density of tuna shoals by the number of fish individuals per $10^5m^3$ inferred from echo-traces similar to the case of hake density (D. Cushing, 1968).

T. Ishii (1968) of the Ocean Research Institute treated echo-traces as index of tuna stock abundance by using pattern analysis.

Noting relationship between tuna distribution and submarine topography K. Shibata (1963, '66) particularly remarked DSL and tuna-echo-trace above top-flatted seamounts (guyots) shallower than surrounding bottom.

M. Nishimura (1967) developed a special fish-counter with greater output and combined electronic computor in counting echotraces for the estimation of fish abundance. Close relation between DSL and the depth of tuna swimming layer was found. Motoo Inoue (1965) confirmed the located tuna species actually by angling lured up fishes through dispersed baits. Fish was proved in early morning descent (dawn till sunrise) and evening ascent (near sunset and dusk). The speed of diurnal migration appears about 200 m depth per one hour. Sonar-type fish scanner is effective in the range of about 1000 m. It was found that tunas swarm near about thermocline or above of it.

Using underwater television and camera equipped to *Tokai-Daigaku-maru* II, Iwashita (1909) studied ecological behaviour of albacore tuna in the Pacific and Alaskan Pollack in the Okhotsk Sea. H. Taketomi (1969) of Tokai Regional Fisheries Research Laboratory has photographed the swimming behaviour of king-crab near Kamchatska in the Okhotsk Sea over the sea bottom by underwater television.

Shoji Saito (1970) of Hokkaido University, *Hokusei-maru,* has developed recently a new gear, vertical longline, in combination of the ordinary horizontal longline and supersonic fish-detector with successful experiments. Three-dimentional distribution of tuna abundance was disclosed down to 400-500 m. depths.

Y. Maniwa (1970) developed FM Fish-finder using supersonic wave of linearly changing frequency which can detect the location of fishes as well as its movement and ecological behaviour by Doppler effect due to the swim of fish shoal for continuous wave of constant frequency.

Biotelemetry intending to catch the movement of fishes directly by sonic tag, telesounder, sonobouy, underwater telemeter and so on are all under experiment in Japan. Another interesting studies are going on by Maniwa and others such as sonic attraction of fishes or sweep away the fish by marine acoustic broad-casting of favourite or disagreeable sounds to them.

Utilization of electronic computor for the oceanographic and fisheries studies became urgent nowadays. Simulation for fisheries forecasting system, demersal, pelagic, coastal and bio-statistics, fish population dynamics, biometric studies, are all their examples now going on. (T. Ishii, Ocean Research Institute and K. Kurogane, T. Kawaii, Y. Shimazu, Tokai Regional Fisheries Research Laboratory 1969). In 1969 M. Nishimura published "Researches on Optimum Frequency of Fish Detector.

## 5. Subarctic Salmon Fisheries in the Pacific

In January, 1966 US R/S *"Argo"* and *"Keltz"* carried out hydrographic surveys over the Pacific subarctic waters. Our knowledge on the environments and fish distribution of the salmon wintering grounds is still very poor. K. Otani (1970) analysed the above observed data and indicated the stronger East Kamchatka Current having the transport of $4.6\times10^6 m^3/s$ for the upper layer above the 150 m. depth with the speed attaining to 100 cm/sec. and the cold water thickness down to 500 m depth in mid-winter, along the east coast of Kamchatka Peninsula.

The subarctic salmon water lies in the less saline area bounded by the southernmost isohaline of 34%.

According to S. Nakamura (1970) of Kushiro Fisheries Exp. St. the drift-net fishing grounds of chum salmon (age 4~6) south to 38°N. from late April to July located in different way such around two central areas, 150°-155°E and 160°-170°E respectively. The most concentrated immature chums were found in the latter area of 160°-170°E in June and July.

A striking fact was reported by T. Kobayashi (1970) of Hokkaido Salmon Hachery that after the downstream migration (from March to July) chum salmon juveniles in the estuarine life were found in the very shallow (nearly about 1 m. depth) beach waters in April and May, and after soon they migrate to the offing water, caught by fine mesh nets. The most dangerous or critical period is suspected to be this nearly one month's life suffering from most severe environmental conditions, for the transitional physiological state of salmon. T. Kubo (1970) of Hokkaido Univ. proved that after hatch-out 130-150 days the said critical period of highest mortality corresponding to the lowering of blood concentration and protein content.

In the period of marine life it is a great problem why salmon schools assemble to "SIOME" or oceanic front. Environmental barrier or attraction of plenty food organisms is usual explanation.

The sharpness of oceanic front defines the degree of concentration of fishes. The movement of front is associated to the migration and location of fishes. Climatic change of oceanic state is reflected to the above conditions and consequently associated to the prediction of the concentration of fish abundance or the start of homing migration.

The world climatic pattern is changing in large-scale from the decade of 1960, comparing the anomaly of 1962-'63 to 1967-'68 (H.H. Lamb, 1966. P. Namias, 1963, 1969, J. Bjerknes, 1966, J. Nemoto, 1967).

T. Fujii (1968), Captain of *Oshoro-maru*, Hokkaido Univ. remarked the close correlation of Sockeye salmon ($5_3$. $6_3$ age) migration in Bristol Bay to the intrusion of Alaskan Stream Water (32‰ isohaline as an indicator) and the maximum fish concentration at that front in June.

T. Yoshimitsu (1958) emphasized the importance of 4°C line at 100 m. depth for the location of favorable red salmon grounds in the waters south to Aleutian Islands, affected by the intensity of Alaskan Stream. The west-ward extended distribution of Bristol origin red salmon subjects to the intensity of Alaskan Stream.

The western subarctic cold water in the Bering Sea extended strongly in some year to east (eg. 1966, '67) and shrinked in some year (eg. 1963) to west in accordance with the variations of fishing localities and harvest (E.

Yoshihara, 1968).

The recent cooling trend (1962-'64) of air temperature over the oriental Siberia has influenced on the reproduction potential of salmons. Air temperature and snow fall in winter (Oct.-Feb.) determine in most cases the abundance of chum salmon juveniles in the Okhotsk Sea side. (O. Sano, 1968). In general, global climatic change affects deeply on the reproduction potential of salmonidae.

## 6. Problems of Fisheries Oceanography in the Japan Sea

The appearance of the cold bottom water near the western coast of Shimane Prefecture fluctuates in accordance with the change of horse mackerel catches at the considerable level of stock size (i.e. a linear relation between the additional cold water and the anomaly of catches with r= +0.82, S. Yamasaki, 1969).

In late years squid fisheries in the Japan Sea developed rapidly, especially in the central area of Japan Sea around Yamato-Tai Bank in summer along the Polar Front, wherein feeding shoals in June and July and sexually coupling shoals in August and September gradually increased. However, in winter no spawning squid group was found in the Japan Sea. In the marginal area of the Tsushima Warm Current with the sharp contact zone of cold water intrusion from north at about 38°N. and 133°E. a most persistent squid fishing ground from July to October is observed. (T. Nasumi, 1969) Another remarkable squid fishing grounds near the oceanic front of Tsushima Warm Current in the western offing of Tsugaru Strait is located in the zone of temperature of 3°-7°C isothermal line. (H. Araya, 1969).

Along the Polar Front of Japan Sea the fishing grounds of *Sakura Masu* (cherry trout) from March to April and of Pink salmon from April to June are caught by drift gill-net. Indices of such fishing localities are 10°C of water temperature, IV-V color of the sea in Forel's scale, echo trace, particularly DSL, indicator species of plankton, intermingled fish species etc. 10°C region at the cold water intrusion to the warm current area in the fishing period of March-June is the general direction for the search of the fishing grounds. By means of fish-fiinder and pole angling catch diurnal migration of fishes (night ascent, daytime descent) attains to the range of 60 m -100 m. (K. Tabata, 1969)

It was found a positive correlation between the catch of young yellowtail and inflowing water transport into the Toyama Bay. (K. Arai, 1969). Yellowtail catch of Sado Island by set-net fishery in summer and winter is associated with the pattern of warm water around Sado Island and cold water in the offing. (M. Kuroiwa, 1969). K. Kaminoyama (1969) studied the recruitment of yellowtail stock in the Wakasa Bay and concluded that the share of the first age group approaching to the Wakasa Bay depends on the thermal pattern in winter, rather than the O-age group catch, and additionally on the current direction before the catch. Y. Ogawa (1969) defined the index of "Warm Current Effect" i.e., Volume transport × *sin* (direction angle) / distance between the fishing ground and current axis and treated the fishing condition of horse mackerel (O-age group) in the Southwestern sea region of Japan Sea from spring to summer, with high positive correlation between them, suggesting continuous supply of juveniles or young fishes from offing to coastal fishing grounds. (Y. OGAWA, 1969).

## 7. Pacific Saury Fisheries

Recent decline (1963-'69) of Pacific saury ("*Samma*" fishery in Japan called hot discussions on its cause and future prospect. The population size, reproduction potential, availability or fishing localities, migration routes, spawning grounds are not still clear in the Pacific Ocean as a whole. Search for new fishing grounds in 1969 brought some successful results such as those in the west-offing waters of North American coast including California Current Area and saury concentration in the mid-Pacific subarctic area near the Polar Front nearly between 160-170°E. Our knowledge of saury distribution is very limited one only in the fishing period from August to December in the high sea and a little more along our Japan coast. However, according to S. FUKUSHIMA (1969) saury distributes from the northern limit in the northwest Pacific 49°N. and in the northeast Pacific 59°N (Alaskan Stream) down to the southern limit as Subtropical Convergence. Fukushima postulates the farthest north distribution in summer concentrating near the Kurile Front in the thin warmer surface water. Basing on the sampling survey of saury in the mid-winter of 1967 and 1968 he found dense distribution of larval and young (immature) saury in the Kuroshio Countercurrent area and convinced it as the important nursery and wintering grounds of saury.

It seems that some minor part of this stock coming in the coastal water area of the Pacific side of Japan. In winter some parts of Japan Sea saury population and those of Pacific saury population mingles each other in the East China Sea. It might depend mostly on the strength of the Kuroshio Countercurrent which is considered to be associated deeply to the intensity of the monsoon in winter. The Kuroshio anticyclonic gyral changes year by year with the fluctuation of the Kuroshio Current and ultimately with the climatic change in the north Pacific Ocean.

The large, medium and small sized saury population for body-length 29-31 cm, less than 24 cm respectively are changing in their length composition year by year and by season (S. ODATE 1956, H. HOTTA, 1960). As seasonal change larger size fish rapidly decreases in the mid- and late- October to medium sized fish. Succeeding fish schools appear in three or four waves and vary to smaller sized fish. The year of large and medium sized fishes in the proportion of half and half appears to be a rich harvest year. It is supposed that after the abnormal year of oceanic climate around 1963 the reproduction potential or recruitment became rapidly declined and reflected to the poor yield of saury. On the contrary from the year 1949 with the introduction of revolutionary fishing method of stickheld-lift net in connection with electric fish-lamp the yield of saury suddenly increased which might be also due to the contribution of increased reproduction potential in response to the improvement of oceanic climate. The reproduction success might be caused by the combination of radiant energy and oceanic fertilization in winter and early spring.

Finally basic studies of wintering and nursery grounds with their drift migration in the Pacific are demanded in near future.

The mechanism of fishing ground formation in the Okhotsk Sea side of Hokkaido (in the fall of 1969 abnormally rich harvest contrary to the poor catch of Pacific side) is left as an interesting problem.

## 8. Tuna Fisheries Resources

Japanese longline tuna fisheries before the World War II was almost limited in the North Pacific area, but after the War from 1948 expanded its grounds toward south and east in the Pacific and since 1952 toward west and south in the Indian Ocean, and also in the Atlantic starting from the western Equatorial region in 1950 expanded its fishing area toward east, north and south.

Thus, until the year 1967 almost all available fishing areas of world oceans were exploited for longline tuna fisheries from nearly 45°N (line of demarkation, Subarctic Convergence) to nearly 55°S (Polar Front, over Subtropical Convergence for *Minami Maguro* or southern bluefin tuna) for warmer water area above approximately 10°C. Although we have still deeper swimming tunas as recently found by echotrace and vertical longline fishing or bait-illured line fishing, tuna stocks are felt in general overfished except some species such as skipjack tuna. The decline of tuna catch per unit effort and longer range cruise caused less economical profits in spite of rapidly increased demand and consumption. On the otherhand developing purse-seining fishery for younger tunas in the tropical latitudes came successively under the control of sustainable catch. International regulation for tuna stocks by the hand of FAO in cooperation of concerned fishing countries is going on through IATTC, ICCAT, IOFC and others.

How to reconcile purse seine fishery and longline fishery for tunas is a suspending problem to be solved. In order to improve the situation of tuna fisheries there remains problems of better utilization of tuna meat through the development of food technology, security of man-power for fishing, not only conservation of tuna stocks efforts of fertilization and mari-culture of tunas and economically, scientifically efficient improvement of tuna fisheries through mechanical for electronic instrumentation, internationally cooperated fishery oceanographical forecasting system (IGOSS) etc.

The most valuable bluefin tuna fishing grounds were exploited in recent years since 1960 in the southern higher latitudes of western Pacific Ocean, Indian Ocean mainly and some part of Atlantic Ocean, so-called "*Minami*

*Maguro*" (southern bluefin).

Most active investigations for this species were carried out by the Japanese fisheries research boats and partly along the coasts of Australian Continent by Australian scientists. The water temperature in the fishing grounds covering the West Drift Zone and its northward extension is about in the range of 8°-15°C corresponding to the adult feeding period) S. SHINGU, 1967, WARASHINA 1968, S. HAYASHI, 1969). In the spawning period (August-October, Western offing of Australia, water temperature higher than 20°C, Mid-spawning period from October-March, in the offing of North-western Australia, north to 20°S . . . temperature 24°-30°C and salinity 34-35‰, in the area south to 20°S . . . 17°-25°C, in late spawning period, December to March in the Western Australia offing, cooler than 15°C) the fish migrates broadly. In the larval period they were found mostly in the northwestern waters to Australia in southern summer (one specimen from northeastern 20°S, 150°E) of temperature 25°-30°C, and in juvenile period in the coastal waters adjacent to Australia, of temperature 16°-20°C and salinity 34.8-8-35.9‰, and in young fish (immature) period in the SE offing of Australia from April to October . . . 14°-19°C, Salinity higher than 35‰, in the South and west offing of Australia from September to March centered at 5-15°C and 34-35.5‰.

## 9. Skipjack Tagging Experiment and Fisheries

In 1968 from March to June 3,936 skipjacks were liberated and 135 (3.4%) among them were recaptured by fishing boats.

Those liberated in the waters south to Miyakozima in March and April (Ryukyu Islands) were recaptured mostly in the adjacent waters of Kyushu in the downstream of Kuroshio, 3 fish in May east of Inubozaki and in June 4 fishes in the southern waters around Idu Is., and moreover, in August 1 fish in the east-offing of Kinkazan recaptured. Skipjack-tunas liberated in the waters southeast to Nozimazaki in June were recaptured partly in the Northeastern Sea-region of Japan and in the waters around Idu Islands separately.

Tagging experiment in 1969, liberated 1958 individuals of skipjack in the waters east of Taiwan in March, by Miyazaki Maru, was also successful with the recapture data (unto end of May, 1969) on the downstream of Kuroshio, in the vicinity of Kyusyu 6, off Sikoku-Wakayama 4, and off Idu 1 successively. Still we have no data of directly northward migrated fish from Bonin-Mariana waters.

Basing on the common type fluctuation of stock-index of skipjack among the Northeastern Sea-region of Japan Population, the Hawaiian Population and the Eastern Pacific Population of skipjack, T. KAWASAKI (1964) assumed a common year-class populations in the north Pacific. B. J. ROTHSCHILD (1965) proposed a theory of skipjack migration covering mid- and eastern Pacific areas basing on the size composition of the catch, larvalfish distribution and tagging experiments.

On the other hand S. NAGANUMA (1968) conjectured some migration routes connecting the mid-Pacific skipjack population to western Pacific population. All those proposed theories should be checked by proper design of tagging experiments. International tagging experiment for skipjack-tuna should be encouraged as for the potential exploitable food resources in the world oceans. We have already some knowledges concerning fishing grounds (45°N-40°S) and obscurely larval distribution (32°N-35°S). The life history of skipjack except the fishing period is not clear. In order to asses the population size and control the fish-stock the necessary investigations should be accelerated by international cooperation.

In recent years the skipjack such in the tropical Pacific western half is very rapidly exploited by Japanese boats and still going on.

In November of 1968, the fishing grounds along Equatorial Current area extended from west to 170°E. A very concentrated favourable skipjack grounds are seen in the waters north to New Guinea in the period of September-December in the terminal South Equatorial Current area. It is well-known that unexploited skipjack stock exists in the southern hemisphere over the equator tremendously. However, supply of livebait for pole and line angling is now a serious problem. Far Seas Fisheries Research Laboratory (Fisheries Agency in Japan) and Shizuoka Prefectural Fisheries Experiment Station have started for its survey and bait-fish sampling in the waters near New Guinea and Bismark, Solomon Islands. The local bait fish such as *"Tai wan Ainoko"*, *"Mizun"* etc. are considered to be highly prospective and the methods of farming and muliculture to be studied more.

The improvement of marketing and light meat technology are national and international problems. The mariculture of skipjack in the warmer tropical waters around islands, atolls and reefs might be encouraged in the international scale. By our experiences of underwater observations skipjack swims down to about 200 m depths. Thermocline topography helps us purse seining of skipjack effectively and make capable three-dimensional utilization of fish stock with supersonic fish finder.

## 10. Pacific Mackerel Fishery

In the waters around Japan Islands Tsushima Warm Current Population (northern and southern subpopulations) and Pacific Populations of Pacific mackerel are marked. (T. Kawasaki, 1969). The Japan Sea Population is in the declining stage since 1962. However, the Pacific Population mackerel is rapidly increased after the year 1958 and apparently substituted the rank of Pacific saury.

The main distribution of Pacific mackerel extends from the waters adjacent to Idu Islands in winter and spring to the waters east to Hokkaido in summer and south to Hokkaido in the fall season. Even in the waters southeast to Kamchatka in the salmon fishing grounds mackerels are frequently caught by salmon gill-net.

According to S. Usami (1969-1970) the catch of Pacific Population mackerel is 770,000 tons. Since 1965 the main spawning grounds are around the Idu Islands Area, especially around the Zenizu Reef area as its center, and the main fishing season coincides to the spawning season corresponding to the water temperature of 15°-20°C and at least above 10°C.

In general, mackerel concentrates in the contact zone of the coastal water and the Kuroshio water or nearly along the shelf-edge of 180-300 m. depths. Particularly Zenizu Reef area corresponds to the frontal zone of upwelled cooler water in the west and Kuroshio warmer water in the south and east. At the hydrographic profile the fish concentrates on the marginal side of the Kuroshio.

The northward migration and the shift of the prosperous fishing period of mackerel accompany with the seasonal northward movement of most remarkable upwelling area and depend on the developing intensity of prevalent wind and northward Kuroshio branch current. The abrupt change of oceanographic condition from the BAI-U (Monsoon Rain) period to the mid-summer is associated to the rapid development of warm current and the northward movement of mackerel fishing grounds.

Stock level of mackerel varies in connexion with the degree of cold water intrusion in winter, and also consequently with winter monsoon and Kuroshio meander.

The offshore migration routes in each stages of mackerel life history in the northward journey should be investigated more.

Owing to the abnormal coldness in 1963-'64 poor catch of winter mackerel fishery off Choshi, southward shift of spring mackerel spawning grounds and the delay of northward migration of them were followed. However, in accompany with the warming of the sea since about 1965 the fertilization of spawning grounds elevated the population level of mackerel in general against the lowering of saury population level.

Since cyclone passage causes the cold water upwelling in one hand and rapid approach of the Kuroshio on the other hand, the fishing conditions of mackerel changes suddenly.

The offshore distribution of mackerel and the availability of unutilized stock of them depend on the varying pattern of the Kuroshio and important to grasp the recruitment of macherel from the point of longterm prediction of fishing conditions.

## 11. Whaling Oceanography

i) In recent years Antarctic whaling grounds shifted gradually to lower latitudes, i.e. blue whale grounds near the pack ice zone in the higher latitudes, and as the target whale species changes from fin whale to sei whale the whaling localities shifted to lowerer and lowerer latitudes, particularly the latest whaling grounds of sei whale is close to 40°S line (northern limit of permissible zone) with considerable catch. Near the region 40°-50°S, 30°-90°E. T. Ichihara (1966) noted the pigmy blue whaleground, as a local stock of new sub-species. In the north Pacific Ocean we can remark the trend of whaling ground shift to lower latitudes. The catch of factory-ship whaling south to 40°S is subjected to USSR fleet. (K. NASU, 1969). More than 50% of world catch of sperm whale is caught annually in the Pacific. (15,000 sperm whales approximately).

A new whaling grounds were exploited in the Tasman Sea. In the whaling period of 1967/68, 51% of total sei whale catch (7119) 3,648 whales (Tasman Sea 1,116, area east to New Zealand 2,532) were caught. (K. NASU, 1969). Generally sei whaling ground is formed between the Antarctic Convergence and Subtropical Convergence in the southern hemisphere.

The southern limit of the distribution of "Minami Maguro" (southern bluefin tuna) coincides nearly the southern limit of female sperm whale and corresponds nearly 8°C isothermal line intersected by the Antarctic Convergence and Subtropical Convergence. (NASU, 1969).

ii) According to Y. MASAKI (1969) the whale catch in the northern waters in the pacific in 1968 by Japanese Motherboat-type whaling is fin-whale 729 (364.5 B.W.U.), sei whale 3,819 (630.5 B.W.U.) & sperm whale 3,000. Since 1963 main target species changed from fin-whale to sei-whale and year by year the % of sei-whale increased (63.6% in 1968), with also notable catch increase of sperm whale in the region south to 50°N. (especially the female whale catch increased). S. MACHIDA (1969) also studied the fluctuation of Subarctic fin whaling in the Pacific, The weight of sei-whale catch increased and surpassed that of fin whale and its central whaling ground moved from northeast to southwest such as from Bering Sea, Gulf of Alaska and south of Aleutian Waters, in late years to waters south of 50°N and west of 160°E, approaching to Japan which caused the restricted whaling area boundary from 45°N to 40°N. Since 1963, oceanic climate in the western Pacific changed greatly. Western cold extremum in 1963 migrated to east in 1964, and successively year by year.

Temperature maps in 1967 and 1968 for June, July and August show the cold water intrusion at about 45°N, 170°E corresponding to the formation of whaling grounds.

## 12. Miscellaneous Results of Fisheries Oceanography

i) "Report on the Studies of Cold Water Mass Affecting on the Distribution of Fisheries Resources and their Fluctuation" was published by NORIN SUISAN GIZYUTU KAIGI (1969).

In East China Sea along or near the Continental Shelf-edge we can see the dense distribution of mackerel, horse mackerel and squids corresponding to their spawning grounds respectively (Z. NAKAI, S. HATTORI, 1964, 1967, HATTORI 1969).

The purse seining fisheries grounds of horse mackerel and Pacific mackerel in the East China Sea are formed in the mixed water area intercepted between the oceanic front of the intruded Yellow Sea Cold Water and the western marginal front of Kuroshio Water, corresponding to the zone of water temperature 14°-20°C, salinity 33.4-34.3‰. In winter and spring the southern and middle marginal area of the East China Sea correspond to the purse seining grounds of wintering and spawning adult horse mackerels and mackerels. (S. KONDO, 1969).

In the northern part of the Northeastern Sea region of Japan squid distribution is in the warmer area of temperature higher than 10°C. In 1963, abnormally cold year, the yield of squid along the Japan Sea side coast and Okhotsk Sea side coast leaped up. Only the catch in the Soya Warm Current area the total catch (fishing period, September and October, 2 months) was 164,645 tons and also favourable catch along the west coast of Hokkaido.

ii) Anchovy and "Sirasu" fisheries. Around the years of meandering Kuroshio the catch of "Sirasu" (larval or baby fish) is rich, such as 11,900 tons in 1952, 11,200 tons in 1056, 9,300 tons in 1959, and 11,800 tons in 1964. Spring borned anchovy in Suruga Bay and coast of Ensyu Nada in the *"Sirasu"* stage is almost controlled by the fluctuation of Kuroshio trajectory. (T. KOHASE, 1969). In the year 1967, abnormal warm year, in Suruga Bay and Ensyu Nada a big catch of *"Taiwan-Ainoko"*—tropical species, was noted. (Z. NAKAI, T. HIRAO, M. KUDO, 1969). Adult spawn-preparing anchovy schools distribute in the waters of 12°-18°C from December to February nearly along the coast of Ibaragi and Chiba prefectures. From March to August spring *"Sirasu"* distribution is seen from Ise Bay, Mikawa Bay, Pacific coastal area of Atsumi Penn., and to western coast of Suruga Bay. (temp. 14°-26°C).

iii) In Tokyo Bay and Ise Bay turbid polluted areas expanded year by year and near the sea bottom due to the decomposition of too much organic matters azoic zone is produced in summer and eutrofication in the upper layer (too much abundant nitrogen compound or ammonia-nitrogen) caused red-tide in the upper layer in summer. Wind-produced upwelling of azoic water brought mass mortality of shells and fishes.

iv) In 1969 the books *"Suisan Bōsai"* (Fisheries disaster prevention) edited by M. UDA (Kyoritsu Shuppan Co. published, in Janese, Price about 8$, 2,800 Yen, 500 pages), and *"Umi"* (the Sea) written by M. UDA (Iwanami Book Co. Publ. p. 242, in Japanese, Price 150 Yen, about 50 Cents), Perspectives in Fisheries Oceanography (Sp. No. of Bulletin of the Japanese Society of Fisheries Oceanography) (Nov. 1969, pp.368, price 8.5 $ are published.

**Concluding Remarks:**

Source materials of this paper are mainly excerpted from the contributions in Bulletin of the Japanese Soc. of Fisheries Oceanogr. Nos. 13~15. (Referred Literatures abbreviated.)