ESTIMATION OF FISHERY RESOURCES BY M-F GIS USING SATELLITE DATA AND ITS APPLICATION TO TAC FOR SUSTAINABLE FISHERY PRODUCTION

YASUHIRO SUGIMORI[1], TAKASHI MORIYAMA[2], BAMBANG TEJASUKMANA[3], INDROYONO SOESILO* AND KETUT SWARDIKA*

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1. Introduction

On the basic condition for lack of food in Japan after the Second World War, the fishing boat fishery has constructed a fishery production system for short term massive gain, using fishery engineering system that mainly aimed increasing fishery capability and purposed higher productivity. However, soon later moving lo "200 Mile Economic Zone System", it is definite that management of fishing boat fishery' 's >n very severe condition, through not only due to losing a lots of the fishery field in world ocean and decreasing fishery catch, but also decline of fish price, decrease of number and aging of fisherman and price up of construction of fishing boat. If above the fishery condition will progress much, the fishing boat fishery, which is the most important supplying method for fishery food might fall into I decline and no more contribute mission in near future.

In 1995, Japanese diet has approved and I concluded "the UN Marine Law Treaty". | The Treaty is to admit the right of property and management of biology resources for the coastal countries which approved for jfix of the Exclusive Economic Zone. Also | the government has enforced the Primitive Law of Fishery in 2001. The above Law shows basic policy for fishery in 21 Century, exchanged by the Promotion Law for Coastal Fishery (1953). In order to solve several problems concerned with present fishery, the Fishery Agency pronounced the Primitive Program for fishery in 2002, and also illustrate practical program, which will be shown below:

(1) Estimation of accurate fishery resource in Exclusive Economic Zone

(2) Establishment of fishery technology corresponding to the Information Age

By the way, according to the Fishery Primitive Program (FPP) in 2001, a ration of fishery by fishing boat in our total fishery shows a very higher value, 80%. Meanwhile self-sufficiency ratio for fishery in 2012 in FPP, is 65%, which is 2.5 times than that of the ratio 53%. In Japan, present conditions for ages of the most fishing boat are close to 20 years olds, which means to be occupied by deteriorated fishing boats. And moreover, construction of new fishing boat seems to be difficult by the reason that at present the fishery resources is declining in fishery field allover the world and cost of construction of new boat is rising up. Then, there is not entire expectation to achieve such a high goal. In order to achieve aim of governmental FPP, it is no choice without improvement of condition for

1. Center for Remote Sensing and Ocean Science (CrcSOS). Udatana University, Denpasar, Bali Indonesia.
2. Japan Aerospace Exploration Agency (JAXA). 1-6-5 Marunochi, C'hiyoda-ku. Tokyo, Japan.
3. Lenibaga Pencrbangan dan Antariksa Nasional (I-APAN). Jl. LAP AN 70. Pckayon, Pasar Rebo. Jakarta, Indonesia-
4. Agency for Marine and Fisheries Research. DKP (SeaCOM), Ministry of Marine Affairs and Fisheries.

fishing boat fishery, concerned with recovering fishery resources in the fishery field, sustainable control and management of fishing catch and well training for fisherman etc.

As mentioned above, it is not easy to find solution on how to find rehabilitation method for recovering fishery resource among the too much hunting and exhaustion of the resources. We only know that catch by fishing boat is related closely to natural increase of fishery resources that it is no expectation to develop the fishing boat fishery without recovering of the resources. Therefore, it is absolutely necessary for us to analyze fishery resource which will be balanced with allowed catching fish resources and establish long term vision for fishery. It is clear that almost fishing boat in Japan will soon exceed 20 years which is a service life of the boat and it is also big problem for fishery which can never overlook.

II. Present condition and point of problem in Japanese fishery,

As mentioned before, fishery catch by fishing boat is closely related to the natural increase of the resources in fishery field. In this paper, one of tentative analysis for finding relation of a fishery allowable catch corresponding to the resources and establishing long-term vision for fishery has been made by Tsuchiya (2005).

Content of the paper is an establishment for prediction of the allowable catch of fishery corresponding to the resources after "n" years later. At the beginning of this work it is necessary to understand not to be easy to derive total data of resources in huge area, even though we could apply the long term data set of the resources. Data set and calculation in this analysis is used for available complex fish resources and simple formula.

Process is to compute an acceptable allowable catch in "n" years later resources, on a basis of resources R at beginning of calculation. Where "a" is the ratio of natural increase of the resources per year and "C" is a coefficient of fishery catch at first year. Then, fishery catch of the resources after "n" year is shown as following equation.

$$C x n - C o x K (l)$$

where K is decreasing coefficient of constant catching coefficient, which is assumed to be declined with constant rate per year. On the other hand, K is fishery catch ratio at first year, and ratio "f, fishery catch allowable after n years will be given by following equation:

$$f = r x K \qquad (2)$$

where f is ratio of the allowable catch in n year later and K is catch ratio in n years later, r is the resource after n year.

The results of calculations arc illustrated in Fig. 1-1 and Table 1. Table 1 is showing fishery catch ratio Kn, the resources r, and a ratio of allowable catch f from 1994 to 2008. These results show that catch ratio K for 8 years from 1994 has a definite relation with real catch ratio by fishing boat, and as ratio of real catch of every year has strong mutual relation with total weight, ton of fishing boat, it is better understood that the rapid decrease of fishery catch by fishing boat during 8 years was dependent on decrease of number of the fishing boats.

Values of r, f, and Kn in Table 1-1 are shown in Fig. 1-1. Fig.1-1 shows a middle term prediction of development of fishery catching capability on a basis of progress for 9 years from 1994. It is clear that the middle term of prediction value through the calculation is well consent with data of the fishery catch for 8 years from 1994 to 2001. It is predominant and understandable matter for us from Fig. 1-1 and Table 1 that for 8 years since 1994 to 2001, value of recovering ratio of fishery resources is less than 0.1, bul since 2003, it changes to increase and value in 2014 becomes 2 times more than that of 1994. Consequently, if we will make coefficient value of fishery catch against the resources, C decreases for 4% per year, a ratio for allowable catch, f, will increase since 2005. When we plot point of the goal value of self-sufficient for catch, 65%/53% = 1.23 in Fig. 1-1, which was reported in "The White Paper for Fishery", the point almost ride on the curve of f in Fig. I -1. We can conclude that if assumption for the calculation would be applied to fishing boat fishery, the purpose in "White Paper" will be achieved well.

The results of calculation (Tsuchiya, 2005) shows an estimation of middle-term fishery resources on a basis of decrease of the fishery catch corresponding to decrease of fishing boat weight Ton. As it is easy to understand above result for general causality, if we will decrease a fishery catch gradually, fishery resources can will be also recovered year by year, and subsequently fishery catch (the resources x ratio of catching coefficient) will increase gradually. As show in Fig. 1-1, curve of resources r shows that fishery resource has been already recovered in 2003, and corresponding to recovering, allowable fishery catch is increasing since 2005.

This paper dare warn that within several years, production by fishing boat will fall down less than allowable catch amount, corresponding to increase of the fishery resources, if several condition of fishery catch ratio and resources for calculation will be used correctly. This means that fishery will not only have big damage in near future, but also have trouble for stable supply of food to the nation, and subsequently make the people anxiety.

By the way, in this paper, representative sort offish resources and allowable fishery catch amount have been only discussed. This result will be almost accepted to settle a stable aim value except scientific discussion in detail. However, we used to target many sorts of fish as fishery resources except a few sorts of representative fish such as tuna and whale etc. In previous paper, Tsuchiya (2005) calculated and applied the allowable catch amount which was expressed by [the resource x allowable catch ratio], but it is the most important matter on how we can determine fishery resources and subsequently take the allowable catch value.

In 1996, Japan has concluded "The United Nation Marine Treaty" and in 1997, the Fishery Agency has adjusted the domestic law. Also the agency has began to control fishery resources corresponding to determination of 'The Total Allowable Catch" for the main sort of fish. At present, TAC fish targets on 7 sorts of fishes such as "sardine", "mackerel", "horse mackerel", "cuttlefish", "snow Crab", and "cod". The Fishery Agency mainly targets 30 sorts of fishes for the evaluation resources, however, they will take fish resources as an object of TAC which will be generally determined by the price, catching amount, fishery catch by foreign fishing boat. Then, in 1997, it is first year of TAC and crisis of fishery for Japan.

Fig. 1-2, shows present result of fishery in Japan which is object on TAC resources, reported by the Japanese Fishery Agency. Fig. 1-2 also presents that through the Fishery Agency reported for 5 sorts of fishes, such as the sardine, mackerel, anchovy, cuttlefish and saury, the fishery of sardine and mackerel falls down to low level standard. The best fishery catch of sardine was reported to be amount of 400 Ton per year during the good fishery catch season. On the other hand, fishery of anchovy is in creasing in high level. In 2002, TAC was determined by the Japanese Fishery Agency, including with amount by the minister, the governor and

Table 1.1 Calculation of Kn, Rn and fn
based on assuming

Year	n	Kn	Cn=c0*kn	1+a-C*Ka	Rn	£=Kn*Rn
1994	0	1	0.24	0.96	1	1
1995	1	0.96	0.23	0.97	0.97	0.931
1996	2	0.92	0.221	0.979	0.95	0.874
1997	3	0.885	0.212	0.988	0.938	0.83
1998	4	0.849	0.204	0.996	0.934	0.793
1999	5	0.815	0.196	1.004	0.938	0.764
2000	6	0.783	0.188	1.012	0.934	0.743
2001	7	0.751	0.18	1.02	0.938	0.727
2002	8	0.721	0.173	1.027	0.949	0.717
2003	9	0.692	0.166	1.034	0.968	0.711
2004	10	0.685	0.16	1.04	0.995	0.711
2005	11	0.638	0.153	1.047	1.028	0.715
2006	12	0.613	0.147	1.053	1.079	0.723
2007	13	0.588	0.141	1.059	1.1249	0.734
2008	14	0.565	0.136	1.064	1.329	0.751
2009	15	0.542	0.13	1.07	1.422	0.771
2010	16	0.52	0.125	1.075	1.528	0.795
2011	17	0.5	0.12	1.08	1.651	0.826
2012	18	0.48	0.115	1.085	1.791	0.86
2013	19	0.46	0.11	1.09	1.952	0.989
2014	20	0.442	0.106	1.094	2.135	0.944
2015	21	0.424	0.102	1.098	2.345	0.94
2016	22	0.407	0.098	1.102	2.584	1.052
2017	23	0.391	0.094	1.106	2.858	1.117

a : Accruement ratio / year of resources a=0.20
Cn: Fishery coefficient/year for quantity of natural resources Cn? C0*Kn
CO: A value of C of the first year CO? 0.24
K: The decrease coefficient / year of fishery coefficient C K? 0.96
The decrease coefficient / year of fishery coefficient C
K? : The fishery coefficient ratio of each age that assumed 1994 a standard
Rn : The quantity of natural resources ratio of each based on 1994 end of the year
Fn : The quantity of fishery ratio of each year based on 1994 fishery a standard

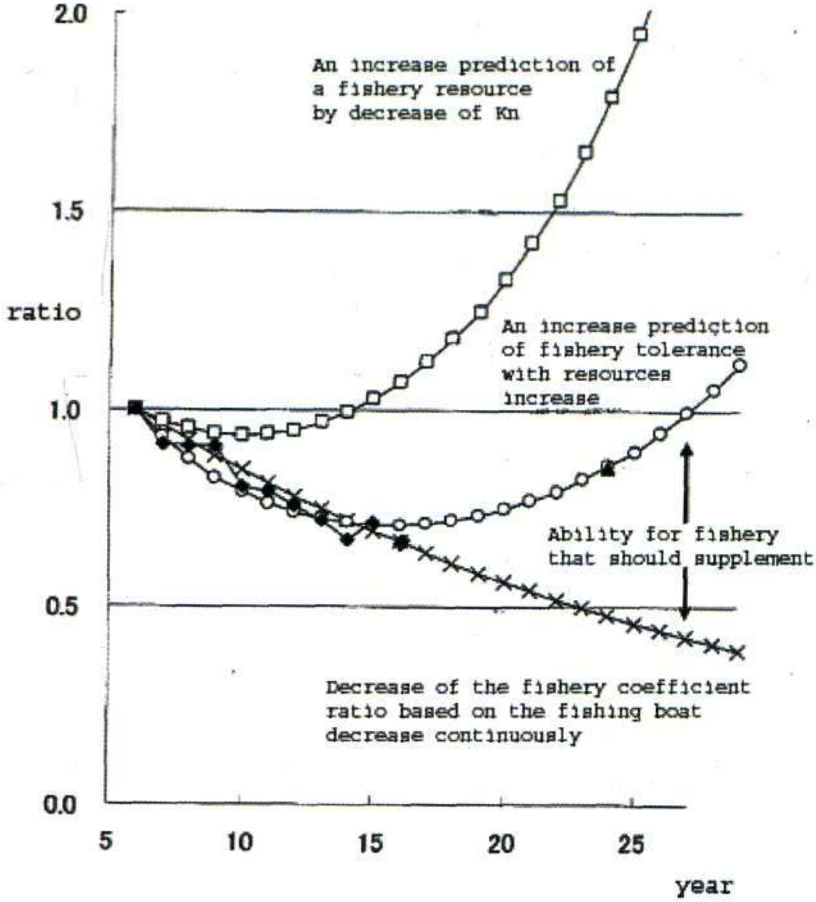


Figure 1.1 The ability fishery prediction for a change of the past nine years

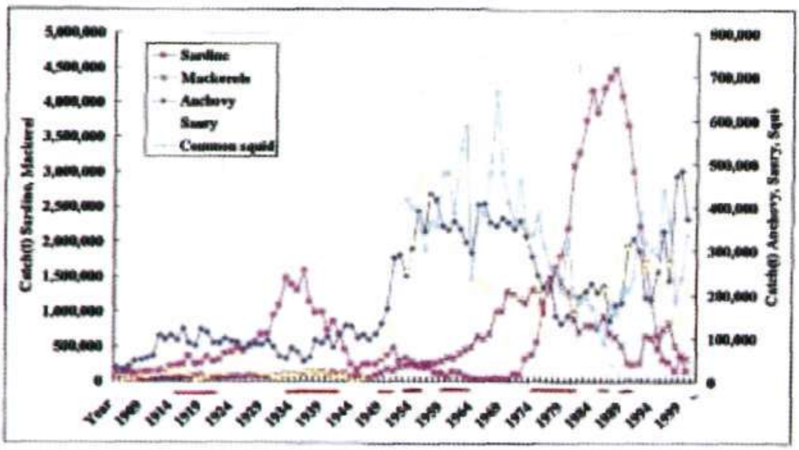


Figure 1.2 Catch history of important fishes in Japan

etc. as follows: Pacific saury was 310,000 ton. sardine was 342,000 ton, mackerel was 693,000 ton and cuttlefish was 530,000 ton.

In 2001, instead of "Coastal Zone Fishery Promotion Law", the Japanese Fishery Agency has set the "Fishery Primitive Law" which intends to illustrate basic strategy of fishery. The next year, 2002, they determine "the Fishery Primitive Plan (FPP)". The basic background of FPP is shown in below:

1. Grasp of exact amount of fishery resources in 200 Excusive Economic Zone
2. Establishment of fishery technology system corresponding to new information age.

Item 1) shows clearly that the FPP aims to control and reserve the fishery resources in EEZ. This means that it is important to monitor fishery resources and study method to control and reserve the resources for the purpose of sustaining the standard level for realization of the maximum sustainable productivity (MSY) of fishery. In order to obtain goal value of recovering fishery catch, the Independent Administration Association, General Fishery Research Center (GFRC) proposes Available Biological Catch (ABC) every year. Before determination for ABC, they has set the fishery managing standard and the catch control rule, and they applied and calculate by the numerical resource model which is approved internationally.

In term of 2), establishment of fishery technology corresponding to new advanced information age, the Fishery Primitive Plan (FPP) aims to develop an efficient and stable fishery management, to rationalize fishing field and maintain basic fishery ground. Items 1) and 2) are interacting together in frame of sustainability of fishery resources, namely, item 1) which aims to increase of fishery catch and hern 2) which aims to reserve and sustain the fishery resources are in opposite, and then. establishment of fishery technology will make the resources decrease.

III. Advanced New Fishery Monitoring System from Space

Monitoring of fishery resources from space is an available advanced technology for investigation of ocean condition and control of fishery through series in global scale. As practical application to fishery study, S. Saitoh (1988,1999) has shown an application of remote sensing to monitoring school of ffeh, baby fish, plankton and fishery ecology and sea bird. Meanwhile K. Saitoh (2003) established his thesis in term of forming of sardine fishing field and its variability, and he applied an ocean remote sensing and marine-fishery GIS. Laura and Polobina (2002) has reviewed the availability of remote sensing for fishery and showed each sensor for each monitoring of fish. Also, they analyzed the satellite altimetry data for finding fish in non floating life and shellfish. Moreover, they studied the relationship between satellite data and tuna fishing, application of satellite data to Vessel Monitoring System (VMS), and applied ocean color data of satellite to monitor ecology of circulation of the ocean turtle. Especially it is predominant result that Laurs ct at (1984) showed an effective of comparison with sea surface temperature by NOAA/AVHRR and ocean color by NIMUBAS-7/CZCS for the detection of tuna fishery that is really predominant result for monitoring fishery field from space.

S. Saitoh (2003) recently summarizes the result of monitoring fishery field in the area surrounding Japan from space. It is well known that good fishery field in offshore of Sanriku close Japan to main island is formed by the mixing areas composed by the Kuroshk) current, including with warm water (heat budget) and Oyashio current involved with a lots of amount of nutrient. Dickey (2002) has classified every ocean phenomena in time-space scale and proposed a best appropriate observation method. Then, from the view of fishery point, he again showed space distribution and time variation of fish groups in Fig. 1-3. Practically, fishery field for fishing boat is dependent on time scale from day to season and space scale from several km to 100 km. However, if we consider the total amount of circulation fish in fishery season, it is necessary for us to think about complicated factors on a capability of fishery catch, nutrition condition of mother fish and reproduction condition, etc. For instance of sardine, the condition of catch is dependent on the time scale from one month to season and on special scale from 100 km to 1000 km (Wada, 1998).

The result of monitoring of fishery resource from space ,at present, is only for fishery field, but not school of fish, and it is not easy at moment to monitor school of fish due to the minimum time-space scale. It is only possible for us to monitor school of fish using satellite data by 1KNOS and ALOS using high special resolution visible sensor, or aerial photography. However until now, we can not see any result of monitoring school of fish using IKNOS, etc. Probably soon we could know the result of monitoring of school of fish using IKNOS ALOS etc data. On the other hand, monitoring and application to fishery has been made by only special remote sensing fishery scientist, but through internet, it will be getting easier to handle data and frequently used by normal fisher man.

By the way, S. Saitoh (2003) has pointed out difficulties to apply data for fishery monitoring, not only for difficulties of monitoring special resolution by satellite and to find school of fish, but also difficulties of monitoring fishery resources below the sea surface. Moreover it is not practical to apply multiple satellite sensors simultaneously and not easy to monitor same area frequently from space. Recent result of development of algorithm for satellite ocean color has advanced well to monitor distribution primary production in underwater and calculate distribution of chrolophyl-a, which is compared with in-situ data to be good agreement (Osawa, 2005). University of Udayana, IOT/CReSOS (institute of Oceanography and Technology / Center for Remote Sensing and Ocean Sciences) in Bali and a few of Japanese private companies are developing Marine/Fishery GIS and producing the vertical distributions of primary production and water temperature in underwater of ocean in Indian Ocean and area of surrounding Japan Islands.

IV. Fishery prediction using Marine/Fishery GIS

In previous chapter, the importance of monitoring for fishery resources from space has been discussed. Advantage for monitoring of fishery from space is to enable of repealing monitoring by multi' sensors with wide global range, which will be hard to include with artificial error, compared with other methods. However, it is necessary for us to consider that satellite monitoring can basically only observe ocean surface layer and will be disturbed with cloud coverage except microwave sensor. Also it is not easy to observe same area simultaneously with different sensors and at moment there are several algorithms to analyze data which is not yet formalized with standard model.

K- Saitoh (2003) has tentatively proposed system for fishery monitoring (Fig. 1-4) which aims to observe growth of fish. Growth offish is definitely dependent upon the condition of growth field and marine ecology that in Fig 1-4, growth of fish is classified into 3 steps as ages of egg, young fish and adult fish. Also, according to the growth condition offish, life field offish is separated into 3 areas such as fishery field, migration field of fish and spawning field. Moreover, Fig 1-4 shows environmental information of distribution area of fish and probing sensor on how to monitor the environment. In general, parameter for classifying an environmental condition of fish is water temperature, salinity, ocean color, phytoplankton, etc., but Fig. 1-4 is mainly applying water temperature, by the reason that water temperature used to be applied as main parameter and can fundamentally reveal living area of fish. Fig. 1-4 is also illustrating combination with

phytoplankton for feeding place, vertical profile of water mass and depth of thermocline which can control the migration of fish, wind field which will influences transportation of fish eggs and field fishing, and precipitation and Sunshine for weather condition. At present, it is not utilized to monitor ocean salinity from space, but now a sensor is being developed which will be operated by NASA in near future.

When user tries to use fishery multi-data by satellite observation, in order to calibrate data, it is necessary to use geographical information. On the other hand, satellite color sensor, MODIS. aboard Aqura and Terra has 36 channels from visible to infrared and send down to the ground receiving station image information with 100 G bits, huge data for one pass which is absolutely necessary to make data processing and analyze efficiently. It is important for us to understand that we definitely need to use "Marine/Fishery Geographical Information System (GIS)" for fishery application.

In a word, GIS (Geophysical Information System) is tool to handle geographical data, analysis and modeling. The system is developed to make data processing and modeling for multi-dimensional and huge land data of satellite as one of geographical data processing. The system can handle, analyze and present special and geographical attribution data, using RDBMS (Relation Data Base Management System). RDBMS is generally independent on and involves with user interface which can accept a request according to the special purpose (Chyou, 2001)

GIS has begun since proposal by Tomlinson (1967) for Canadian Geographical Information System, which is not map for special use, but a system to enable of easy accessing by making data base with uniform format of positioning information of all lands of Canada. After the work by Tomlinson, McHarg (1969) has proposed a concept of layer which was basic function of present GIS in "'Journal of Design with Nature". The layer system in GIS can integrate with the several sciences such as agriculture, botany, computer science, economy, photometry geodesy anil geology. Rhind (1990) summarized the available parameter for investigation using GIS,

(1) Location
(2) Condition
(3) Trend
(4) Routing
(5) Partem
(6) Modeling

On the other hand. Simpson (1992; 1994) has reviewed an application to study for fishery science, combining with satellite data and GIS after discussion of capability of GIS using satellite data. Content of his discussion is an application of GIS, involving with 3 components of Industry-Research-management.
Meanwhile, Meaden (1996; 1999) proposed application of land GIS to oceanography. Shibazaki (1993) and Saitoh (1999) proposed application of GIS to fishery science. Actually, K. Saitoh (2003) has proved availability of fishery GIS through the study of fishery field formation and variability of resource of sardine in Pacific ocean close to Japan Island. In his study, from the point of view of application of GIS to fishery, the content is as follows,

(1) Where is fishery field?

(2) What is a relation with ocean condition?

(3) Where is a area to be reserved fishery resource?

(4) How much is fishery loss ?

(5) What is a safety and profitable | course for navigation?

(6) What is a provision for unidentified | ship?

Especially, definite difference between land and marine GIS is that marine GIS has I fundamentally data base which is widely scattered, quick time variation, multi-I dimension concerned with horizontal, ! vertical, altitude in air and time.

At the beginning, the results of K. Satoh [2003) work, concerned with marine / fishery GIS, will be introduced. He applied satellite image of ADEOS/OCTS RTC (Real Time Coverage) Ver.4 for 8 months, since Nov 1996 to June 1997. The data of depth was used topography and depth (ETOPO 5:5 minute Griddod Evaluation Data) which was produced by NGDC (National Geophysical Data Center/USA). The data of fishery field was applied result (QRY) of purse seine net, collected with JAFIC. QRY is a data of condition/one operation including with data of fishery field, sort of fish, fishery catch, and condition of fish grouping. Total data number which was included with dat3 set of sardine and others is 110,000 data since 1988 to 2000. Available position data for data processing without cloud for season of fishery of sardine was only 20% of total data set.

As shown in Fig 1-5, method of data processing is separated into 3 stages which are to determine the past fishery field after analysis of fishery field data, to estimate depth of fishery field by comparison with data of QRY and depth, and to compare with data of satellite image and QRY. Comparison with satellite image and QRY has been made by time and special variations. Final image data for combination in GIS base is produced. Secondly, result of fishery field formation is made from QRY data since 1989 to 2001 and after data approximation analysis, historical fishery field formation data was produced.

On the other hand, past location of depth for fishery field formation was made by matching with the bottom topography map (5x5 minutes mesh), produced by NGDC and QRY data. Also he made a histogram of fishery field depth and area data for field depth formation. Comparison and evaluation between satellite sensor, OCTS and QRY data has been made by following steps.

to calculate statistical value of 5x5 pixel surrounding area at the center of fishery field

to eliminate data covered by cloud through eye measurement for the calculation.

Statistical value is calculated with total value of image effective pixel except cloudy and bad images, averaged, maximum, minimum and standard variation one. These numerical data is visualized in 3 dimensional distribution map, associated with relation of season, fishery amount, satellite SST and Chl-a in SST X-axis, Chl-a Y-axis and fishery catch Z-axis. Through these data arrangement, we can better understand fishery field in analogue image.

Unfortunately, ADEOS can only monitor from November 1996 to June 1997 and could not observe in summer season. Also, environmental data to form the fishing field is not successive and then, he applies the method of optimum linear interpolation to distribute the data. In such way, he established environmental data set to form better fishing field, and finally made fishery GIS map after data processing in GIS base. Fig.l- 6 shows the GIS model and Fig. 1-7 illustrates map of the purse seine fishing field for sardine after data processing of 12 years fishery.

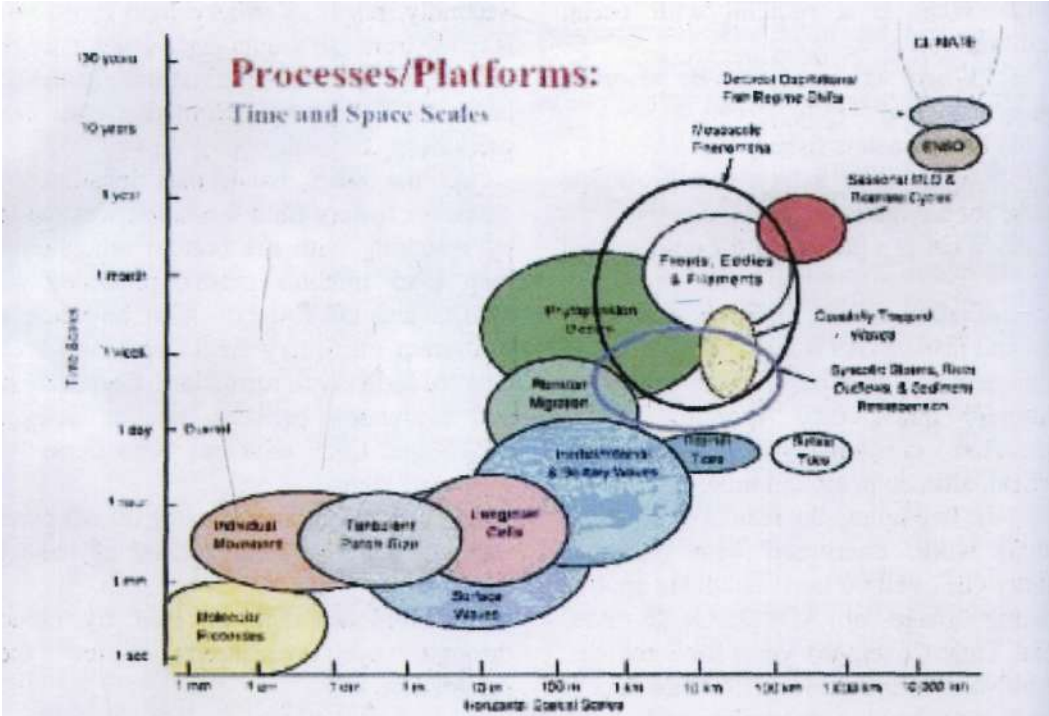


Figure.1-3 Time and space scales for fishery

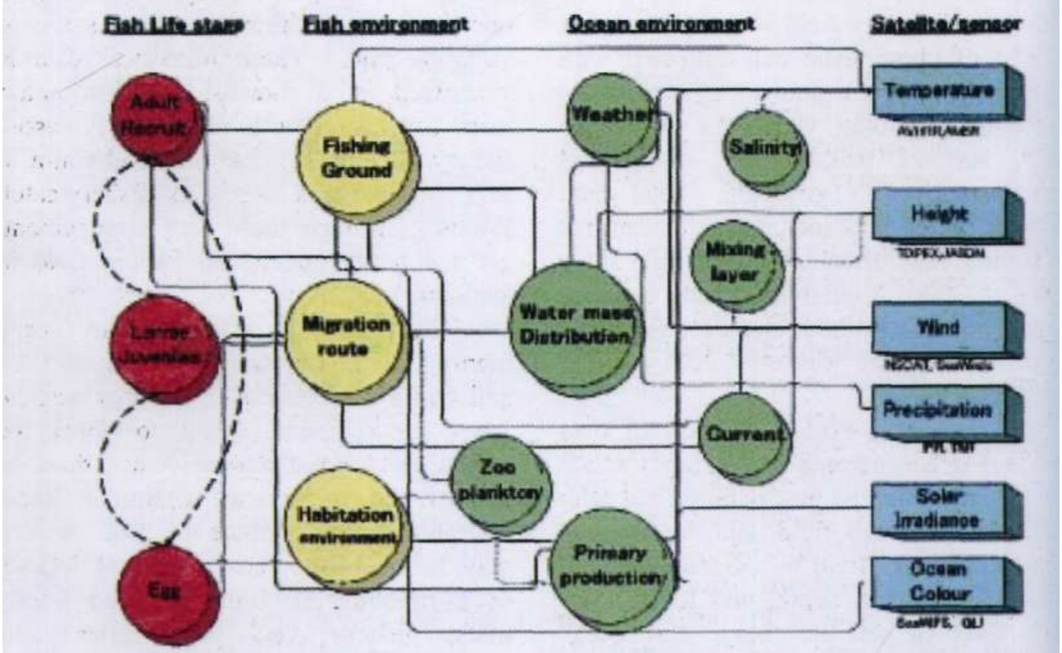
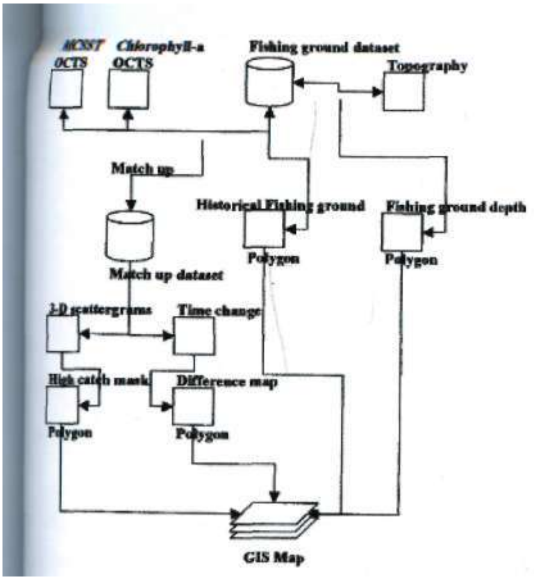


Figure 1-4 Concept of multi-Sensor Remote Sensing for Fisheries

which can indicate a formation of fishery field in high possible establishment. This results shows good agreement with prediction for *formation of the field by* Mihara (1998) and Kuroda(1991).



GISMap

Figure 1-5 Process of Fishery GIS using Satellite Data

V. **Establishment of Total Allowable Catch (TAC) by general fishery prediction data**

Japan has approved "International Marine Law Treaty" and concluded it in 1996, which has determined the set of "200 mile Excusive Economic Zone" and admitted a setting right of exclusive economic zone, concerned with a control of biology resources for coastal zone country. Also, in 2001, the government has established 'The Fishery Primitive Law" and implemented simultaneously, and consequently, Japanese fishery headed forward to resource controlling fishery. However, basically fishery concerns with work for the wild animal and then it is not only associated with discussion of economy, but also with biology. As fishing boat fishery used to essentially apply the fishing field to free competition, in good fishery field, excessive fishery is getting to be intensified, and investment for fishery will lose good balance with earnings. Consequently, natural limitation for biological production (maximum *sustainable yield, MSY) can determine* fishery supply. The management for reproduction is definitely dependent on contribution to production by young fish which was hatched in the area of management and space of area for reproduction can control a fishery of resource management. On the other hand, if fishery will compete with other proteins as food production, fishery will lead up to too much hunting in the case without sustainable fishery.

a. **Offshore Fisheries and TAC System**

During 1950 to 1960, Japanese fishery moved from the coast to offshore and developed one of the biggest productions for fishery in the world. However, it means that coastal fishery resource was exhausted and fishery has to move to offshore and deep ocean unwillingly. It became finally a type of drain (Hirasawa, 1984). In 1977, at the begging of 200 EEZ age, Japanese fishery has been skipped out from area of EEZ in foreign countries. For instance, Northward fisheries for salmon and cod by mother ship system could not make operation in USSR and USA waters, and finally decreased the number of fishing boat and vanished with the government guarantee. Also as the coastal and offshore fisheries have developed an advanced fishing engineering and number of the approved fishing boat became surplus (Horiguchi, 1977). The law of 200 miles EEZ has made not only Japanese fishery change, but also fisheries of every country and many countries have introduced TAC (Total Allowable Catch) at this turning point.

Although we used to hear "Fishery of resources controlling type", it means to combine the fishery resources with the production together and rationalize it well. The content is separated into two terms.

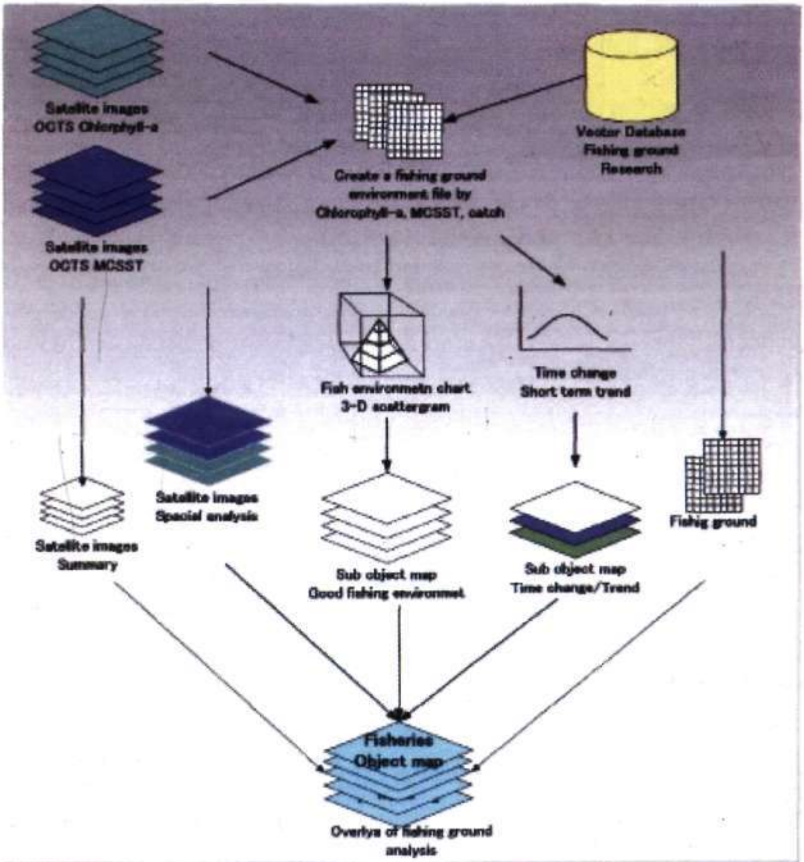


Figure1.6 Developed fishery GIS System

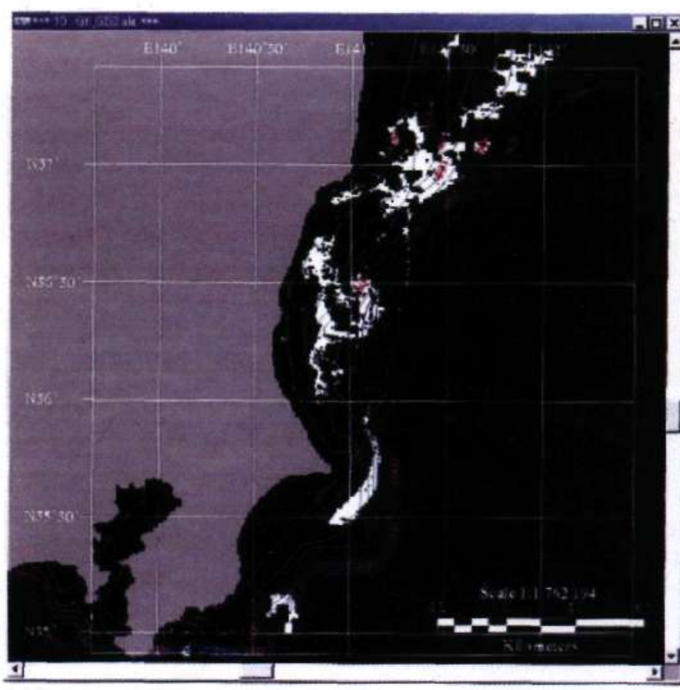


Figure 1.7 GIS model image of Sardine fishing ground

The first is about how to control the fishery resources and the second is about how to find a method for optimum investment for fishery (Hasegawa, 1994). The former is the problem how to find the optimum number of fishing boat and date in the fishery field and make balance them well for requirement of maximum sustainable fishery. The latter is an unreasonable problem by surplus investment of each fishing boat or company which will occur by a preoccupation competition. Consequently, system of Japanese fishery has become in Situation of "surplus investment" and "preoccupation competition" and finally on the point of view of economy, become to the high cost constitution in small fishery field.

Offshore fisheries is separated into 3 items, which are the offshore dredge, the big and middle types purse seine and the saury stick net, and these items are fishery by permission with the minister and offshore cuttlefish fishery is permitted by the governor in Japan. The above fisheries are controlled by TAC system since 1997 in Japan.

When we will discuss main fishery in TAC system,

(1) In term of the offshore dredge, there are several bottom fishery resources such as flatfish, plaice, cod, etc. These resources is small number of lay eggs and when it will occur too much hunting, it will take a long time for recovering and difficult to conserve the resource.

(2) Sardine, mackerel. Pacific saury and horse mackerel are involved in TAC object fishes. The reason why these fishes are object to TAC is better self recovering and more production than that of too much hunting fishery and in the ocean of East China Sea and Yellow Sea, a few countries are competing together by fishing. Namely, it is necessary for Japan to establish TAC system for these sorts of fishes through making negotiation and collaboration with neighbor countries.

(3) in term of deep sea fishing, the fishery resources are included with bonito, tuna, salmon, trout and cod which are living in the 200 Miles EEZ or the international water. Then it is necessary for each country to control the resources through collaboration together. For instance, we have a committee ICCAT(Intemational Committee for Control *of* Atlantic Tuna) for control Atlantic tuna, which can diced TAC that will distribute the amount of TAC to each country.

By the way, if we dare not apply TAC system, we can suppose what kind of problem will occur. The following 4 items will come.

(1) Irrelevant application of fishery field. Namely, it is free for any fishing boat to enter into any fishing field, and then is not easy to make the field in optimum condition. Primitively it is easy condition for fishery, due to the common fishing field that in order to obtain averaged same income by the first and last entering boats into the field, many fishing boats used to concentrate in good fishing field.

(2) Surplus investment. Namely, as competition with fishing boats to catch the fishery resources used to be accept, more modem and higher technology boat will win the fishery competition and the normal fishing boat will be cxpulsed gradually. Consequently, equipment competition of the fishing boat will continue forever.

(3) Into fishery of small fish. During the competition of fishing in the field, to maintain the fishery amount, losing group boat has to make fishery which has a low price in fishery market to keep partition share of fishery. For example, we can see irrational fishery of mackerel by purse seine in offshore.

(1) Price collapse. Due to the concentrating field formation of fishing season and increase of fishery production when the price of fish is getting low, surplus fishery will invite generally price collapse.

It is definite and understandable for us that fishery by fishing boat fishery will make itself decline and subsequently offshore fishery is possible to be vanished in future by above 4 items, (1), unsuitable application of fishing field, (2), surplus ' investment, (3), fishery of small fish, and (4), price collapse by surplus fishery. Therefore, it is absolutely necessary for each country to understand that TAC system is so important for suitable and good balanced fishery in near future.

As an introduction of TAC system for recovering fishery resources, one of the good examples can be found in "Treaty" of US~Canada associated with halibut in the North Pacific Ocean. Fishing of halibut in the North Pacific Ocean has been made by US and Canada since at the end of 19th century, but through rapid development of fishery for halibut, the resource was suddenly decreased and depleted. On the basic condition of the resource of halibut, US and Canada have begun to control catching halibut resource and established the collaborative management function. At first, they began to investigate the resource of halibut and consequently set the standard of Total Allowable Catch (TAC) in individual ocean area in 1932. After setting of TAC, the resource has been recovered remarkably and total fishery of halibut has been increasing greatly. This means that they succeeded to control allowable of catching resource biologically through avoiding of too much hunting. However, on the view point of recovering resource, they have succeeded, but on the view point of economy, the price of halibut fishery became down and it has been contrasting the fishery which could not give any benefit (Sakuramoto, 1998).

In 1973, Prof. Christy in University of Lord Island proposed some method on how to distribute a benefit to fisherman according to rate of TAC. In term of fishery of halibut, it was an important system for TAC to control the resource, but it provided also problem that the preoccupation competition was getting to be hard and the fishery cost was higher than that of before. Then finally as shown by Prof. Christy, Transferable Individual Quota (1TQ) which aimed to distribute the fishery benefit to individual level has been proposed.(Hasegawa, 1993a; 1994a, b).

The background of development of TAC system was based on the conclusion of the UN Marine Law Treaty back that each country has to have a right and obligation to control the fishery resources in the 200 mile EEZ. The UN Treaty has mentioned that in order to handle the right of controlling the fishery resources, each country has to have an obligation of controlling the resources and to establish TAC system. Subsequently, many countries have decided to establish the system for maintenance of the right.

b. Application of Marine-Fishery GIS and TAC system

As mentioned before, TAC system has contributed well to increase of fishery amount by recovery of the resources in several cases. On the other side, it has constituted the fishery system which could not give enough economic benefit. In 200 mile EEZ, TAC system can be evaluated only to contribute to politics for settlement of international fishery trouble, such as division of territory of marine fishery field, data collection of fishery resources in their own EEZ, determination of the resources partition to their own country and partition of the rest resources to foreign country etc., more than management of biological resources.

However, a fundamental importance of TAC system is that at first, we have to start of monitoring the resources for the good management of the resources. In one of good example, we can see the estimation of whale resource by "International Whale Committee (IWC)" which has continued the useless political and sentiment discussion to the proposal by Japanese government, concerned with scientific evidence with observations. The monitoring of fishery resource is practically made by in situ field observation by vessel, satellite observation in global scale and analyses of the past field data. Especially, in this paper, we will try to apply the result of satellite monitoring of fishery data including with in situ and the past data to Marine-Fishery GIS and combined finally with TAC system.

VI. Relation between Economic Allowable Catch (EMAC) and TAC system in Contribution Economy

Monitoring of fishery resources from space is available in the categories of observation of ocean-fishery condition, fishery management, investigation *of* conservation sort of fish and operation in fishery field. In application to fishery research, practical application from space can cover to monitor a fish group, egg and young fish, phytoplankton and sea bird, etc. However, as mentioned before, present monitoring from space is mainly concerned with fishery field, but not fish group due to the technical matter.

In term of fishery information, in 1969 the Fishery Agency in Japan has established the Japan Fishery Information Service Center (JAFIC), which can manage not only information of fishery-ocean condition, but also save the past huge data associated with fishery field and fishery production. On the other hand, general ocean information in Japan is managed by the Japan Ocean Information Center (JOC) in the Hydrographies! Office, which can formally collect data of each organization, such as the Self-Defense Navy, the Safety Maritime Agency, Japan Marine Science and Technology Center (JAMSTEC), Japan Meteorological Agency (JMA), Fishery Agency and each university. By the way, currently some of private companies, such as the Kokudo Kankyo Co., the Vision Tec Institute, etc. concerned with fishery information have delivered real time fishery information to end users. Some of company can serve advanced 3-dimensional fishery information, including with horizontal and vertical water temperature profiles and chlorophyll distribution.

As mentioned before, Marine-Fishery GIS is constructed and visualized as 3-Dimcnsional Scattergram including with seasonal fishery, satellite SST and satellite Chl-a, which makes a marine area data forming good fishery field. Consequently, long term fishing field, concerned with specified sort of fish is estimated through the .mapping. The result of study of Marine-Fishery GIS, associated with sardine (K. Saitoh, 2003) illustrates comparatively good agreement between real fishery resource of purse seine sardine and estimation by Marine-Fishery GIS.

K. Saitoh (2003) has tentatively made Marine-Fishery GIS to predict good fishery field of sardine and estimate fishery resource which can be applied to the total allowable catch, TAC. It was successful result of a tentative study in term of sardine. Fig 2-1 shows the concept of the total system which begins to construct a Marine-Fishery GIS for special sort of fish to estimate fishery resource, using satellite, in-situ and past fishery data, and its application to establishment of TAC. When an estimated resource of special sort of fish by Marine-Fishery GIS would be practically within almost same amount of

Fishery GIS will be useful to estimate the fishery resource in the field and can inform fisherman how much they can catch the fish which is restricted by the government through TAC.

After fishery has been made through estimated resource by Marine-Fishery GIS as well as the amount of government restriction by TAC system, it is necessary to make an economical arrangement and balance through distribution market of same sort of fish from other domestic and foreign productions. It is an idea of "Economic Allowable Catch". The Japanese government has decided TAC, concerned with sort of fishes such as sardine, mackerel. Pacific saury and horse mackerel, on the basic assumption of competition with fishery product of foreign countries, but in the special fishing field area the competition is not only with foreign country, but also with domestic fishery. As an example, fishery in East China Sea is not only competition with fishery by Korea, China and Taiwan- but also more complexity by domestic fishery from Kyushu Island, Tyugoku Area and Kansai Area. Through above process such as appropriate fishery amount restricted by TAC is necessary again to make an arrangement with distribution market by Economic Maximum Allowable Catch (EMAC). After arrangement by EMAC, we can approach to Final Allowable Catch (FAC) which is fundamentally a complexity with distribution market in domestic area and foreign country.

On the other hand, after Final Allowable Catch (FAd) has been decided, TAC will inform to the big fishery company and local domestic end user, fisherman. The process is not simple flow and determination of TAC will be collaborated and made with JAFIC, the private company and other governmental organization. Practical fishery production according to the restriction by TAC will be concerned with the Fishery Agency, local government, the National Fishery Association, Domestic Fisher)' Association, etc. Fig. 2-2 shows system for governmental contribution to TAC in j Ibaragi Prefecture. It is understandable 10 know that before fishery production many organizations of national and local governments and the associations will be concerned with determination of TAC and fishery in the field.

By the way, as mentioned at the beginning of this paper, most fishing boat in Japan is now going to be over lifetime, close to 20 years and definitely necessary to reconstruct again. This problem will be concerned with support by the society of ship building industry. Consequently, 3 groups will concern with achievement of this matter, namely, (1) technical group of the execution and estimation of the fishery resource by Marine-Fishery GIS(JAF1C, private company, related governmental organizations), (2) the official and governmental management group of determination of TAC, using estimated resource through GIS (the Fishery Agency, the domestic government National Fishery Association, domestic fishery association), and (3) the group concerned with distribution marketing, making an arrangement of fishery amount and construction of fishery boat (new associations). Fig. 2-3 shows the Total System for Marine and Fishery Industry word.

In Fig. 2-3, we understand that there is a lack of function between First group and Third group which has to make an arrangement of distribution marketing against estimation of fishery resource by GIS and fishery by the determination of TAC. The important problems for establishment of the Total System for Marine and Fishery Industry word will be illustrated as follows:

(1) Technological importance for determination of Marine-Fishery GIS,

(2) Official importance for determination of TAC and arrangement with the distribution marketing, EMAC,
(3) Profitability with income from fishery production and expense for reconstruction of fishing boat and operation. Restriction of number of ship and political guarantee for vanishing boat.

Item (2) seems to be the most important and difficult problem which is not only concerned with distribution marketing, but also with international relation, earth environment (global warming) and migration in global scale, and education for young fisher man, etc.

VII. Long term vision for fishery

At present, many people concerned with fishery are anxious to make warning and planning for near future development of fishery, due to the reason that almost fishing boat will finish lifetime within few years later. Actually national potential and technology for reconstruction of vessel are still in very high level, but financial matter is different from above items, because that it is doubtful for fisherman whether loan for reconstruction of fishing boat from bank can balance well with income from fishery in ocean, or not. Of course, the government will discuss and make good arrangement with finance organization, but it is definitely necessary for fishery society to have political strategy. Meanwhile, it is not only necessary to discuss the reconstruction of vessel, but also to discuss the matter of education for younger fisherman, technical development for advanced fishing boat, etc.

According to 'The Japanese Fishery Primitive Law (FPL)" in 2001, the fishery amount by fishing boat keeps very high value, around 80%. When we try to compare with self-supplying fishery food in 2012, it is going to aim in 65% and 1.2 time, as 53% more than that of 2001. Suppose at the present condition where most fishing boat has just passed lifetime and the plan of reconstruction of vessel is not promoted well, it might be very hard to achieve the purpose. It is absolutely necessary to improve the fishery by fishing boat and program the total marine fishery system in long terni vision. As mentioned before, fishery is closely related to natural multiplication of the resources and without them there is no fishery production. Then, in order to aim the future development of fishery, it is necessary how to make a balance between the fishery resource and Final Allowable Catch (FAC) and to find long term vision for fishery.

The problems for long term vision in the future remain a several items as follow. Item (1) Development of advanced technology such as remote sensing to monitor fishery resources in global scale; Item (2) Research and development of TAC and EMAC on how to relate the fishery distribution market; Item (3) Development of technology related to fishery and its labor; Item (4) Measure for fishery labor and training for fisher man; Item (5) Measure tor preservation of the earth environment; and Item (6) Establishment of the development and research center for fishery general technology and economy development. We will discuss the Items in more detail in the followings.

(1) Development of advanced technology (GIS) such as remote sensing to monitor fishery resources in global scale

Although no satellite aiming only for fishery has been yet launched by NASA, JAXA, or ESA so far, there are several useful satellites which can be applied for fishery, such as NOAA series (SST), MODIS (chlorophyll), TOPEX/POSEDON (main current and eddies). ADEOS (chlorophyll), ALOS (identification of location of fishing boat), AMSAR (SST), E-ERS (SST and wind vector), ENVISAT (SST, ALT, wind vector, chlorophyll). It is necessary for us lo develop the technology for data processing, but more important matter for us to apply the satellite data to finding good fishery field, using in situ observation data and past fishery data.

When we will apply the satellite data to the numerical simulation for studies of oceanography and meteorology, it is important to make a simulation before the analyses. In term of application to fishery, it is important to develop Marine-Fishery GIS that will apply to establish a prediction model for fishing field and fishery amount. It is , also necessary to make an arrangement with the huge past fishery data and ocean condition, and finally make computation by super computer for prediction of location of the fishing field and fish group.

Of course, the reason why we predict the fishing field and fishery amount using the GIS is definitely to establish appropriate TAC system. As introduced in the previous chapter, tentative study for establishment of the GIS has been made by K. Saitoh (2003) which was on the half way. Probably we can not refer any study except his work in the world. Even though we might predict to search fishing field, using the GIS for purpose of establishment of TAC, the fishes appointed to TAC remain about 10 sorts, and wc need to understand that it is huge labor for us to make the GIS using the huge past data, satellite data processing and sea truth by in situ observation data.

Namely at moment, we are standing at just starting point for this work. Even though K. Saitoh has made tentatively the GIS for sardine in the field of Sanriku offshore between Kuroshio and Oyashio front, but as the sardine was appointed sort offish by the reason of international competition, it is still some problem whether the fishing field in Sanriku offshore for sardine is appropriate field or not.

(2) Research and development of TAC system and its relation of EMAC to fishery distribution market

When we could succeed to establish TAC for each sort of fish in time-space dimension through constitution of Marine-Fishery GIS, it is really necessary to make an arrangement of distribution marketing between domestic and foreign fishery. It is fundamentally new science from data processing of satellite and determination of the GIS, that is study of fishery economics, concerned with social problem of 200 mile EEZ, the Fishery Primitive Law, Fishery fundamental Plan, and so on.

However, it is basic problem for determination of TAC, EMAC and FAC that will concerns closely with strategy of the government. Consequently, without study of this distribution market, we can not keep the stable fishery production and defense declining of the fishery industry world any more. Namely, study of fishery distribution market is the second important problem after study and development of Marine-Fishery GIS.

Scientific research for fundamental fishery distribution marketing is composed by (1) "the fishery production and management", which are concerned with discussion of matter from large to small fishery capital, (2)"the fishery strategy", related to setting of fishery law and economical fishery policy, (3) "the fishery management", associated with maintenance of fishery resource and determination of TAC, (4) the fishery partnership union", concerned with fishery function with the National Fishery Association and local fishery association, (5) the "fishery distribution marketing, processing, consumption", and (6), "the development of coastal zone and preservation of environment".

(3) Development of technology for fishery and fishing labor

Technology that has supported ship building, machinery, measurement, information, telecommunication, etc. in Japan is still in the top level in the world. However, general system of fishing boat fishery has not yet kept top level even in the golden age of fishery. It is evaluated that after big fishery company has left from fishery business, fishery technology in Japan has quickly retreated from the level of other foreign countries. According to the retreat of fishing boat fishery in Japan, human brain for technology was wasted away to other industrial word, and gradually fishery in Japan will decline in near future. In order to defense the fishery decline, it is so important for us to grow fascinate fishery. What is the fascinate fishery is to sustain stable profit through controlling fishery, and then, it is important to recover and maintain the fishery resource that we have to apply remote sensing from space for monitoring of fishery resource and to establish Marine-Fishery G1S to enable of determining TAC for sustainable fishery.

(4) Counter measure against fisher man and education

The government in Japan has increased an support and contract projects to the fishery industry and planned the development and utilization for advanced fishery technology. Current younger does not want to work in dirty and severe condition job that fishing boat fishery is really representative. It is necessary to improve these worst condition. What is necessity to improve is to make the severe works on board mechanizing and to reform the life environment on board. Actually

government has made the improvement to reform the condition of aging business and lack of labor. However, it is the most important on how to transfer advanced and experienced technique from old to younger fisherman, and it is important to establish the new education and training center immediately.

(5) Measure to preservation of (he earth environment

After the 17th century Industrial Revolution, huge fossil fuel has been consumed and discharged into air and consequently it has become the Green House Effect and warming the earth. It does not only change the earth environment, but also change the atmosphere and ocean circulations. For fishery condition, it seems to make change the distribution of fishery resource and migration offish in global ocean.

Meanwhile, by the industrialization in developing countries, in global scale, pollution has diverged and gives damage the coastal fishery in domestic and neighbor country. In term of the distribution marketing, when polluted fishes would be recognized, immediately the cycle of EMAC-FAC becomes in unstable and the stable supply by sustainable fishery amount could not be made.

(6) Establishment of the development and research center for fishery general technology and economy development.

At present, it is prospected that in near future, human will become in the condition of a lack of food supply in global scale. Fishery has to take an important role of supplying animal protein to the people. However, as mentioned before, fishery in Japan is now going to decline and situation of fishing boat fishery is in crisis.

In order to improve the worst condition, development of advanced technology and management have been made for well balance of the budget by fishery, but when the fishery company will decide to reconstruct fishing boat, it is absolutely necessary for company to consider whether new reconstructed fishing boat with income from fishery operation, or not

In this paper, involving with government strategy, collaboration with space agency, distribution fishery marketing, banker, ship building industry, we have discussed with and proposed matters monitoring fishery resource from space, development of Marine-Fishery GIS, estimation of fishery resource, establishment of TAC, determination of EMAC and FAC cycle and estimation of balanced number of reconstruction of fishing boat. On the other hand, it is so important to establish a long term vision for fishery strategy which is unavoidable key. We shall look for the stable management of fishery and develop the advanced technology and the total fishery system by all nations. In order to achievement of above requirement, we now intend to propose 'The International Center for Development of General Fishery Technology and Economy **.

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