Condition of Sablefish Stocks in recent years in the Eastern Bering Sea, Aleutian Region and Gulf of Alaska Based on the Results of Field Surveys

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Condition of sablefish stocks in recent years in the eastern Bering Sea, Aleutian region and Gulf of Alaska based on the results of field surveys

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Abstract

The recent groundfish surveys have clearly proved the entry of a strong year class of the exploitable stocks in a large expance of waters extending from the eastern Bering Sea to the Canadian waters in 1979 and 1980. This strong year class having an extremely high abundance, which is believed to be 1977 year class, brought about a drastic change to the abundance and size structure of the whole stocks in a short period of time after it entered. This leads us to think that the sablefish recruitment is not stable from year to year, but that it is largely influenced by the entry of a strong year class which occurs suddenly. Furthermore, the latest studies reveal that the life of sablefish is much longer than previously thought, and that the stocks consist of the fish of many year classes. In view of these points, particularly of the occurrence of a strong year class, the stock assessment through a production model previously applied is not considered to give an adequate evaluation. In this paper, the recent stock condition of sablefish was examined on the basis of the results of each of the groundfish surveys, and it was determined that the ABC (Acceptable Biological Catch) after 1983 could be set at 3,000 - 5,000 tons in the eastern Bering Sea, 2,300 tons in the Aleutian region, and 24,000 tons in the Gulf of Alaska.

Introduction

Sablefish (Anoplopoma fimbria) is one of the important groundfish species for fisheries in the North Pacific. The distribution of sablefish is extended over a wide range of areas. In the Asian side, it is distributed from the Suruga Bay to Hokkaido, then through the east coast of

Kamchatka to Cape Navarin of Siberia. In the American side, the distribution is seen from the eastern Bering Sea to the Aleutian region, and, then, throughout the Gulf of Alaska up to Baja California. The population density is high in the American side, particularly in the southeastern part of the Gulf of Alaska. And the same is very low in the Asian side.

Sablefish has been fished by the North American fishermen since the end of the 1800s. The fishery operations, then, were extremely limited to regional operations. But, as the 1960s entered, Japan and the Soviet Union began to engage in large-scale groundfish fisheries in the Bering Sea as well as in the northeastern Pacific Ocean. And correspondingly the fishery operations for sablefish were widely expanded over the major distribution areas. The sablefish catch by all the nations concerned registered a peak of 66,700 tons in 1972. But, the annual catch thereafter began to fall under the catch limitation imposed by the United States and Canada, and the estimated catch in 1980 was 25,000 tons.

The trends of sablefish stocks have been analyzed on the basis of the CPUE data obtained by the Japanese longline vessels that have consitently maintained their fishery operations mainly for sablefish in most of the major distribution areas. In 1977, the United States and Canada enacted laws establishing a 200 mile fishery zone, and imposed new and various regulatory measures on foreign fisheries operating fisheries within a 200 mile zone from their shores. As a result, the CPUE data of the Japanese longline vessels after 1977 not only lost the continuity with the past, but it became difficult to use such data as an index to correctly represent the trend of the overall stocks. Since 1977, field surveys for groundfish resources have actively been conducted by the research institutes of the countries concerned in order to break off the narrowing down of the study on the fishery biology based on the commercial fishery information.

These groundfish surveys have provided us very useful information to study fishery biology of sablefish. In this paper, the recent stock condition of sablefish is assessed on the basis of the results of the Japan-U.S. joint longline surveys as well as the results of the longline survey by Aomori maru and the U.S.-Japan joint trawl surveys in the eastern Bering Sea, Aleutian region and Gulf of Alaska. The author would like to further examine the ABC (Acceptable Biological Catch) of sablefish after 1983 in these regions, as well as some management problems.

Stock Condition in Recent Years

Commissioned by the Fisheries Agency of Japan, Aomori maru, a fishery training boat of fishery high school of Aomori Prefecture, conducted the groundfish survey in 1969 in the Gulf of Alaska with the use of bottom longline gear. The purpose of the navigation of Aomori maru was chiefly to provide training in actual fishery operations to the students, and subsidiary to obtain the data resulted by the operations. This type of navigation by Aomori maru was conducted only once. However, the information obtained through this operation by non-commercial vessel regarding the population density is very valuable considering that it was done at a time immediately after the Japanese longline fishery

began to be undertaken over a large expanse of the northeast Pacific Ocean. The operations were mainly conducted in the depth range of 401 ~ 800 m of the Kodiak and Yakutat areas (Fig. 1). The operations in the said areas lasted 19 days, consuming 3,454 hachi and resulting in a total catch of 33,444 sablefish. The average catch rate in the Kodiak Yakutat region was 9.68 fish per hachi (Table 1). Based on the size composition data, the catch weight per hachi was calculated to be 30.2 kg.

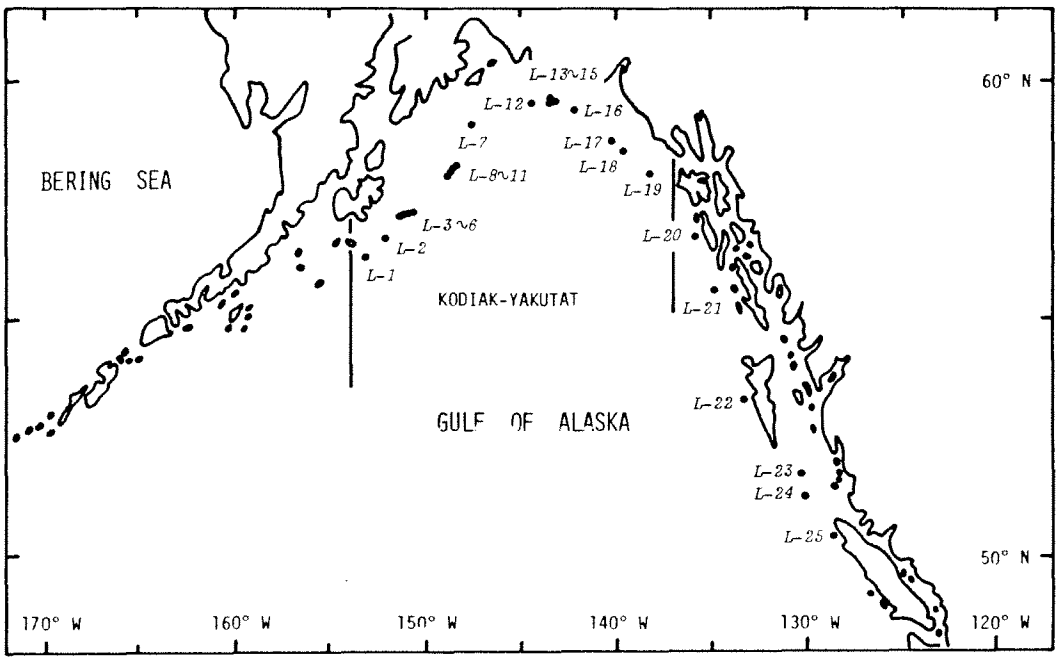

Fig. 1. Longline survey area and positions by Aomori maru in the Gulf of Alaska in the summer of 1969.

In the Aomori maru survey, the longline with 55 hooks attached per hachi was used. But, in the Japan-U.S. joint longline surveys since 1979, the longline gear with 45 hooks was used. For the purpose of comparison, if the value from Aomori maru should be converted in terms of 45 hooks on the basis of the relationship between the hook space and the average catch rate (Sasaki, 1979), the average catch per hachi in 1969 would be 8.22 in number and 25.4 kg in weight.

In order to make comparison between the results of Japan-U.S. Joint longline surveys since 1979 and the results of the 1969 Aomori maru survey, calculation was made on the average catch in number and in weight per hachi in the 401 - 800 m depth range of Kodiak-Yakutat region from the data of joint longline surveys since 1979. The results are as follows:

Average catch	1969	1979	1980	1981	1982
Number/hachi	8.22	5.58	5.60	8.71	11.48
Weight/hachi (kg)	25.4	16.7	15.6	22.3	30.2

Table 1. Records of longline operations by Aomori maru in the Gulf of Alaska in the summer of 1969.

Area	Operation number	Date	Depth (m)	Number of hachi used	Number of hooks used	Bait	Mean soaking times	Number of sablefish caught	Catch[a] rates
Kodiak	L- 1	June 11	450-730	120	6,600	Squid	8^h-40^m	1,226	10.22
	L- 2	12	450-830	160	8,800	"	9 -35	1,111	6.94
	L- 3	13	410-630	180	9,900	"	10 -07	2,053	11.41
	L- 4	14	500-550	200	11,000	"	10 -16	2,347	11.74
	L- 5	15	580-700	230	12,650	"	13 -30	2,219	9.65
	L- 6	16	510-600	240	13,200	"	16 -20	2,121	8.84
	L- 7	18	760-800	150	8,250	"	11 -34	940	6.27
	L- 8	19	480-610	215	11,825	"	15 -35	1,921	8.93
	L- 9	20	500-750	220	12,100	"	14 -00	1,249	5.68
	L-10	21	500-700	249	13,695	"	14 -14	1,977	7.94
	L-11	22	500-700	160	8,800	"	11 -13	855	5.34
				2,124	116,820			18,019	8.45
Yakutat	L-12	June 24	550-600	170	9,350	Squid	10^h-00^m	1,968	11.58
	L-13	25	500-750	180	9,900	"	11 -45	2,774	15.41
	L-14	26	550-700	180	9,900	"	12 -50	2,315	12.86
	L-15	27	550-750	170	9,350	"	11 -30	1,314	7.73
	L-16	28	500-680	180	9,900	"	11 -05	2,333	12.96
	L-17	29	500-800	190	10,450	"	10 -50	2,226	11.72
	L-18	30	550-800	190	10,450	"	15 -00	1,675	8.82
	L-19	July 1	600-650	70	3,850	"	8 -03	820	11.71
				1,330	73,150			15,425	11.60
Southeastern	L-20	July 2	500-780	80	4,400	Squid	7^h-52^m	1,097	13.71
	L-21	3	600-800	50	2,750	"	8 -10	806	16.12
				130	7,150			1,903	14.92
Charlotte	L-22	July 4	740-870	50	2,750	Squid	6^h-00^m	652	13.04
	L-23	5	500-650	60	3,300	"	7 -10	643	10.72
	L-24	6	720-880	60	3,300	"	4 -00	864	14.40
				170	9,350			2,159	12.72
Vancouver	L-25	July 7	640-1,450	45	2,475	Squid	6^h-35^m	383	8.51

a Number of fish caught per hachi.

The exploitation of the sablefish stocks in the Gulf of Alaska was intensified after 1968, when Japan began to operate longline fisheries. Even before that year, there were some Japanese vessels operating to catch sablefish with the use of longline gears. U.S. and Canadian fishermen, too, have long been engaged in this type of fishing. But, these fisheries were limited to certain sites. So, it is imagined that the stock level in the whole Gulf of Alaska was in a slightly exploited state. The stock condition in 1979 and 1980 indicated a reduction of 32% in number and 34 ~ 39% in weight from the level of 1969. But, in 1981 the stock condition rose 6% over the level of 1969, and in 1982 the same rose 40% in number and 19% in weight over 1969. The size composition data indicates the fact that this increases of stocks was caused by a large influx of extremely abundant young fish that are believed to be the 1977 year class, in the depth range of 401 ~ 800 m since 1980 (Fig. 2). The size composition in 1979 and 1980 as compared with that in 1969 shows that the overall hill was lowered in proportion to a decrease in abundance. But, the range and mode of the size composition practically remains unchanged as compared with 10 years ago, showing that the sablefish stocks in the 401 ~ 800 m depth range of Kodiak and Yakutat areas are still maintained in an extremely stable composition even after 10 years of full-scale exploitation.

Above examinations are based on the survey data from the 401 ~ 800 m depth range in Kodiak and Yakutat areas. So, they do not apply to the stock condition in the whole Gulf of Alaska. But, after 1969 the sablefish stocks in the Gulf of Alaska have chiefly been exploited by the

Japanese longline vessels in the 401 ~ 800 m depth range. It is also noted that the biomass in the 401 ~ 800 m depth range in the Kodiak-Yakutat region accounts for about a half of the total of the biomass in the 401 ~ 800 m depth range in the whole Gulf of Alaska. Therefore, we should not commit a serious mistake if we would extend the result of our studies over the whole region of the Gulf of Alaska.

As earlier stated, the level of the adult stocks in 1979 in the 401 ~ 800 m depth range in the Gulf of Alaska as compared with that in 1969 was believed to have declined 32% in number and 34% in weight. In the period from 1969 to 1978 the cumulative catch by all the nations concerned in the Gulf of Alaska amounted to 242,300 tons, with an annual average of 24,230 tons. The major part of this catch was taken in the depth below 401 m by the Japanese longline vessels that were not allowed to catch sablefish in the depth above 400 m. The CPUE (kg/hachi) in 1969 obtained from these longline vessels was 23.5. The CPUE in 1976 was 18.6, 21% less than in 1969. The CPUE in 1979 was 10.9, 54% less than in 1969. But, it is noted that, as against 18.6 indicated in 1976, the CPUE in 1977 when U.S. enacted a low establishing a 200-mile zone was 13.9, showing a drastic drop. This clearly shows that there is a qualitative discontinuity between the data before 1976 and the data after 1977. Under the circumstances, considering that the CPUE in 1976 declined 21% from 1969, the estimated 34% reduction in the biomass in 1979 from the level of 1969 on the basis of the data by research vessels is considered substantially reasonable even in view of the change in the CPUE as reported by commercial vessels.

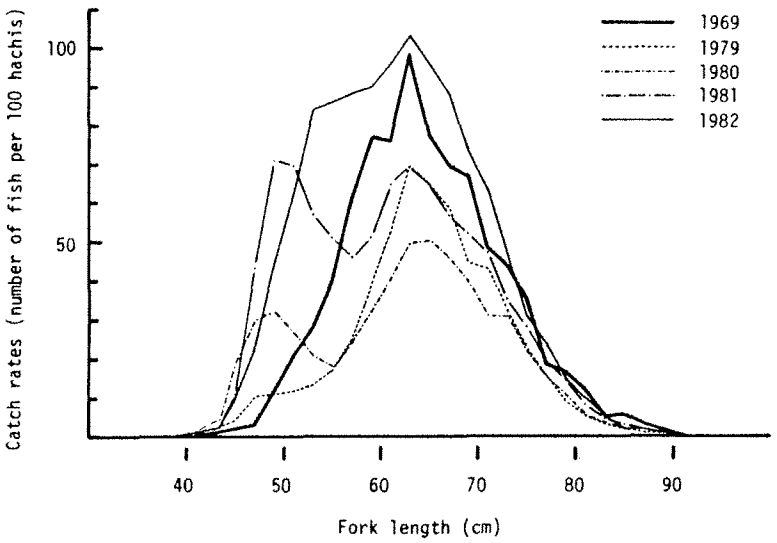

Figure 2. Size compositions of sablefish weighted by catch rates in 401-800 m depth range of the Kodiak-Yakutat region in the Gulf of Alaska from 1969 and 1979-1982 longline surveys.

To summarize the above observations, the biomass in the Gulf of Alaska was almost in the unexploited state in 1969. But, thereafter an annual catch of 24,000 tons on the average had been maintained. Then, after 10 years, that is, in 1979 the biomass decreased 34% from the level of 1969. The stock condition in 1979 was still favorable in both abundance and size structure. It maintained the condition, which could effectively use the chance of the rising of a strong year class, which is brought on irregularly. The stock condition in 1982 sharply expanded on account of an recruitment of extremely abundant young fish, which are believed to be the 1977 year class, showing a 19% rise in the biomass from the level of 1969. Further, the middle and large size stocks with 58.1 cm of fork length or larger increased 73% over 1979. After 1983 the population may decrease, but it is expected that the biomass will continue to increase for the time being.

Estimation of Biomass in 1982

Since 1979, large-scale trawl surveys have been carried out jointly by Japan and U.S. in the eastern Bering Sea and the Aleutian region including the continental slopes. Trawl surveys as well as longline surveys were conducted in 1980 in the Aleutian region and in 1982 in the eastern Bering Sea. The reports on the 1982 trawl surveys have not been released yet. Based on the 1979 surveys the sablefish biomass in the eastern Bering Sea was estimated to be 45,400 tons (Bakkala et al., 1981). Only a preliminary information is available of the results of the 1981 surveys in the eastern Bering Sea. But, the biomass was estimated to be 47,000 tons, 3.5% larger than in 1979 (NWAFC, computer output, July, 1982). According to the 1979 survey report, 97.2% (44,200 tons) of the sablefish stocks were concentrated in the southeastern waters of the Pribilof Is. But, the 1981 surveys revealed that 40% (18,800 tons) of the stocks were also distributed in the northwestern waters of the Pribilof Is. In the Aleutian region, the 1980 trawl surveys revealed in a preliminary report that the biomass of sablefish in the 101 ~ 900 m depth range in the Aleutian region excluding Bowers Bank was estimated to amount to 19,464 tons (NWAFC computer output, Feb., 1983).

In 1980, aside from the trawl surveys, the longline surveys were conducted in the Aleutian region, and the relative value of the sablefish biomass in the 101 ~ 900 m depth range was estimated to be 23,602. In 1982, the longline surveys were conducted in the eastern Bering Sea, the Aleutian region, and the Gulf of Alaska, and the relative values of the biomass in respective regions were obtained. If the estimation were made of the biomass in respective regions in 1982 by relating the biomass estimates by the 1980 trawl survey conducted in the Aleutian region and the relative values of the biomass obtained by the longline survey, the biomass was estimated at 27,658 tons in the eastern Bering Sea, 25,552 tons in the Aleutian region, and 263,869 tons in the Gulf of Alaska. Likewise, the biomass in the Gulf of Alaska in 1979 was estimated at 155,618 tons. This shows the biomass in 1982 increased by 108,251 tons from the level of 1979.

The longline survey area in the eastern Bering Sea did not extend beyond N59° unlike the case of the trawl surveys. The ratios of the biomass in respective regions are clear from the results of the 1981

trawl surveys. If the longline survey results were extended over the whole area of the eastern Bering Sea by applying those ratios, the biomass in the whole eastern Bering Sea in 1982 could be estimated at 32,788 tons. The biomass in the eastern Bering Sea in 1981 was estimated at 47,000 tons on the basis of the trawl surveys. This figure did not include the Region I. Taking that into account, the biomass in the whole eastern Bering Sea in 1981 could be estimated to amount to approximately 55,000 tons. Then, the biomass of 32,788 tons for 1982 earlier estimated through the relationship of the biomass estimate by trawl surveys with the relative values of the biomass obtained by longline surveys is considerably low as compared with the foregoing estimate.

In an area like the Aleutian region where the variations in the depth are sharp and the bottom contours are rough, a stable trawling operation is extremely difficult. The difficulty increases as the water gets deeper. In fact, the 1980 trawl surveys in the Aleutian region were conducted under many restrictions. In addition, the estimate of the biomass was tried, assuming the vulnerability of the trawl gear as 1.00. Taking these into consideration, the estimate of 19,464 tons of the sablefish biomass in the Aleutian region in 1980 should be considerably underestimated.

Acceptable Biological Catch after 1983

It is necessary to maintain a certain level of adult stock in order to effectively use the opportunity of the rising of a strong year class, which is difficult to forecast. What measure of adult stock should be maintained is not clear at this point of time. Although the level of adult stock size in 1977 is not so clear, assuming that it is not so different from the level in 1979, the level of adult stock in 1979 may be good enough to be able to breed the year class having a similar abundance as the 1977 year class, given a proper environment. This could be a yardstick in determining the biomass level that is capable of breeding an abundant year class.

As earlier mentioned, the biomass level in the Gulf of Alaska in 1982 is higher by 19% than that in 1969 when the stock condition was almost in the unexploited situation. In the 10 years after 1969, namely, in 1979 the biomass level declined about 34%. But it still maintained the condition in terms of abundance and size structure, capable of effectively using the chance of the rising a strong year class, which occurs irregularly. There seems to be no direct relationship between the size of adult stock and the recruitment. So, there is no guarantee that the recruit will increase if the biomass would be expanded over the level of 1979. Therefore, if the consideration would be given to maintain the biomass at a level not lower than the level in 1979, an annual catch of 24,000 tons, the average of 10 years from 1969 to 1978, if maintained for the next 10 years, will not cause to reduce the biomass level in the Gulf of Alaska below the level of 1979. The catch level of 24,000 tons represents 9% of 263,869 tons, which was the biomass in the Gulf of Alaska in 1982. Since the estimated biomass in 1982 was considerably understated, the exploitation rate of the stocks through the catch of 24,000 tons will actually be far lower than 9%.

Following the case of the Gulf of Alaska, if the exploitable rate of 9%

should be applied to the current biomass estimated in 1982 in the eastern Bering Sea and the Aleutian region to determine the ABC in 1983 in the said regions, the answers are 3,000 tons in the eastern Bering Sea, and 2,300 tons in the Aleutian region. The biomass estimated by the trawl surveys in the eastern Bering Sea in 1981 amounted to 55,000 tons. Assuming that no change occurred in the biomass in 1982 as compared with 1981, the ABC in 1983 is estimated at 5,000 tons, which is 9% of 55,000 tons. The exploitable rate of the stocks based on this catch level shall actually be considerably lower than 9%, considering that the current biomass estimate in quite understated.

Discussion

In the recent years, field researches have actively been undertaken by the research institutes of various countries, aside from the Japan-U.S. longline surveys. All these surveys have clearly established the entry of a strong year class having a high abundance in a large expanse of waters extending from the eastern Bering Sea to the Canadian waters in 1979 or 1980 (Bakkala et al., 1981; Beamish et al., 1980; Zenger, 1981). This year class is tentatively considered as the 1977 year class. But the abundance of this year class is extremely high so that it brought about a sharp change to the abundance and the size structure of the whole stocks as it entered.

As long as the surveys up to 1982 reveal, there has not been observed any recruit of a remarkably abundant year class after the occurrence of the strong year class which is believed to be the 1977 year class. This leads us to think that the sablefish recruitment is not stable from year to year, but that it is largely influenced by the entry of an strong year class which occurs suddenly. So far, the sablefish stock assessment and stock management has been conducted following the MSY theory which is based on the production model (Low and Wespestad, 1979; Sasaki, 1978; U.S. Department of Commerce, 1978). But, if it is true that the recruitment is not stable and that the life of the sablefish is longer than previously thought as reported by Beamish and Chilton (1982), and that the stocks consist of many year classes, it can be said that the stock analysis results through the production model which is based on the catch and effort data obtained from a relatively short period of fisheries will not provide a reasonable assessment. If it is true that the biomass fluctuations of the sablefish are affected by the occurrence of strong year classes with an extremely high abundance, by estimating the recruitment of strong year classes through field investigations and by calculating the yield per recruit, it will be possible to estimate the maximum sustainable yield that can be expected from the strong year classes in the future. A number of parameters are necessary to estimate the maximum sustainable yield from the recruitment. But, in the case of the sablefish, reasonably reliable values of these parameters are not available yet. Therefore, at this point of time, it is difficult to accurately estimate the maximum sustainable yield from the said strong year class which is believed to be the 1977 year class using a yield per recruit model.

In this paper, we have estimated the ABC after 1983 on the basis of the results of a variety of groundfish surveys made by research vessels. But, these estimates are based on the assumption that the natural fluc-

tuations of the biomass in the future will not differ so much from the fluctuations observed from 1969 to 1978. So, it will be necessary to continue extensive surveys and to carefully keep track of the general change that may occur in the sablefish stocks, while at the same time, it is important to enhance the reliabilities of the variety of parameters necessary for a stock model analysis so that we will be able to make a stocks analysis through models in the future. The current biomass level in the Gulf of Alaska is considered high. So, we consider it very possible to maintain the allowable catch indicated in this paper.

In the eastern Bering Sea and the Aleutian region, the spawning of sablefish is not effectively linked to the reproduction of the fish stocks. The stock in these regions is considered to have been maintained by the fish that migrated chiefly from the northeastern Pacific (Kodolov, 1968). It has been proven by the tagging experiments that the sablefish stocks from the eastern Bering Sea and the Aleutian region and those from the northeastern Pacific mix with each other (Pasquale, 1964; Pattie, 1979; Sasaki, 1979). But, it is impossible that all the sablefish in the two regions will return to the northeastern Pacific, and it is possible to think that many of those sablefish will just remain in the two regions. Then, from the point of view of the overall sablefish stocks in the North Pacific, those remaining stocks can be considered as emigrant stocks that do not contribute to the reproduction. Although it may not be necessary to pay particular attention to maintain these stocks, since there is no accurate information it may be reasonable to keep the exploitable rate after 1983 at 9% of the biomass herein estimated. At any rate, it will be necessary to clarify the scale and pace of intermixture of stocks between the regions.

The sablefish stocks in the Gulf of Alaska are managed under the division of 5 districts. According to the results of the 1982 longline surveys, the difference in the stock size between the areas has been considerably narrowed as compared with the previous year. This leads us to think that the inter-mixture between the areas are quite active. The results of tagging experiments made in the recent years also indicate an active migration of sablefish in the Gulf of Alaska (Sasaki, 1980). Therefore, we think there is no reason for managing the stock under divisions. But, if it is considered necessary to manage the stocks under divisions for a reason other than biological reasons, the management of stocks should be done through allocating the allowable catch in proportion to the biomass. The results of the longline surveys reveal that the ratios of the biomass among districts are 13% of the western district (Shumagin area), 52% of the central district (Chirikof + Kodiak area), 15% of the Yakutat W of 140°W, 6% of the Yakutat E of 140°W, and 14% of the open sea area of Southeast.

In addition, Bracken (1982) concluded on the basis of the tagging experiments that the sablefish in the Gulf of Alaska actively migrate. At the same time, he considered that the young sablefish that occurred in the southeastern Alaska migrate west, where they grow, and then return to the southeastern Alaska for spawning. But, if it is so, the size composition in the Shumagin and Chirikof areas, which is in the west, should be small as compared with the size composition in the Yakutat and Southeastern areas, which is in the east. But, actually no

such tendency can be observed. From this point of fact, it is thought that, though there may be such movement by some of the fish, the majority of the fish do not make such regular movement. It follows that, if the exploitable rate in the western district of the Gulf of Alaska is controlled, the stock abundance in the east cannot be expected to rise.

Conclusion

After examining all the results of various field surveys made by the longline vessels as well as by other types of research vessels, it can be established that the ABC (Acceptable Biological Catch) for sablefish after 1983 will be 3,000 ~ 5,000 tons in the eastern Bering Sea, 2,300 tons in the Aleutian region, and 24,000 tons in the Gulf of Alaska. If the 24,000 tons in the Gulf of Alaska should be divided under the 5 management districts in proportion to the current biomass, the figures should be 3,100 tons in the western district, 12,500 tons in the central district, 3,600 tons in the Yakutat W of 140°W, 1,400 tons in the Yakutat E of 140°W, and 3,400 tons in the open sea area of Southeast.

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