Review of Problems on Stock Assessment of Marlins Laying Stress on the Coverage of landing and Catch and Effort Information in the Pacific Ocean

Yuji Uozumi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu City, Shizuoka, 424-8633, Japan

Introduction

Recent increase of concern on bycatch species stimulates to promote stock assessment activity on marlins, which are not only the major bycatch or secondary species in the tuna fisheries, but also the major target species of recreational fishing. The stock assessments of marlins have been carried out by the production models in the past, but it was often hard to get reliable results from the models without putting subjective constrains on model parameters.

The results of stock assessment of the Atlantic marlins in the ICCAT show the current biomass of Atlantic blue and white marlins is well below the biomass at the MSY level, even though the catch somewhat below but close to the MSY level continued to occur for many years. This discrepancy also pointed out that there are many difficulties in the stock assessment of marlins (Suzuki and Uozumi, 1999)

These difficulties probably come from the problems on catch and effort data and/or model itself. At present, the main available data of marlins for the stock assessment are still catch/effort data of the commercial longline fisheries. Since size data are not sufficient for the introduction of age structure model so far, a family of the production model with landing and catch/effort data is still the major tool for stock assessment of marlins. Therefore, the major concern in this review is focused on problems related with the coverage of the landing and catch/effort data of the longline fishery.

1) Landing information

The landing information on marlins for the whole Pacific Ocean is not available, except for the FAO statistics. Based on the FAO Year book (1996), recently 47,000 metric tons of marlins are caught in the Pacific. Blue marlin occupied about 42% of the total catch, striped marlin occupied about 25%, and sailfish is 10%, black marlin is 5%, but "marlins" occupied 19% of the total, respectively (Fig.1). The category of "marlins" includes catch of other marlins than blue marlin, striped marlin, black marlin, and sailfish, and also includes the catch of species unknown. The catch of this category attained to nearly 9,000 tons recently, and the amount of this category has the third biggest one in the Pacific. The figure of this category shows the uncertainty in the landing information of marlins.

Table 1 shows the list of country, which have reported the catch of marlins in the Pacific to FAO. Even though it is supposed that there must be many countries which catch marlins as target, bycatch, or recreational in the Pacific Ocean, only four countries reported blue marlin catch, and the only three countries reported black, striped marlin and sailfish. These few number of countries, which reported marlins catch, clearly points out about the insufficiency of the landing information. Furthermore, there is another problem on the landings. There is no Japanese black marlins catch. This catch is included in the catch of blue marlin. This problem is mainly related with the statistics of marlins caught by the various coastal fisheries in Japan. The catch of sailfish by Japan, Korea, and Taiwan include the catch of spearfish, though the species specific catch of these two species started to collect in the Japanese longline fishery recently. It is probable that there may be other source of biases in the landing information. Therefore, it is necessary to review and check the catch of marlins country by country in detail.

Recently, international organizations such as SPC, IATTC, and ISC established a bycatch working group or a marlins working group. These activities enhance to increase the quality and quantity of the landing information of marlins. These activities may minimize the uncertainty in the landing information. But it may still difficult to obtain the landing information in stock by stock basis. In the future, it is necessary to gather by stock basis, especially for the marlins such as striped marlin and sailfish, which have some sub-populations in the Pacific Ocean.

Furthermore, we need to take care the change of the coverage in the catch reporting by these working group activities. The working group activity will increase the coverage of reporting. Increase of coverage itself is a potential cause of increase of catch, even though actual catch does not increase. In the Indian Ocean, the significant increase of billfish catch is observed (IOTC, 1998). But IOTC recognized that these increase of the billfish catch is derived from two sources. One is actual increase of catch by fishing activities, and the other is the increase in coverage of information on landings by the hard effort of IPTP for improvement of statistics. But the percentage of each source is unknown. In the Pacific Ocean, there is a possibility that the same phenomenon may occur as in the Indian Ocean. If we do not take care this historical change of the coverage in landing information, this change may introduce some biases in the stock assessment. Therefore, we need to recognize sufficiently about the historical change in the quality and quantity of the landing, when we use the landing information, whose coverage has been improved year by year.

2) Catch and Effort information

Catch and effort information of the commercial longline fishery is the most important information to develop the abundance index for the stock assessment of the marlins. The data from commercial longline fishery have some advantages for the stock assessment use compared with the other fisheries. One is good time series coverage. The Japanese longline fishery database is available from 1952 to now. More than 45 years data is available for the stock assessment. For the production type analysis, the longer data is better, especially the data started from the virgin stock is desirable, provided that any changes in fisheries such as catchability and selectivity are standardized correctly in the model. Local fisheries have also long history. But there is often lack of quantitative information especially in the earlier period.

The other is good area coverage. The longline fishery has much bigger fishing grounds than the coastal fishery such as harpoon and driftnet fisheries and recreational fishery. This means the data of commercial longline fishery has good area coverage.

But, there are also some disadvantages in the commercial longline fishery information. One is that the most longline fisheries do not target marlins. Then, fishing ground of longline fishery is not suitable sampling area to cover the distribution area of marlins sufficiently, even though the area coverage of the commercial fishery is much larger than the other fishery such as recreational one. The longline gear has been developed to catch tunas, which are distributed in the deeper water column than marlins. Then the longline gear may not be an effective gear to sample marlins. The problem of longline gear data is mainly composed of the two dimensions, horizontal sampling coverage, which means the distribution of the fishing grounds, and the vertical coverage of the fishing effort, which means the vertical distribution of hooks. Both of them are important factors to evaluate the reliability of the CPUE.

a) Horizontal Coverage

For development of the abundance index, there must be historical consistency in the sampling area, because the density of marlins is significantly different among the areas, and there is a high possibility that the historical trend of the abundance may be different among the areas. Therefore, it is necessary to continue sampling from the same range of area. If the change of the fishing ground was random, the change of the fishing ground might not introduce serious bias in the CPUE trend. But the fishing operation did not occur randomly. So, it is necessary to be cautious on the change of the fishing ground.

Fig. 2 shows the area where the fishing effort of the Japanese longline fishery has continued to occur from 1952 to 1996. If no fishing continued to occur more than three years in a 5x5 block, the block is eliminated from this figure. Due to no fishing effort of the Japanese longline fishery in the eastern Pacific in the 1950s, it is possible to see the historical trend of CPUE only in the western Pacific from the 1950s.

If the data from 1965, when the fishing effort of the Japanese longline fishery had spread out in the whole Pacific Ocean, are used, it is possible to see the CPUE trend in the much wider area as shown in Fig. 3. But the data in the earlier period (1950s), in which blue and striped marlins are supposed to be close to virgin status, are missed in the assessment.

Fig. 4 shows the geographical distribution of blue marlin's CPUE obtained by the Japanese longline fishery in the 1960s when the Japanese longline fishery expanded in the widest area in the Pacific Ocean. Comparison between Fig. 3 (sampling area) and Fig. 4 (distribution area of the population) shows the horizontal coverage of the Japanese longline fishery database for the blue marlin stock. Though the large part of the high abundance area of blue marlin has been covered by the database, some significant part of the distribution area has not been covered.

Fig. 5 shows the geographic distribution of striped marlin obtained by the Japanese longline fishery in the 1960s. Comparison between Figs. 3 and 5 clearly shows that the large part of the high abundance area of striped marlin has not covered.

The fishing ground of the Japanese longline fishery is much wider than the other fisheries. But the fishing ground is not stable, and the marlins are usually not target species. Then there is a discrepancy in the distribution between marlins and fishing effort as shown in Figs. 2-5.

Generally, it is desirable to use the data sampled from the wider area, because the historical change of abundance is different among the areas. But in the out side of the major fishing ground, the occurrence of the fishing effort is so variable, but not random. Then this variation may introduce serious biases in the abundance trend. So, it is safe way to use the data in the area where the fishing efforts continuously occur. Then the area used for the analyses should be limited as shown in Figs. 2 and 3.

This is a dilemma. To minimize this dilemma, we need many efforts for the investigation on how the variation in the fishing effort distribution affects the CPUE trend, before the selection of the data and area stratification. Some sensitivity analyses on the area selection are desirable to evaluate the effect of the change of the areal coverage. These careful investigations may increase the areal coverage.

b) Vertical Coverage

The longline fishery targets tunas, which are distributed in the deeper water than marlins. Then, there is also discrepancy in the vertical distribution between marlins and fishing effort.

Fig. 6 shows the percentage of the time spent of blue marlins in each water column off Hawaii obtained by the bio-telemetry observations of six blue marlin individuals (Holland et al., 1990). This figure clearly shows blue marlin is mainly distributed in the shallower water than 100m depth, and mainly distributed in the shallower than 50 m depth in both day and night.

Fig. 7 shows the record of hook depth of standard deep longline gear, which is commonly used in the tropical waters by the Japanese longline fishery (Okamoto and Uozumi, 1997). These figures show the shallowest hooks located at around 100m depth where is the deepest layer of the marlin's distribution. This figure clearly shows the vertical coverage of the deep longline gear. The regular longline covers shallower water than the deep longline gear, but even the regular longline does not cover the water column shallower than 50m depth, except for swordfish longline gear, which may cover deeper water than about 30m depth. But the swordfish longline gear is mainly used in the restricted temperate waters in the Pacific.

There is a clear discrepancy in the vertical distribution between hooks and marlins. Longline gear only covers the deepest section of marlin's distribution. If the vertical distribution of marlins changes with abundance of marlins and/or with some environmental factors, there must be serious biases in the CPUE trend obtained by the longline gear due to the lack of vertical coverage.

As the results of the insufficient coverage of the horizontal area and the vertical water column, especially for low coverage in the shallower waters where is the most important layer for marlins, there are so many ZERO values in the CPUE distribution. Then some statistical problems are derived from these insufficient sampling such as heavily skewed distribution of CPUE. It is necessary to use the specific treatment using mixture models, such as the negative binomial with added zeros (SCTB, 1998)

Hinton (1999) presented the results of CPUE standardization, incorporated with the depth of thermocline, depth of the longline gears, and the vertical distribution pattern of blue marlin. This work is up dated one of Hinton and Nakano (1996). The results shows the effective efforts for blue marlin continued to decreased in the recent years, when the deeper longline gear introduced year by year and these deeper longline gears occupied the majority of the gears used in the tropical waters. Then the obtained CPUE trend by this result is clearly different from the trend of standardized CPUE obtained by GLM method only with area, season, and gear configuration (Uozumi unpublished) as shown in Fig. 8.

These differences suggested that there is a high possibility that the standardization by the GLM method may be insufficient, especially for the gear effect (e.g. change of efficiency of the gears by gear configuration and area). It is strongly recommended to validate how the gear effect is sufficiently evaluated in the GLM analyses.

Furthermore, the vertical distribution of marlins is very limited to the surface layer and affected by the vertical temperature profile. There is a little overlap in the vertical distribution between sampling gear and marlins. Therefore, the change in the vertical distribution of both hooks and marlins are supposed to affect substantially the value of CPUE. It is strongly recommend to incorporate the information on the vertical distribution pattern of marlin and hooks of different gears, and relationship with oceanographic condition in the CPUE.

Furthermore, the problem may become more complex due to the oceanographic condition. Fig. 9 shows how the oceanographic condition, mainly shear current, affects on the depth of hooks (Okamoto and Uozumi, 1997). Top figure shows the depth trajectories of the deep longline under no shear current condition. The hooks located at around the depth, calculated under the catenary assumption. But under the existence of the shear current, the hooks dropped into the deeper layer once, then all hooks were pulled up to the shallower layer by the shear current bottom figure in Fig. 9).

These figures show that the depths of hooks are very different under the different oceanographic conditions. Then the efficiency of the longline is also different among the areas, even though the same gear is used. Oceanographic conditions which affect on the gear efficiency such as shear current is also important factor in the CPUE standardization.

General Conclusion

The review of the coverage of the basic data for the stock assessment of marlins clearly shows there are some serious problems on the coverage of the basic data, which cause the uncertainty in the results of the stock assessment of marlins. The detailed investigations such as comparisons of CPUE among areas, gears including different countries, etc will give us some ideas to increase the area coverage. Some additional information obtained from bio-telemetry tagging and archival tagging, and underwater observation of gears and relationship of marlins and gear distribution with oceanographic conditions may give us more quantitative information on vertical coverage. These information make it possible to develop more sufficient standardization of longline CPUE of marlins, incorporating the horizontal and vertical variation of marlins and hooks.

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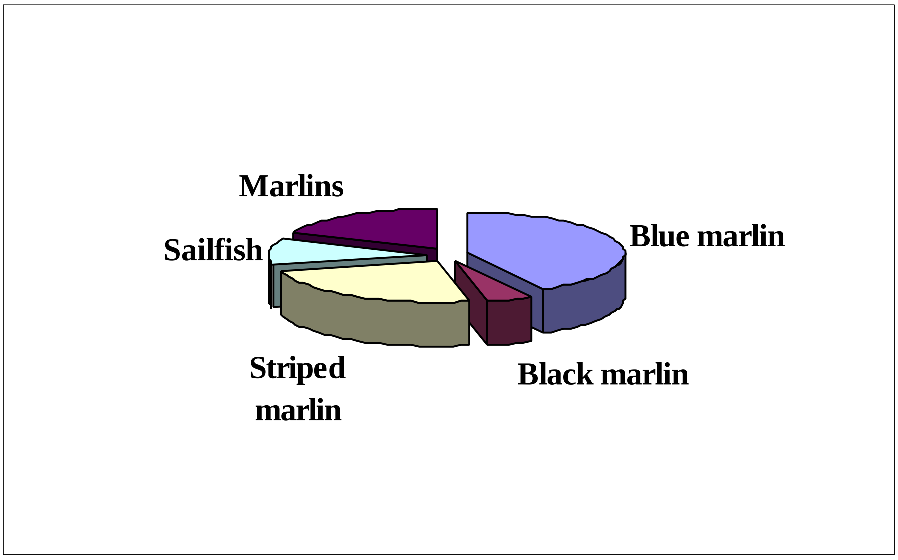
Table 1. List of countries, which reported catch of marlins in the recent ten years (FAO, 1996).

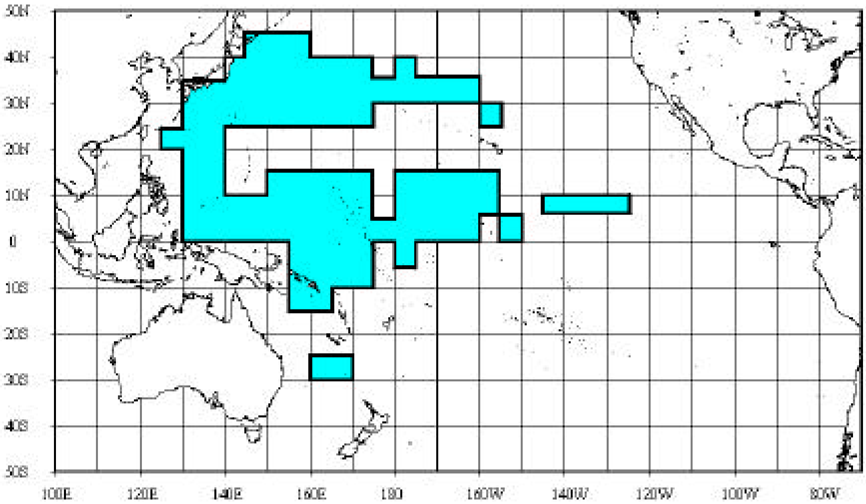
Blue marlin	Black marlin	Striped marlin	Sailfish	Marlins
4	**3**	**3**	**3**	**11**
Japan		Japan	Japan	
Korea Rep	Korea Rep	Korea Rep	Korea Rep	Korea Rep
China Taiwan	China Taiwan	China Taiwan	China Taiwan	China Taiwan
Philippines				Philippines
				Malaysia
				N Marianas
	Tonga			Cook Is
				Mexico
				Solomon Is
				Fr Polynesia
				New Zealand
				USA

Fig. 1. Species composition of marlins catch in the Pacific Ocean in the recent ten years



(FAO, 1996).

Fig. 2. The area where the fishing effort of the Japanese longline fishery continued to occur



during 1952 to 1996. The 5x5 block where no fishing effort continued to occur in more than three years is eliminated .

Fig. 3. The area where the fishing effort of the Japanese longline fishery continued to occur during 1965 to 1996. The 5x5 block where no fishing effort continued to occur in more than three years is eliminated .

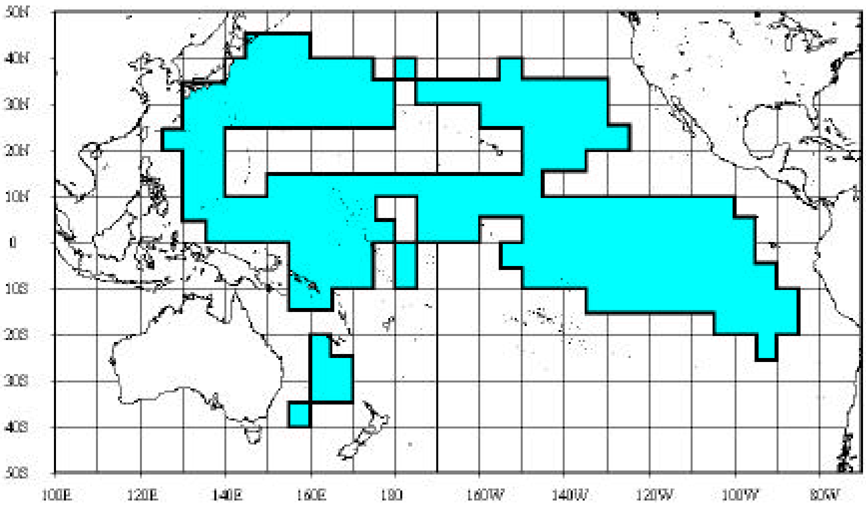
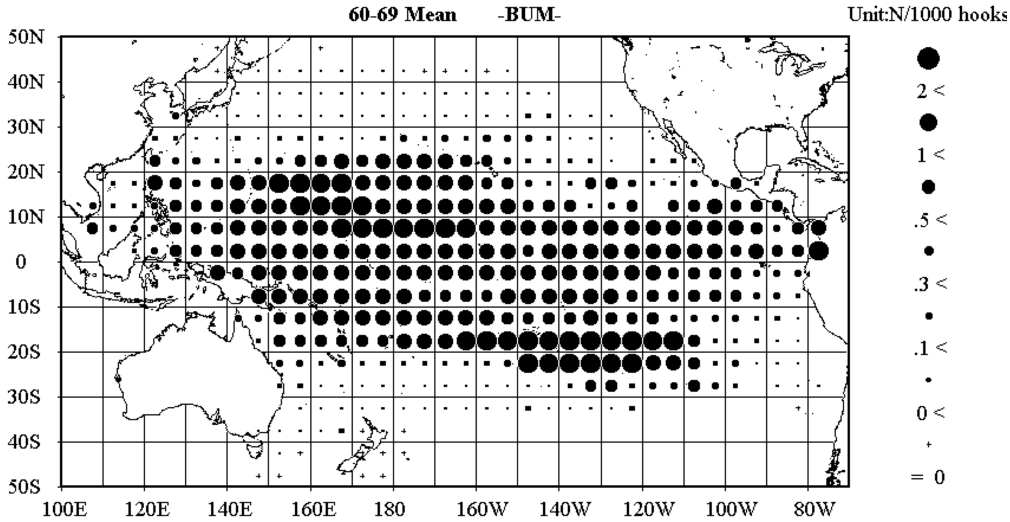


Fig. 4. Geographic distribution of CPUE for blue marlin obtained by the Japanese longline fishery in the 1960s.



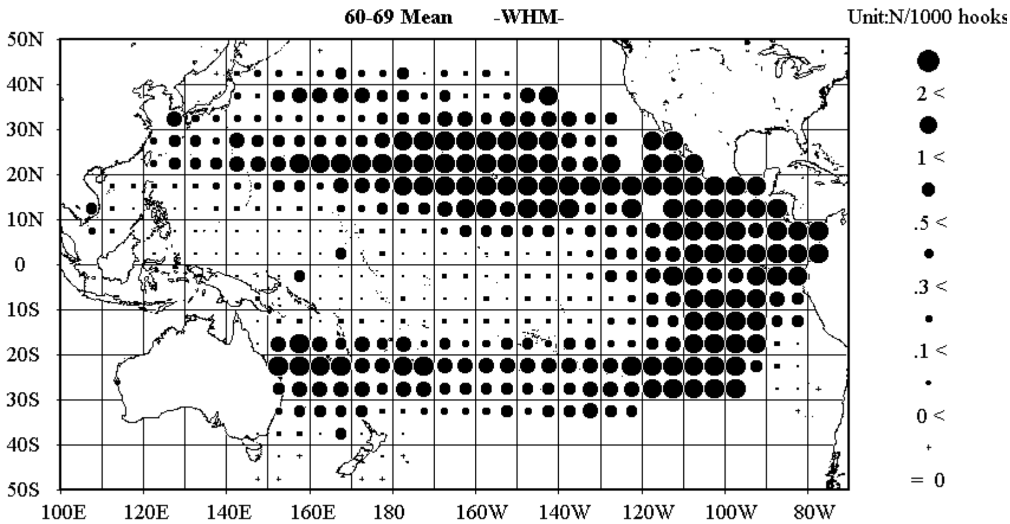


Fig. 5. Geographic distribution of CPUE for striped marlin obtained by the Japanese longline fishery in the 1960s.

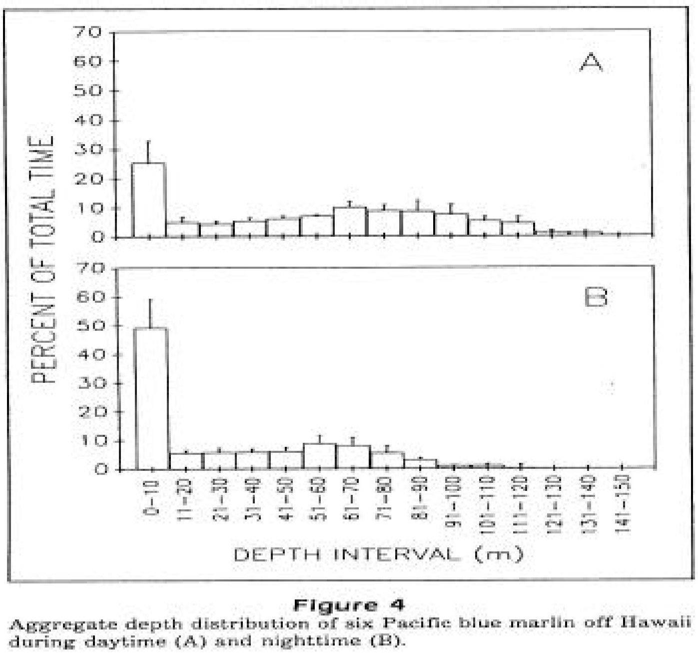


Fig. 6. Aggregated depth distribution of six blue marlin off Hawaii during daytime (A) and night time (B) cited from Holland et al. (1990).

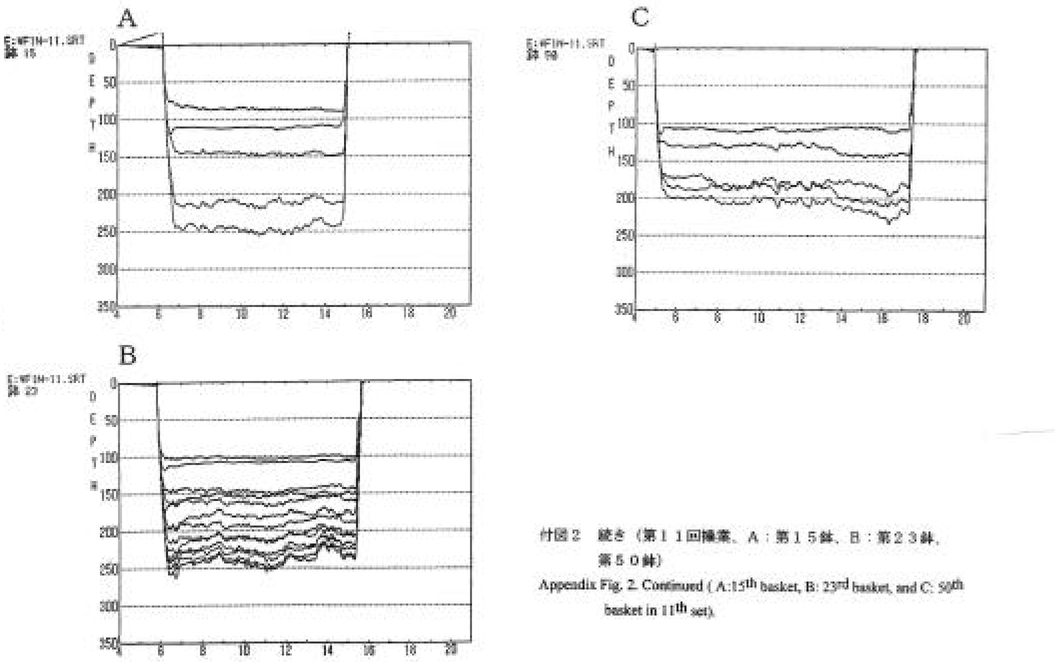


Fig. 7. The hook trajectories of the deep longline gear cited from Okamoto and Uozumi (1997). Each line shows the trajectory of a hook.

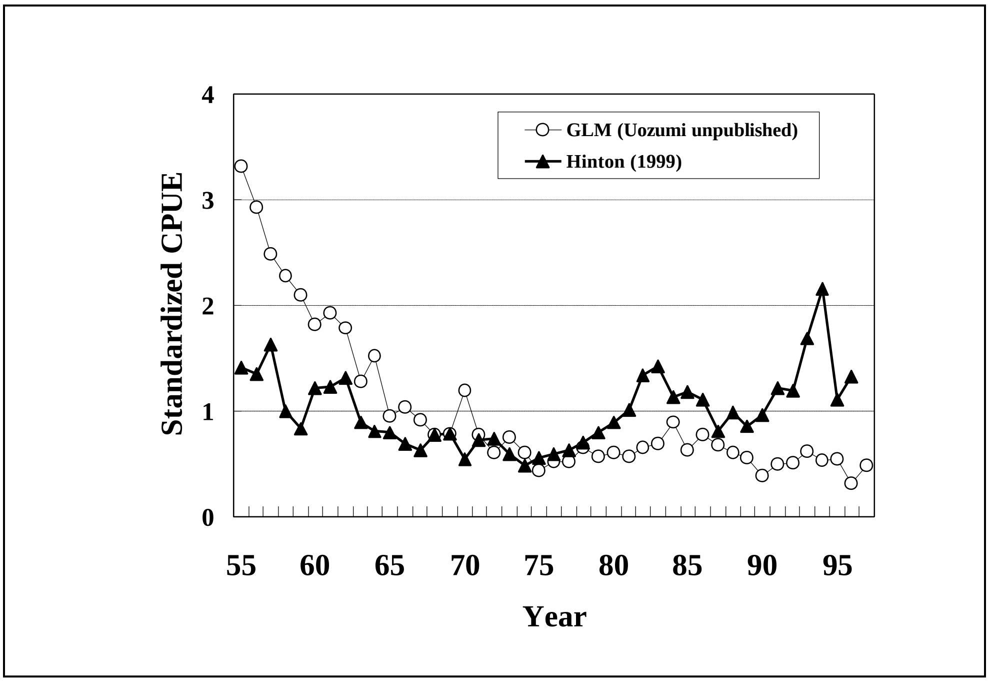


Fig. 8 Comparison of the standardized CPUEs by the conventional GLM method (Uozumi unpublished) and by Hinton (1999).

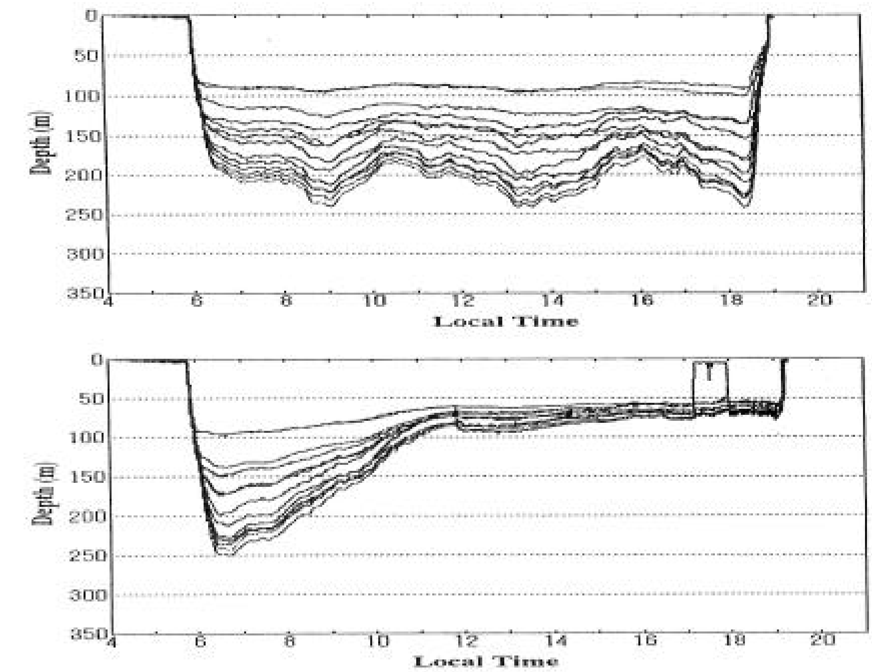


図 24 同一鉢内での鈎の水深変化の差（上:第 14 回操業 第 36 鉢、 下:第 13 回操業 第 36

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