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Simple Discussions on Relationships between the Vessel Tonnage, the Kind of Bait Used and the Atlantic Albacore CPUE

Abstract

Catch statistics of commercial fishery are essential materials for fish stock assessment. However, the catch per unit effort (CPUE) estimated from the materials is subject to variations introduced from the non-static fisheries factors. These factors should be thoroughly recognized before the raw material could be properly used in the assessment. The present paper dealt with two commonly ignored factors occurred in the catch statistics of Taiwanese Atlantic albacore longline fishery: vessel tonnage and the kind of bait used. These two factors were found from the study to have obvious relationships with the Atlantic albacore CPUE: vessels with higher tonnage had lower albacore CPUE, and higher percentage of saury bait used might obtain higher albacore CPUE. Their effects were regarding to the shifting of target species of the fishery. Therefore, it is suggested that adjustments for the two factors should be made to the nominal statistics before the statistics being used in the assessment; unless the target species effect has somewhat been taken into account.

Key words: Atlantic albacore CPUE, Vessel tonnage, Bait, Target species

Catch statistics of commercial fishery are essential materials for fish stock assessment. They provide a basis for computing or estimating the index of stock abundance (catch per unit effort, CPUE) and other important parameters, such as fishing mortality, exploitation rate and those related to the surplus production(1). In case that efficiency of fishing vessels increases over time, however, using raw material will overestimate the abundance and underestimate the fishing mortality(2). Besides, due to the non-static situation of the fisheries, many other factors, such as target species, fishing location, fishing time, qualification level to the data, or even the vessel captain(2) may also produce variations to the raw material and restrict their usage in appraising the stock abundance.

Atlantic albacore longline fishery is one of the most important tuna fisheries of Taiwan(3). Its nominal catch statistics are no exception to the variation-causing factors mentioned above. Before performing stock assessment on the fishery by CPUE, these factors should be recognized as much as possible in advance.

Some of the factors in the catch statistics of Taiwanese Atlantic albacore longline fishery have already been studied, such as the target species, fishing location and fishing time(4-5). The present paper dealt with the other two possible factors: the vessel tonnage (in gross registered tonnage) and the kind of

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bait used. These two factors have usually been treated with little consideration in standardizing the fishing effort of the fishery, since they were not considered to have significant effects on the albacore's CPUE due to the passive characteristics of the longline gear and some other reasons. Nevertheless, the albacore CPUE of Taiwanese longline fishery by vessel tonnage and bait used (the kind of baits used in fishing operations) showed a close relationship between the albacore CPUE and the two factors (discussed later in this paper). The present paper focused on these apparent discrepancies and has discovered that these discrepancies were mainly caused by the shifting of target species from albacore to bigeye tuna during the fishery's history. Therefore, this study suggested that, before the statistics to be used in the assessment, adjustments for the effects of vessel tonnage and bait used should be made to the nominal statistics; unless the target species factor has somewhat been taken into account.

Material and Methods

Data studied were the 1980–1993 original logbook data of the Atlantic longline fishery of Taiwan, which were collected and made accessible to computer by Tuna Research Center (TRC), Institute of Oceanography, National Taiwan University. (Data of 1984, 1991–1993 have been updated after this paper was accepted due to new information come.) These data included fishing date, vessel's official coding number, surface temperature, kind of bait used, hooks deployed and catches in number and in weight of 13 species .

The first digit of the vessel's official coding number indicates the vessel's tonnage class defined by Taiwanese Fisheries Bureau. The present paper used that tonnage class definition. Three tonnage classes were thus defined: vessels with gross register ton less than 200 t were ranked as tonnage 1, between 201–500 t as tonnage 2, and between 501–1000 t as tonnage 3.

The baits used by Taiwanese longliners are saury, mackerel, scad, squid, milkfish, and others (for example, moonfish). Vessels used more than one kind of baits in a day's operation are not uncommon. Thus, an extra kind of bait was defined for this case and coded in the computerized data as 'combined baits'. There were seven kinds of baits in all defined in this study.

There are many ways may be useful to make allowance for the effect of shifting target species, such as the changes of the albacore (ALB) catch composition, of the number of branch lines per basket, of the distribution of fishing, or of the bigeye tuna (BET) CPUE[5-7]. We simply considered the changes of the ALB catch composition as representation of the effect of shifting target species. The ALB, BET and yellowfin tuna (YFT) catches in number per 1000 hooks (the CPUEs) and the catch composition of ALB were then calculated by ther three tonnage classes and the seven kinds of bait used, for the original and the SRL (Species-specified Regular Longline) logbook data. The SRL data were part of the original logbook data and were segregated in terms of catch composition[5]. The percentages of ALB catch in a day's total catch were all higher than 90% in SRL data.

Results

I. Vessel Tonnage

Fig. 1 shows the annual mean ALB CPUE of Taiwanese longline fishery by the three vessel tonnage classes. If disregarded the data of 1988 in tonnage class 3 (tonnage 3), an inverse trend between the ALB CPUE and the tonnage classes could be found: vessels of higher tonnage class performed a lower ALB CPUE.

Fig. 2 is the annual percentage of operation days deployed by vessels of the three tonnage classes. The original data from vessels of tonnage 1 ended in 1988, but the data of 1988 was disregarded since it

Fig. 1. The annual mean Atlantic albacore (ALB) CPUE of the Taiwanese longline fishery by tonnage class.

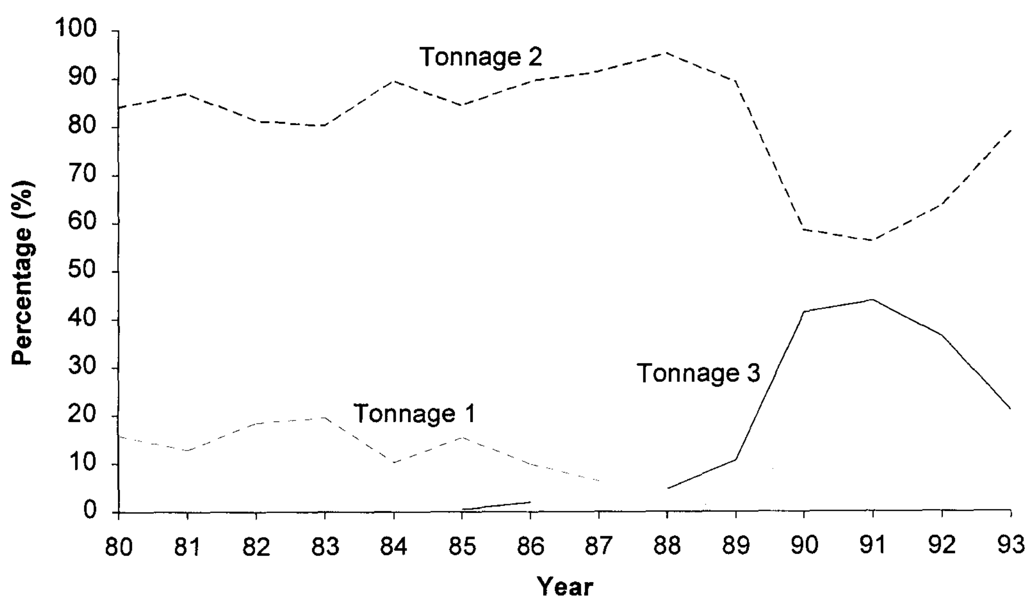


Fig. 2. Composition of the operation days of the three tonnage classes in 1980–1993.

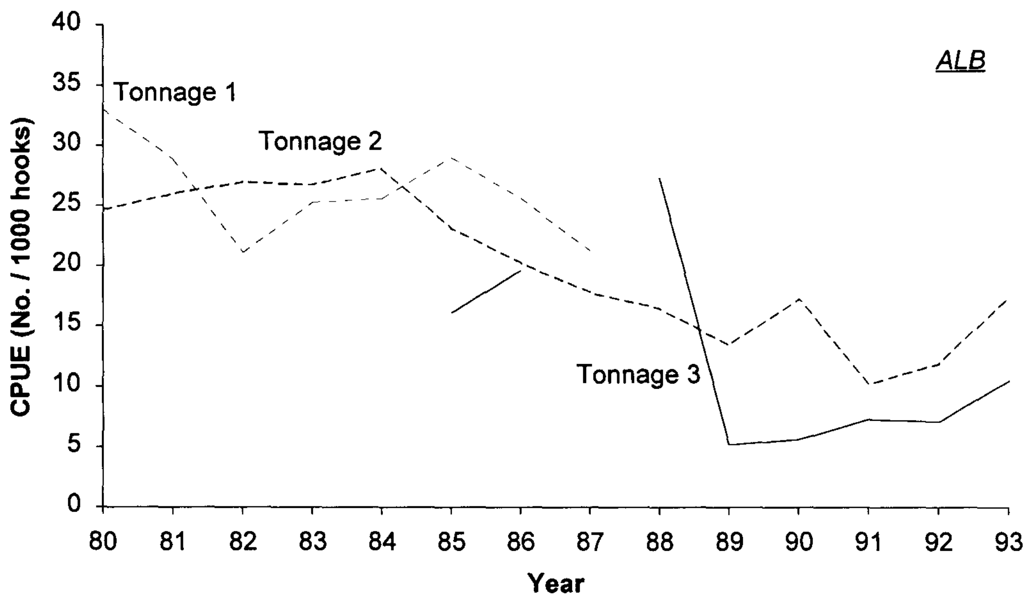


Fig. 3. CPUEs of the Atlantic albacore (ALB), bigeye (BET) and yellowfin (YFT) tunas by the three tonnage classes in 1980–1993.

contained only two days' operations. The data from tonnage 3 started from 1985 to 1993 with 1987 missed. Only the data from vessels of tonnage 2 covered the whole study period, and composed consistently the highest part of the fishing operation days in the Atlantic Ocean. Thus, tonnage 2 (the dominant tonnage class) was selected as reference to compare the ALB CPUE variation between vessel size.

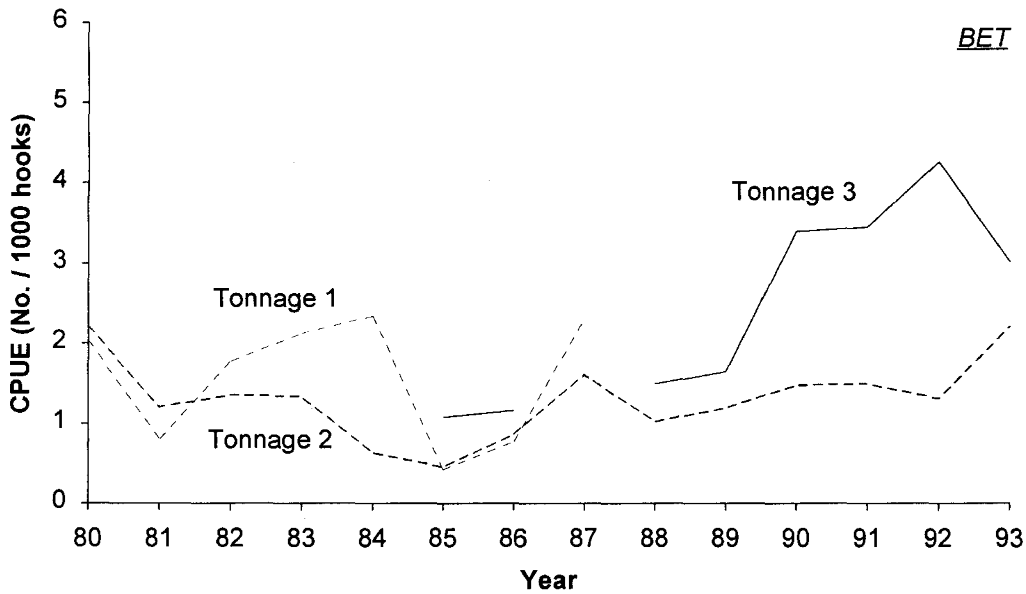
Operations of vessels of tonnages 1 and 3 composed minor part of the total operation days in the Atlantic Ocean before 1990 (Fig. 2). Their variations of ALB CPUE were not substantially so important for our study. From 1990 onwards, however, a large amount of increase in operation days was noted in tonnage 3. Their operations have occupied almost half of the yearly total.

Fig. 3 is the annual CPUE variations of ALB, BET, and YFT by tonnage classes. ALB CPUEs of vessel tonnages 1 and 3 did not deviate much from that of tonnage 2 before 1989. But from 1989 onwards, the trend of tonnage 3 was very different from that of tonnage 2; it declined sharply from about 30 fish/1000 hooks to the level about 5 fish/1000 hooks.

Fig. 4 shows the catch composition of ALB by vessel tonnage classes. The percentage of ALB caught by all the three tonnage classes were similar before 1989; but from 1989 onwards, the percentage of ALB caught by tonnage 3 dropped sharply while that by tonnage 2 kept stable.

Fig. 5 is similar as Fig. 3 but plotted using segregated SRL data which comprised more than 90% of ALB catch in a day's total tuna catch. Except for the 1985 and 1986 of tonnage 3, the ALB CPUE of both tonnages 1 and 3 were close to that of tonnage 2 during the whole study period. The apparent deviation in ALB CPUE of tonnage 3 from that of tonnage 2 in Fig. 3 in and after 1989 was not noted in Fig. 5.

Re-arranged the ALB CPUE by tonnage classes in Fig. 5 (Fig. 6), two levels of ALB CPUE could be found: The higher level was around 25–40 fish/1000 hooks and was mainly of years before 1989 and in 1993 (denoted by rectangles in Fig. 6). The lower



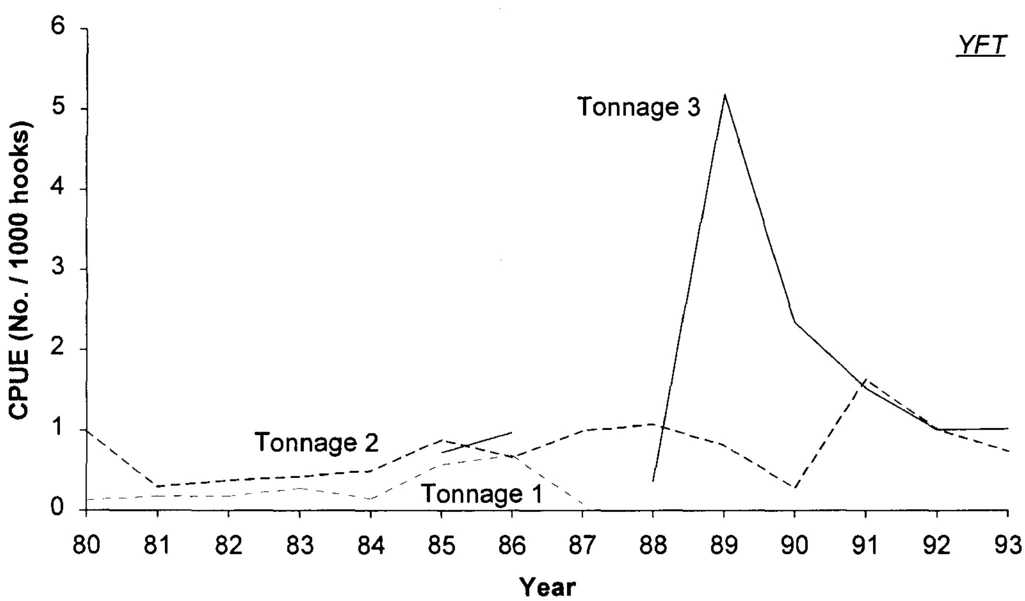


Fig. 3. (Continued.)

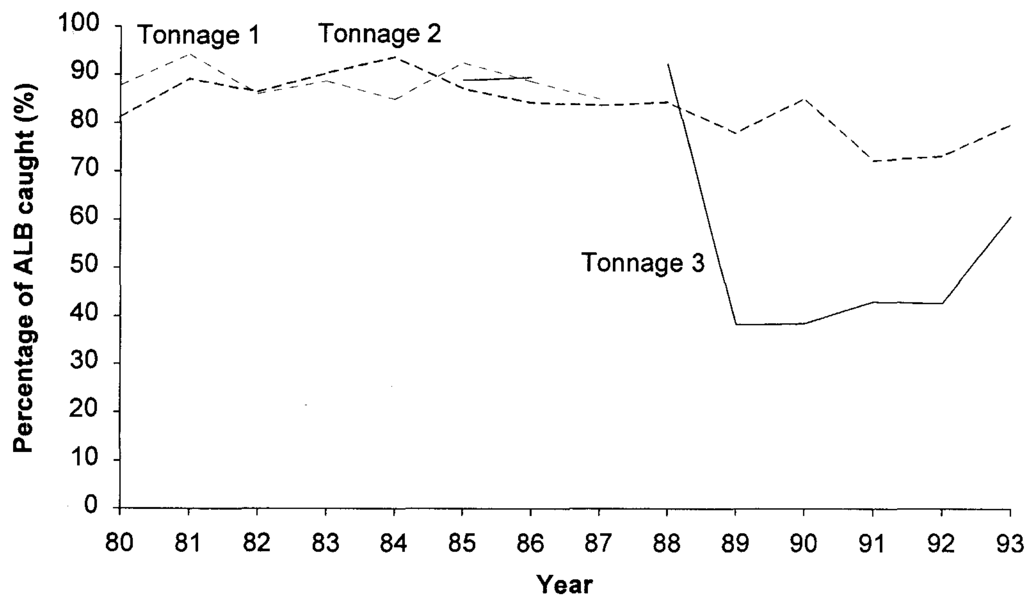


Fig. 4. The annual mean percentage of the Atlantic albacore (ALB) caught by Taiwanese longliners by the three tonnage classes in 1980–1993.

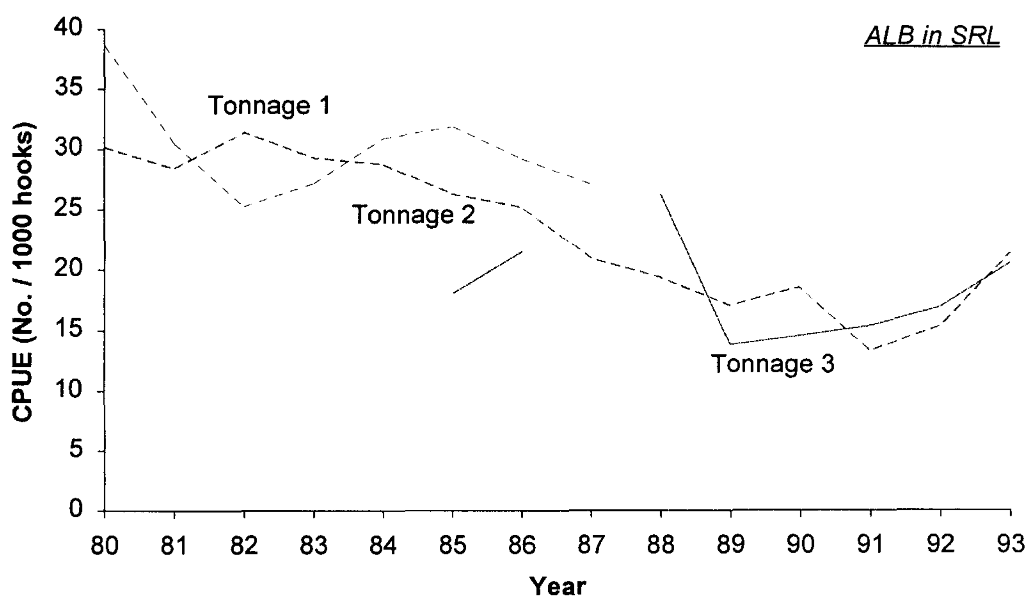


Fig. 5. CPUE of the Atlantic albacore (ALB) by the three tonnage classes in 1980–1993 for the segregated SRL data, which comprised more than 90% of albacore catches.

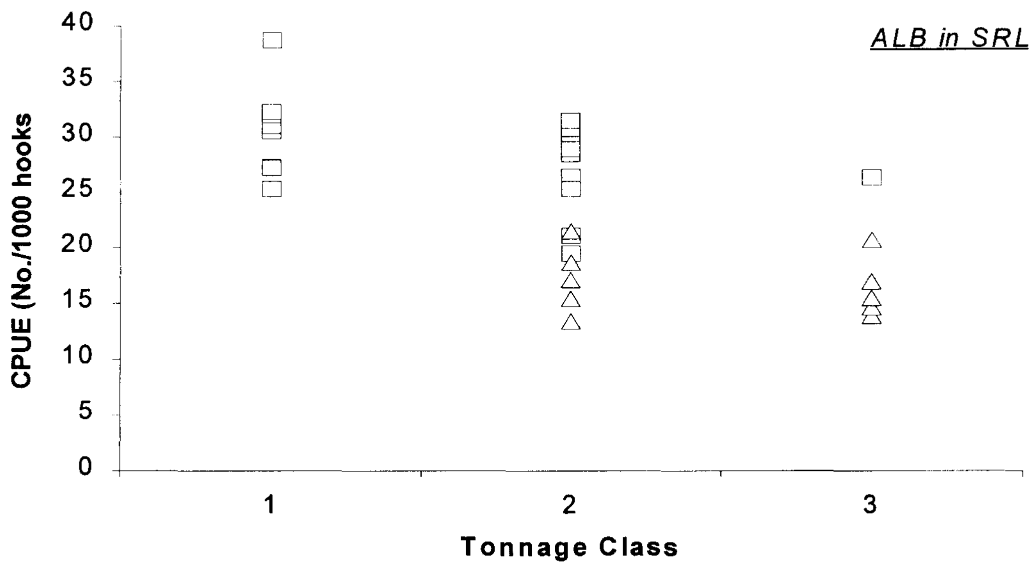


Fig. 6. The annual mean Atlantic albacore (ALB) CPUE of Taiwanese longline fishery by tonnage class for the segregated SRL data which comprised more than 90% of albacore catches. Rectangles denote the data before 1989 and in 1993. Triangles denote 1989–1992 data.

level was around 10–20 fish/1000 hooks and was of years 1989–1992 (denoted by triangles). The low level of ALB abundance index was still noted in segregated SRL data, but the inverse relationship between ALB CPUE and vessel tonnage classes was no more so obvious as in Fig. 1.

II. The Kind of Bait Used

Fig. 7 shows the annual percent of the seven kinds of bait used and variations of ALB and BET CPUEs. The saury bait was the one used mostly, and the annual ALB CPUE was closely related to the percent of saury bait used. The three years with lowest percent of saury bait used (1990–1992) were also the years with lowest value of ALB CPUE; but, on the contrary, they were the years with highest BET CPUE.

Fig. 8 delineates the relationship between ALB CPUE and the percent of saury bait used. A linear relationship with correlation coefficient (r) of 0.82 could be found between the two. The higher the percentage of saury bait used, the higher the ALB CPUE obtained.

Fig. 9 replots ALB CPUE against the percent of saury bait used as in Fig. 7, but using data of segregated SRL. The linear relationship between ALB CPUE and percent of saury bait used was not so clear as in Fig. 8.

Discussions

I. Vessel Tonnage

For trawl fishery, vessel tonnage has already been concluded many times to have significant effects on the catch rate of fishes[2,9-13]. For longline fishery, on the other hand, few discussions on this factor have been made because the longline gear is considered as a passive gear. That is, the longliner does not chase the target actively during its fishing operation; and an increase in vessel size of the longliner does not necessarily show a corresponding increase in

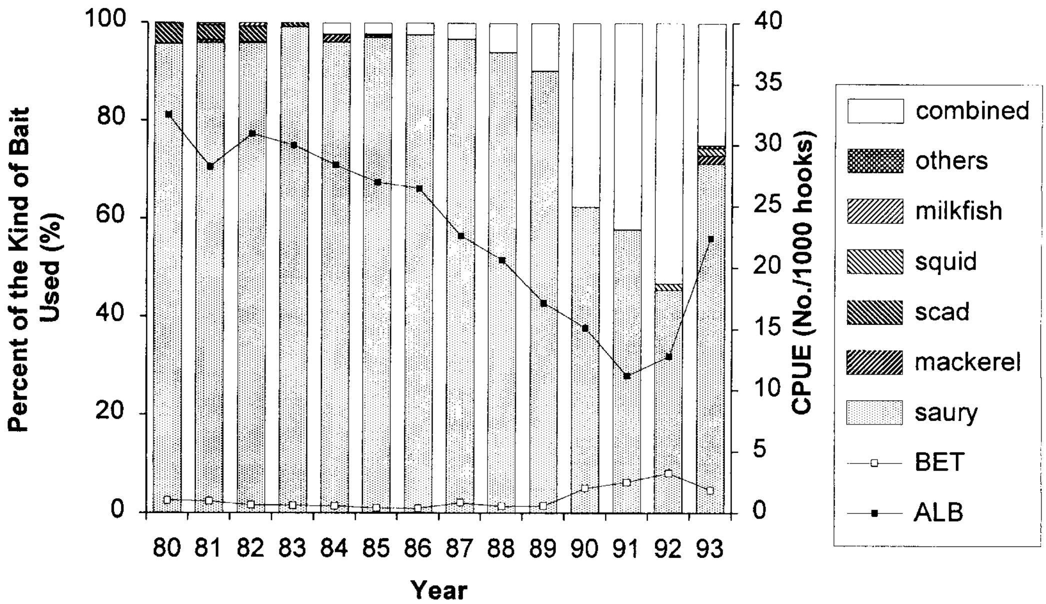


Fig. 7. The annual percentage of the seven kinds of bait used (bars) and the annual Atlantic albacore (ALB), bigeye tuna (BET) CPUEs (lines).

fishing power or CPUE. Nevertheless, the annual mean ALB CPUE of Taiwanese longline fishery by vessel tonnage (Fig. 1) showed an inverse trend between the ALB CPUE and the tonnage class if disregarded the data of 1988 in tonnage 3: Vessels with higher tonnage had a lower ALB CPUE. This trend was discorded with the common knowledge on passive gear; if it was true, the effect of longliner's vessel tonnage should also be considered in the effort standardization of the fishery.

From Fig. 2 we find that the percent of operation days of tonnage 3 started to increase in 1989 and increased significantly from 1990 onwards. Meanwhile, their ALB CPUE declined sharply (Fig. 3). From their increase in the CPUEs of YFT in 1989 and of BET from 1990 onwards, however, it was noted that this decline of ALB CPUE in 1989–1993 of tonnage 3 was the result of their shifting of target species, from ALB to YFT in 1989 and to BET from 1990 onwards. Since that most of Taiwanese deep longliners (or longliners with super-freezers) are vessels of tonnage class 3, and that these deep longliners are targeted on BET or YFT, it may be proposed that the uncommon relationship between ALB CPUE and vessel tonnage was the consequence of shifting of target species of the fishery.

As shown in the catch composition of ALB (Fig. 4), the percentage of ALB caught by all the three tonnages were similar before 1989; but the ALB percentage caught by tonnage 3 dropped sharply in 1989 and the latter years. By replotted the ALB CPUE trends by tonnage classes using the segregated SRL data (Fig. 5), we could find that, except for the 1985 and 1986 of tonnage 3, the ALB CPUE of both tonnages 1 and 3 were close to that of tonnage 2 in the whole studied years. Using segregated SRL data was to make allowance for the effect of shifting of target species; and the closeness of ALB CPUEs among the three tonnage classes implied that, the differences among them in Fig. 3 were not obvious when the effect of shifting target species has been taken into account. In other words, the vessel size

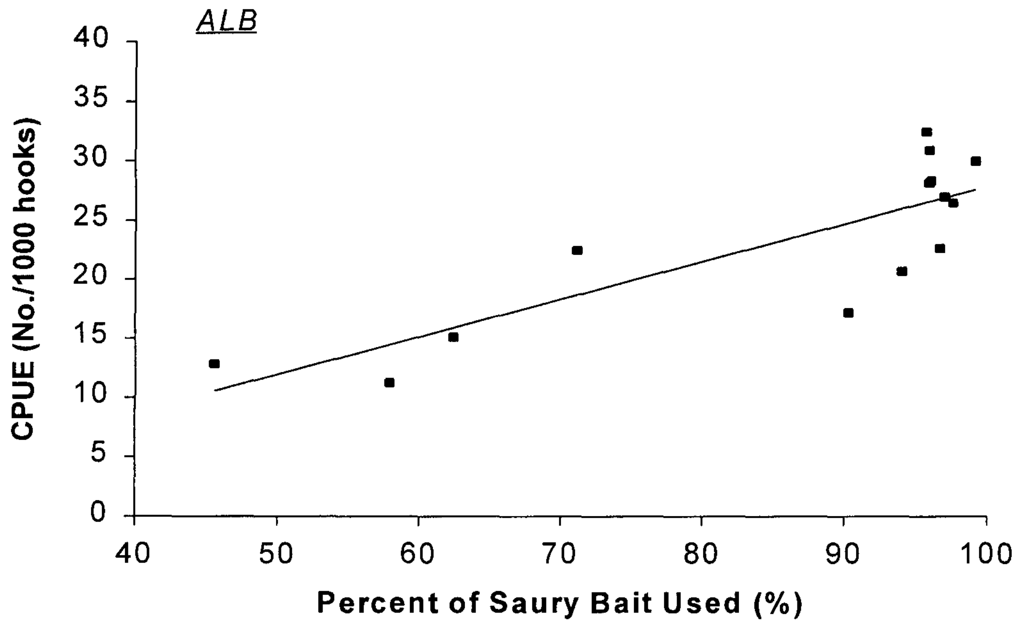


Fig. 8. Plot of the Atlantic albacore (ALB) CPUE against the percent of the saury bait used by Taiwanese longliners in 1980–1993. Each single point denotes a year's mean, and the line indicates a linear relationship between the two variables with a correlation coefficient of 0.82.

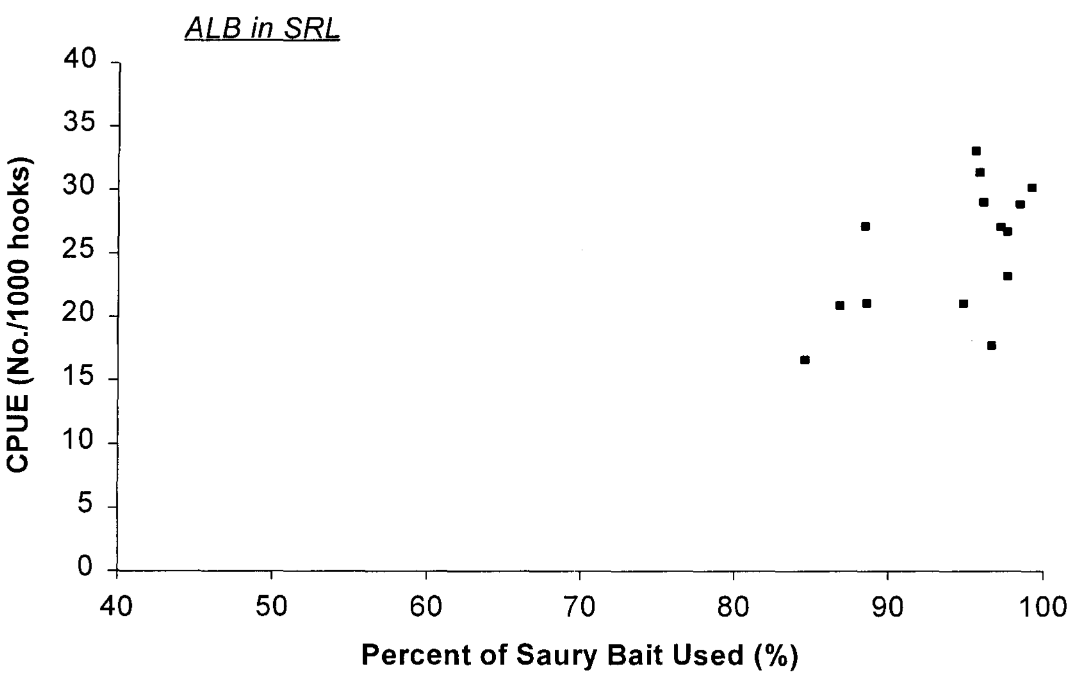


Fig. 9. Plot of the Atlantic albacore (ALB) CPUE against percentage of the saury bait used by Taiwanese longliners in 1980–1993 for the segregated SRL data. Each single point denotes a year's mean.

effect might be omitted in the case when the target species effect has been included in the model to evaluate the CPUE of ALB. This target species effect could be made allowance for by segregation through the catch composition[5], by the number of branch lines per basket[6], by the change in distribution of fishing[7], or by the BET CPUE.

The mean yearly ALB CPUE in SRL by tonnage class (Fig. 6) showed two levels of ALB CPUE. The higher level was found in the years before 1989 and in 1993 (rectangles in Fig. 6); the lower one was found in 1989–1992 (triangles in Fig. 6). At both levels the CPUEs among tonnage classes were similar. This might indicate that there was a difference in the ALB stock abundance around these two periods. But, the inverse relationship in Fig. 1 was no more obvious.

II. The Kind of Bait Used

The kind and size of the bait used is one of the most important factor in evaluating the CPUE of longline fisheries[7]. This factor, however, was seldom used in standardization of the fishing effort of the fishery concerned. The relationship between the kind of bait used and the CPUE variation is so far not clear is one of the reasons of this consequence.

Taiwanese longliners used more than five kinds of bait. Among which, the saury bait was the one mostly been used. Fig. 7 showed that the annual CPUE of ALB was closely related to the percent of the saury bait used. And Fig. 8 indicated that there existed a linear relationship between them with r=0.82. This implied that the percent of saury bait used would affect the CPUE of the Atlantic ALB; the higher the percentage of the saury bait used, the higher the ALB CPUE obtained.

From the low level of ALB CPUE and the high level of BET CPUE in the time when low percentage of saury bait was used in 1990–1992, a target-species effect might have existed therein. Replotting the ALB CPUE against the percent of saury bait used using the segregate SRL data (Fig. 9), the linear relationship between the two was not significant any more.

Recapitulated from the above results, both the vessel tonnage and the kind of bait used had relationships with the Atlantic ALB CPUE; furthermore, these relationships were regarding to the shifting of the target species from ALB to BET by the Taiwanese longliners. The present study therefore suggested that before the stock assessments being performed using statistics of the fishery, adjustments for the two effects should be made to these statistics; unless the target species effect has somewhat been taken into account.

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船噸級及使用餌料種類與大西洋長鰭鮪單位努力漁獲量之關係的初步探討

摘 要

漁獲統計資料是進行漁業資源評估的基礎資料，但由這些資料計算出來的單位努力漁獲量（資源豐度指標），很容易受不穩定的漁業因子所影響而產生變異。爲能將統計資料合適地應用於資源評估，應該儘可能地將那些因子辨識出來。本報告對台灣的大西洋長鰭鮪延繩釣漁獲資料，提出並討論兩個常被遺漏的因子：船噸級別及使用餌料種類。從研究結果中發現，這兩個因子與大西洋長鰭鮪之單位努力漁獲量的變化有明顯的關連：船噸級愈大，單位努力漁獲量愈低；使用秋刀魚當餌料的比例愈高，單位努力漁獲量愈高。而且這些關連都與台灣延繩釣漁船的標的魚種移轉（從長鰭鮪移轉至大目鮪或黃鰭鮪）有關。因此本報告建議，除非標的魚種因子的影響已經事先被考慮過，不然該漁業的原始漁獲統計資料在應用於評估之前，應先根據這兩個因子作校正。

關鍵字: 大西洋長鰭鮪單位努力漁獲量，船噸級，使用餌料種類，標的魚種

張水鍇, 許建宗 (1994) 船噸級及使用餌料種類與大西洋長鰭鮪單位努力漁獲量之關係的初步探討. 水產研究, 2(1): 7–18.