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A Study on the Light Seine Fishery in the Taiwan Strait

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Abstract

Taiwan Strait is the traditional fishing ground for light-seine fishery. Recently, fishery resources in the Taiwan Strait have been dwindling year after year. However, although the number of light-seine fishers has been decreasing, yield has remained relatively smooth and steady.

There are many upwelling regions in the Taiwan Strait. Large quantities of plankton reproduce in these upwelling areas and the hydrological conditions there are stable, which is favorable for fish to concentrate and seek food. The light-seine, which mainly catches pelagic fish, destroys marine geologic environment lightly and damages only a few young fish. The pelagic fish stocks recover quickly, and the annual catch of the pelagic fish in the Strait has not reached the maximum sustained yield. Therefore, light-seine fishery in the Taiwan Strait has a bright future. However, since the catch per unit of effort (CPUE) of light-seine in 1996 was under the highest point of the regression curve of growing tendency, the fishing effort should not just be increased without considering its economic results.

Introduction

There are abundant fish resources, especially pelagic fish, in the Taiwan Strait. The light-seiners and trawlers in the Fujian Province have been fishing in the Strait for so many years now. The yield of both fisheries accounted for more than 40% of the total marine catch in the entire province. Although the number of light-seiners has been decreasing recently, the yield of light-seine fishery has remained relatively smooth and steady; this is also despite the decrease in bottom fish resources in the Taiwan Strait. On the basis of the environmental characteristics of the fishing grounds and the status of fish resources, seizing the correct developing direction have become the key to develop the marine capture fisheries in the Strait steadily and continuously. The light-seiners of the Fujian Province fishing in the Taiwan Strait were taken as an example. As the impact of the operating characteristics of light-seiners on the fish stocks and on the geologic environment were analyzed, the maximum sustained yield and optimum fishing efforts were also calculated. Some suggestions on how to get better economic results by developing light-seine in the Taiwan Strait were also presented.

Materials and Methods

Data sources

Production data on capture fisheries in the Fujian Province from 1986 to 1996 were taken from the annual fisheries statistics in Fujian Province. Data on the commercial yield and fishing effort were collected from 50 sample trawlers and 50 sample light-seine fishers in the Taiwan Strait. The ranges of installed main engine power are 136-441 kw for trawlers and 136-316 kw for light-seiners. Materials about the upwelling regions were taken from the results of the “Minnan-Taiwan Bank Fishing Ground Upwelling Ecosystem Study” undertaken through the cooperative efforts of the Xiamen University, Fujian Fisheries Research Institute and Fujian Institute of Oceanology in 1991 (Huasheng et al. 1991).

Methods

Mathematical and statistical methods were used to analyze the present production situation. The relationship between the environmental characteristics of fishing grounds was analyzed based on ecological theory (Huasheng et al.1991). The fish stocks size and catchable yield in the Taiwan Strait were assessed using Schaefer and Fox models based on data gathered from several investigations (Tianyuan 1997). The maximum steady and optimum fishing effort of light-seine fishery was assessed using Schaefer and Fox models (Zhengbin et al. 1998). The optimum fishing effort of both sampling vessels was also obtained through the correlative cure between the CPUE and fishing effort (Chinlou et al. 1986).

Results and Discussion

Production analysis

Since the 1980s, the yield of marine capture fisheries in the Fujian Province has been rising yearly, from 548 thousand tonnes in 1986 to 1737.7 thousand tonnes in 1996, with 12% annual increment. During this period, the fishing efforts exerted into operation in this Strait also increased each year. The number of marine fishing motor boats also increased from 30,032 in 1986 to 42,203 in 1996, with an annual increment of 3.4%. The engine power installed in fishing motor boats likewise increased from 597.2 thousand kw in 1986 to 1461.8 thousand kw in 1996, the increment rate per year is 9.4%. The gross tonnage increased from 316 thousand tonnes to 537 thousand tonnes within ten years, with an annual increment rate of 5.4%. During this period, the engine power of light-seiners fishing in this Strait decreased from 36,363 kw to 28,487 kw, with an annual decrement rate of 2.47%. However, the yield increased from 75.9 thousand tonnes to 88.3 thousand tonnes, with an increment rate of 1.5%. The details are shown in Table 1.

It can be seen that the pressure on the fish stocks in the Taiwan Strait has increased each year, with a corresponding increase in fishing efforts in this Strait. According to investigations conducted (Gangchuan et al. 1991), the catch component and construction in the Taiwan Strait have changed with the annual change in fishing efforts. The general changing tendency is that the fish species is changing from higher qualitative levels to lower qualitative levels; from middle and large population to middle and small population. The dominant degree of the dominant fish species is from higher to lower. The replacement of main species is obvious. Furthermore, the ecological target of fish species composition is becoming simplified, miniaturized, low-aged and matures early. All the phenomena show that the fish resources in the Taiwan Strait have been suffering serious destruction. Therefore, the rational distribution and utilization of fish resources have become the keys to develop sound capture fisheries in the Strait.

From Table 1, it can also be seen that the proportion of installed power and yield of light-seine fishery to those of the total marine capture fisheries decreased each year. The proportion of installed power was reduced from 6% in 1986 to 1.9% in 1996 and the proportion of yield decreased from 13.9% in 1986 to 5.1% in 1996.

The main reasons are that since the operation of light-seine needs newer technology and operation of the seiner requires extensive labor, some light-seiners could not get better fishing results. Furthermore, the economic value of the pelagic fish is lower and the economic results of light-seine fishery is not significant compared with other types of fishery. Fishers therefore hesitate to invest on light seine fishery.

Table 1. The yield and fishing effort of marine capture fishery and light-seine fishery in the Fujian Province (1986-1996).

Year	Marine capture fishery			Light-seine	
	Gross tonnage (tonnes)	Marine engine power (kw)	Yield (tonnes)	Main engine power (kw)	Yield (tonnes)
1986	316052	597218	548125	36363	75997
1987	327901	667161	684354	45462	132739
1988	352692	718110	696276	51734	98681
1989	382493	756582	774817	50327	102118
1990	404351	842396	829691	45323	76397
1991	433031	909191	947769	43017	85827
1992	455662	1065807	1042233	33322	80522
1993	442092	1089103	1222432	28415	93300
1994	463160	1184963	1443566	27318	82276
1995	521808	1403894	1619996	27505	81922
1996	537367	1461791	1737682	28486	88344

Analyses of characteristics of the fishing grounds and pelagic fish stocks

Based on investigations conducted (Huasheng et al. 1991), there are many upwelling regions in the Taiwan Strait as it has a distinctive natural topography and it is influenced by seasonal wind and tide. The upwelling may bring water with high extents of nutrients from the subsurface into the surface layer. It therefore provides vast amounts of nutrients and organisms, which help plankton to flourish abundantly. At the same time, since the role of its driving force may adjust or alter the pattern of hydrology distributions and provide suitable hydrological conditions in the fishing ground, a better environment could be created for fish to feed, spawn school and concentrate, and hence form a central fishing ground. There are abundant fish resources, especially pelagic fish, such as *Decapterus maruadsi* and *Pneumatophorus japonicus*, in the Taiwan Strait. The pelagic fish belongs to a selective life history, with shorter life cycle, quicker generation replacement, rapid growth, earlier sexual maturity and faster resources recovery. According to the assessment of several investigations on fish resources in the Taiwan Strait (Tianyuan 1997), the pelagic fish stocks in this Strait (including both ends) are about 640 thousand tonnes with a catchable yield of 330 thousand tonnes while the demersal fish stocks are 435 thousand tonnes with a catchable yield of 175 thousand tonnes. In the demersal fish stocks, the maximum continuous yield of hairtail is 50-60 thousand tonnes, with a total allowable catch of 40-50 thousand tonnes. The stocks of crustaceans are 98 thousand tonnes, and its catchable yield is 120 thousand tonnes. The stocks of cephalopoda are 98 thousand tonnes with a catchable yield 35 thousand tonnes. Details are shown in Table 2.

Impact of operational characteristics of light-seine on fish stocks and geologic environment

In the practice of light-seine fishery, the pelagic fish are attracted by light to concentrate, then the seine net is cast into the water. When the concentrated fish are surrounded by the seine net, a line is pursed. The ground rope sinks and moves the boat forward while restricted by the pursing force. Its movement track is like a suspended curve. The pressure exerted by the ground rope on the sea bottom is light and the length of time that the ground rope stays on the sea bottom is relatively short (about 8 minutes according to the usual practice of light-seine) (Xiansheng et al. 1997). Its impact on the geologic environment is therefore relatively light. Except for *Etrumeub micropus*,

Table 2. The state of fish utilization and potentialities (1000 tonnes).

Fish species	Stocks	Catchable	Catch
Pelagic fish	640	330	303.9
Demersal fish	435	175	199.0
Hairtails	50-60	40-50	93.2
Crustacean	98	120	94.7
Cephalopoda	98	35	99.4

other pelagic fishes are usually not attracted to light during their reproductive season (Gangchuan et al. 1991). Since the light-seine generally does not catch the reproductive individuals, it gives the pelagic fish the opportunity to reproduce. Furthermore, the selectivity of light-seine to fish is another advantage, which means that it seldom harms young fish. Obviously, light-seine is one of those scientific and efficient methods of catching pelagic fish.

Maximum steady yield and optimum fishing efforts of light seine

Based on the fishing efforts (the standardized fishing efforts) and yield of light seine fishers in the Fujian and Kwangchow Provinces fishing in the Taiwan Strait during the period 1971-1994, maximum steady yield can be obtained using the Schaefer and Fox models (Zhengbin et al. 1998). The equations for calculating maximum steady yield and optimum fishing effort of light-seine fishery are:

Schaefer model:

$y_e = 3.0679\ f_e - 2.3268 \times 10^{-5}\ f_e^{\ 2}$

$(n = 22,\ F = 9.103 > F_{0.01} = 7.95)$

Fox model:

$y_e = 3.4938\ f_e\ e^{-0.00001308f}$

$(n = 22,\ F = 8.44 > F_{0.01} = 7.95)$

where y_e, is catch and f_e is fishing effort under equilibrium state. The regression curve of the relation between equilibrium yield and CPUE is shown in Figure 1. The results indicated that MSY (maximum steady yield) for light-seine in the Taiwan Strait is 98,231~103,273 tonnes and the optimum fishing effort (f_{msy}) is 65,925-76,453 kw. Since the actual yield and fishing effort put in the Strait from 1986 to 1996 were lower than the calculated value of MSY and $f_{msy,}$ the development of light seine fishery has high potentials.

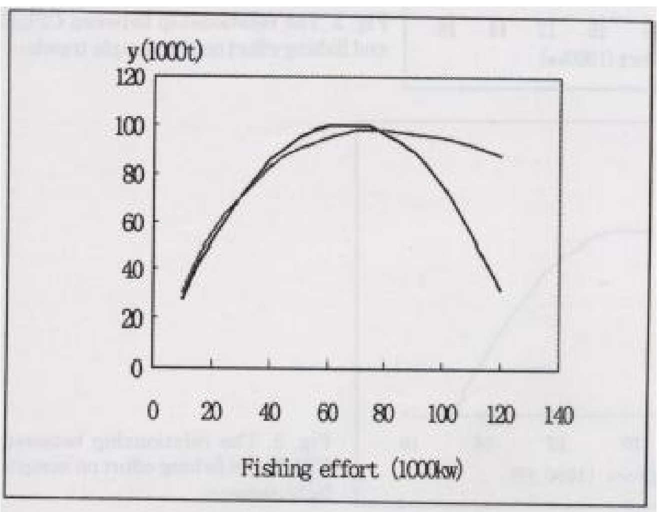

Fig. 1. The relationship between equilibrium yield and CPUE on light seine fishery.

Analysis of optimum fishing effort

Based on the sampling data listed in Table 3, a growing tendency of CPUE can be developed through the least squares method. The long term tendency of CPUE is:

Trawl fishery:

$CPUE = 0.773 + 0.404f - 0.0253f^2$

$(R = 0.85,\ n = 11,\ F = 5.7 > F_{0.05} = 5.12)$

Light-seine fishery:

$CPUE = -3.26 + 0.1.206f - 0.0605f^2$

$(R = 0.88,\ n = 11,\ F = 24.6 > F_{0.01} = 7.6)$

where CPUE is catch per unit of effort, and f is fishing effort with unit of 1000 kw. All these correlation coefficients are obviously different to zero, which indicates that the power of engines is one of the main factors affecting CPUE. The CPUE of trawl fishery decreases each year, but that of light-seine fishery remains relatively smooth and steady. Although the increment rates per year of installed engine power on trawlers and on light-seiners are similar (8.6% for trawlers and 10.8% for light-seiners), the CPUE of the trawl fishery decreased a lot compared to that of the light-seine fishery,

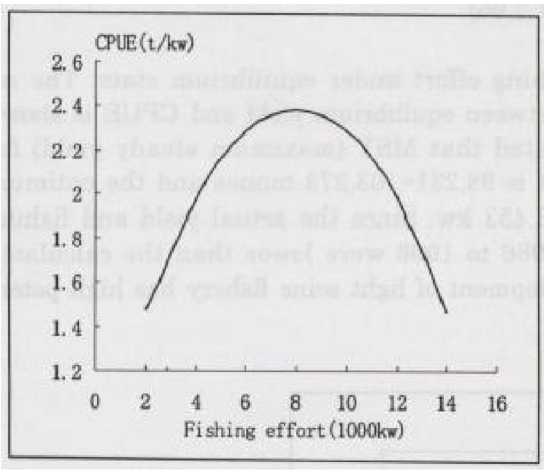

Fig. 2. The relationship between CPUE and fishing effort on the sample trawlers.

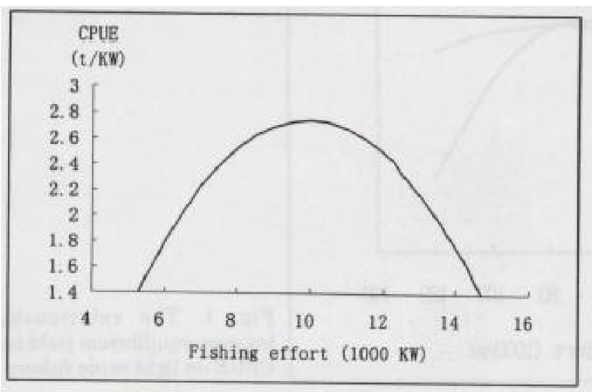

Fig. 3. The relationship between CPUE and fishing effort on sample light-seiners.

Table 3. The fishing effort and catch per unit of effort on sample trawlers and light-seiners (1986-1996).

Year	Trawlers		Light-seiners	
	Marine engine (kw)	CPUE (t/kw)	Marine engine (kw)	CPUE (t/kw)
1986	8254	2.39	7250	2.32
1987	9717	2.75	8010	2.50
1988	10569	2.42	8200	2.72
1989	8813	2.07	9850	2.92
1990	13550	1.60	10500	2.62
1991	11031	1.84	11586	2.45
1992	12501	1.75	12113	2.10
1993	12750	1.67	13258	2.15
1994	13605	1.62	13124	2.22
1995	13701	1.60	13151	2.30
1996	14050	1.55	13254	2.25

which shows that light-seine fishery in the Taiwan Strait has a better developing future as compared with trawl fishery.

The regression curve of light-seine fishery and trawl fishery first rising then falling with increasing fishing efforts are parabola-like (Figs. 2 and 3), which indicates that if other factors are not taken into consideration, the highest fishing efficiency power of sampling vessels will be maintained at 9,967 kw for light-seiners and 7,984 kw for trawlers. This also indicates that the development of light-seine fishery has better potentials than that of trawl fishery. However, since the CPUE of both fisheries in 1996 was under the highest point of the regression curves, fishing efforts should not just be increased without concrete basis that it can get better economic results.

Conclusion

1. There are many upwelling regions in the Taiwan Strait. Large quantities of plankton reproduce in these upwelling areas and the hydrological conditions there are stable, which is favorable for pelagic fish to concentrate. According to the assessment of several investigations, pelagic fish in the Taiwan Strait, such as *Decapterus maruadsi* and *Pneumatophorus japonicu*s, are abundant, which therefore have some potentialities to be developed.

2. The operating methods of light-seine fishery does not cause severe damage to the marine geologic environment and therefore harms young fish stocks on a minimal level. The pelagic fish stocks recover quickly, and the reproductive individuals of *Decapterus maruadsi* and *Pneumatophorus japonicu*s are generally not caught by light-seine. Light-seine fishery is therefore one of the scientific and efficient methods of catching pelagic fish.

3. From the calculations of CPUE, the fishing efforts of both fisheries in the Strait could not obtain the desired maximum economic yield. This is

mainly related to the economic value of pelagic fish and the operating technology of light-seine fishery. Therefore, if light-seine is to be developed continuously, the technique of pelagic fishing must first be further developed to promote the market price of the species fish as well as improve the fishing equipment and technology to increase the fishing results.

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