Studies on the Coastal Fisheries Resources in Sendai Bay and Adjacent Waters-I Small Trawl Nets Resources

Tsuyoshi KAWASAKI*

(Received May 31, 1976)

In order to prepare materials for a re-evaluation of the coastal fisheries, the present state of the living resources taken by small trawl nets in Sendai Bay and adjacent waters was studied. Using the statistical data of catch and effort during 1957-1973, the following results were obtained.

1) Within less than two decades the fishing efforts of the small trawl nets in Sendai Bay have increased by 6-7 times.

2) The density of the total stock as the object of the small trawl nets in Sendai Bay shows a general tendency toward decline.

The stock levels of flounder and plaice, the commercially most important fishes in Sendai Bay, have greatly diminished since about 1965, falling into the overfished states.

4) The fluctuation in catch and CPUE of Pacific cod and Alaska pollack well reflects the fluctuation in their stocks.

Recently the necessity for the "re-evaluation of coastal fisheries" has been widely discussed, in connection with the Third United Nations Conference on the Law of the Sea. But the actual state of the living resources as the object of the coastal fisheries is rather less known than those taken by the far seas and offshore fisheries, due to the insufficiency of basic data to be analysed and the complexity of the fisheries structures.

Our laboratory is on the way to work on the present conditions of the resources of the coastal fisheries, *i.e.*, small trawl nets, gill nets, angling and longline, in Sendai Bay and adjacent waters as a model area. A general view on the existing state of the small trawl nets resources is presented in this paper as the first trial.

Sendai Bay is opened to southeast and the continental shelf is well developed there. Sendai Bay is utilized as the fishing grounds by the fishing vessels of Miyagi and Fukushima Prefs., the former operate in the offing of Haragama to Kinkasan Island and the latter between Hirakata and Yuriage. The major fishing ground is the area shallower than 100 m deep but a part of vessels of 10-15 tons operate in the deeper area and the number of them has been increasing recently.

Materials

Data used are from Miyagi Pref.'s Statistical Yearbook of Agriculture, Forestry and Fisheries, 1957-1973, and Fukushima Pref.'s Statistical Yearbook of Agriculture, Forestry and Fisheries, 1959-1973. Catch and days at sea by tonnage, 0-3, 3-5, 5-10 and 10-15 and catch by species of the small trawl nets are described in these books.

* Faculty of Agriculture, Tohoku University, Sendai 980.

Results

Change in fishing efforts Days at sea were used as fishing effort but they have to be standardized between tonnage strata and between years. Firstly, the author calculated catch per day at sea for each year and each tonnage stratum of each pref., which was averaged throughout the years. The ratios between these averages for each tonnage stratum were assigned to the unit of effort for each tonnage stratum. These values are shown in Table 1.

Secondly, the author made standardization of fishing effort between years. In case of trawlers hauling power is mostly affected by horsepower of the main engine. The horsepower were examined from the registers of the licensed vessels. The mean values

Table 1. Catch per day at sea in kg and unit of effort for each tonnage stratum for each prefecture

Tonnage stratum		0-3	3-5	5-10	10-15
Prefecture					
Miyagi	Catch per day	58	100	204	551
	Unit of effort	0.6	1.0	2.0	5.5
Fukushima	Catch per day	102	146	210	689
	Unit of effort	1.0	1.5	2.1	6.9

Table 2. Average horsepower of small trawler's main engine by prefecture, by year and by tonnage stratum.

Parentheses show the case in which data was not available. Values in parentheses for 1962 and 1963 are interpolated and those for 1959 are substituted by those for 1960

Prefecture	Miyagi				Fukushima			
Tonnage	0-3	3-5	5-10	10-15	0-3	3-5	5-10	10-15
Year								
1957	12.1	14.6	24.7	45.4				
1958	15.2	14.7	24.4	47.2				
1959	14.3	15.5	24.6	50.1	(8.2)	(18.4)	34.0	60.9
1960	16.5	15.8	25.6	52.4	8.2	18.4	34.5	60.0
1961	16.5	17.1	26.1	54.4	7.6	16.3	34.3	62.6
1962	16.5	17.7	25.8	53.9	(7.5)	(23.9)	(39.6)	(64.9)
1963	16.5	18.8	25.9	56.8	(7.5)	(31.5)	45.0	67.3
1964	16.5	19.9	25.4	59.3	7.5	39.0	60.9	83.7
1965	16.5	21.0	28.1	62.7	10.0	40.0	55.0	88.9
1966	16.5	20.8	29.9	65.2		38.0	54.4	92.2
1967	16.5	19.2	29.5	66.6		36.5	50.4	92.3
1968	16.5	19.2	30.8	74.4		36.9	50.7	95.2
1969	16.5	19.2	32.9	76.3		35.0	53.2	95.4
1970	16.5	19.2	36.0	78.1		35.0	56.7	101.2
1971	16.5	19.2	35.7	80.3		31.9	56.4	102.9
1972	16.5	19.2	35.7	80.3		35.8	55.7	102.8
1973	16.0	29.8	37.8	79.9		38.3	54.7	104.7

Fig. 1. Year-to-year change in total effort for Miyagi (MG) and Fukushima (FS) Prefs.

Fig. 2. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for total catch in Miyagi Pref. Numerals show years.

of the horsepower for each tonnage stratum of each year are shown in Table 2. As a rule the horsepower have considerably increased year by year.

The unit of effort in a given year was corrected by the ratio of the horsepower of the year to that of the standard year, taking 1965 and 1966 as the standard year in Miyagi and Fukushima Prefs., respectively, on the assumption that the fishing efficiency is in proportion to the horsepower. The unit of effort for each tonnage stratum of each year thus obtained was multiplied by days at sea and the corrected days at sea were summed up through the entire tonnage strata, thus giving the every year's total effort.

In Fig. 1, the year-to-year changes in total effort are shown for the vessels of Miyagi and Fukushima Prefs., indicating 6-7 times increase through this period in both the two prefs.

Fig. 3. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for total catch in Fukushima Pref. Numerals show years.

Fluctuation in stock For the examination on the fluctuation in stock two kinds of relation, the relation between fishing effort and catch and the relation between effort and CPUE, were used. Fig. 2 is for the total catch in Miyagi Pref. and although catch increases with the increase in effort, CPUE is constant as a whole. In case of Fukushima Pref. (Fig. 3), in contrast with the increase in catch with effort, CPUE decreases largely. Unchangeableness in Miyagi Pref.'s CPUE is contributed by the recent heavy increase in the catch of Alaska pollack, *Theragra chalcogramma*, as will be seen later. As seen so far, it can be said that the density of the total stock is constant or declining in this area.

There are two species groups, each of which exhibits the specific type of fluctuation

in stock different with one another. The first group includes the commercially important fishes of *Pleuronectina*, flounder, *Paralichthys olivaceus*, and plaices (ishigarei, *Kareius bicoloratus*, makogarei, *Limanda yokohamae*, and magarei, *L. herzensteini*), small in migration, shallow in distribution and narrow in natural fluctuation in recruitment,

Fig. 4. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for flounder in Miyagi Pref. Numerals show years.

Fig. 5. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for flounder in Fukushima Pref. Numerals show years.

Fig. 6. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for plaices in Miyagi Pref. Numerals show years.

Fig. 7. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for plaices in Fukushima Pref. Numerals show years.

the entire range of which are covered with fisheries. In the initial step of exploitation of these resources, the increase in catch and the decrease in CPUE (density or population size) proceed according as the effort increases. When the effort increases further, the increase in catch stops and next it begins to decrease, in contrast with the continuous decrease in CPUE. Such situation is called overfishing.

Fluctuation in stocks of flounder and plaices in Sendai Bay has revealed the typical process above mentioned. Namely, the flounder in Miyagi and Fukushima Prefs. have fallen in a complete overfished state after the peak at 1961–1964 and 1969, respectively. (Figs. 4 and 5) Similarly, the stock of the plaices has decreased with the peak at 1968 in Miyagi Pref. and 1964 in Fukushima Pref. (Figs. 6 and 7)

CPUE of octopuses, *Octopus vulgaris* and *Paroctopus dofeni dofeni*, have declined in Fukushima Pref. despite the increase in catch, showing the effect of fishing.

The fluctuation in the stocks of the second group is supposed to be reflected by that in catch. In this case, the fluctuation in catch corresponds well to the fluctuation in CPUE. The most typical example is Pacific cod, *Gadus macrocephalus*, and both catch and CPUE were high for 1960–1967 in Miyagi Pref. and 1963–1966 in Fukushima Pref. (Figs. 8 and 9) The increase in catch and CPUE of Alaska pollack has become conspicuous after 1964 (especially after 1971) in Miyagi Pref., the fishing ground of which is situated in the southernmost area of their range. (Fig. 10) As seen in Fig. 11 the correlation between catch and CPUE of Alaska pollack is very high, indicating co-variation in catch

Fig. 8. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for Pacific cod in Miyagi Pref. Numerals show years.

Fig. 9. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for Pacific cod in Fukushima Pref. Numerals show years.

Fig. 10. Relation between catch in tons and effort in corrected days at sea (solid line) and relation between CPUE and effort (broken line) for Alaska pollack in Miyagi Pref. Numerals show years.

Fig. 11. Correlation between catch in tons and CPUE for Alaska pollack in Miyagi Pref. Numerals show years.

and stock.

The fluctuations in catch and CPUE of rockfish, *Sebastolobus macrochir*, squid, *Doryteuthis bleekeri*, and crabs are also supposed to reflect the natural fluctuations in their abundance in the fishing ground or their population.

Discussion

OKIZAKI and KOMATSU¹⁾ worked on the flounder and the plaices in Sendai Bay using the 1956–1965 data of small trawl nets in Fukushima Pref., concluding that for the makogarei and the flounder “the increase in fishing effort thereafter is allowable” and for the ishigarei “it is feared that this species will be overfished and the lessening of efforts is desirable.” KUROGANE²⁾ made “diagnosis on stock” by the BEVERTON-HOLT’s isopleth yield curve from the 1965–1971 data of small trawl nets, gill nets and longline in Fukushima Pref. He pointed out that “further intensification of fishing would result in not only the decrease in CPUE but also the decrease in catch.” By the present study it becomes clear that the resources of the flounder and the plaices in Sendai Bay got into the overfished state since about 1965. When we consider only the small trawl nets fishery, lowering of the fishing intensity to half of the present level is recommended.

According to SURVEY AND RESEARCH DIVISION OF FISHERIES AGENCY³⁾, although the Pacific cod are scarcely distributed around 1955 along the coast of Iwate Pref. to south Aomori Pref., their population size became large since about 1960 and the spawners began to appear in the coastal region. Next, according to FISHERIES RESOURCES INVESTIGATIONS

BY THE SCIENTISTS OF THE FISHERIES AGENCY⁴⁾, the level of these adult fish have depleted to 1/2-1/3 after 1968 and their larvae have been scarcely found since 1970. As the stock of Pacific cod along the Pacific coast of Honshu is supposed to be consisted of one subpopulation, the fluctuation in catch of Pacific cod taken by the small trawl nets in Sendai Bay well reflects the fluctuation in stock mentioned above.

From Funka Bay to the coastal area off Sanriku District, there exists a subpopulation of Alaska pollack called "B-type Group" or "Esan-origin medium-sized Group", which began to increase after 1961 in the waters off Sanriku and has reached a very high population level recently. The increase in catch of this species in Sendai Bay well reflects such situation of stock.

Acknowledgement

The author expresses his sincere thanks to Tohoku Bureau of Agricultural Policy, Miyagi and Fukushima Prefectural Governments and Fukushima Fisheries Experimental Station for their help in preparing data.

References

- 1) K. OKIZAKI and A. KOMATSU: in "Data on Improvement of Coastal Fisheries Structure", Fukushima Prefecture, 1967, pp. 35-52.
- 2) K. KUROGANE: Mimeograph, 1972.
- 3) SURVEY AND RESERCH DIVISION OF FISHERIES AGENCY: Major Fisheries Resources around Japan, 1967, pp. 1-189.
- 4) FISHERIES RESOURCES INVESTIGATIONS BY THE SCIENTISTS OF THE FISHERIES AGENCY: Report of Fisheries Resources Investigations by the Scientists of the Fisheries Agency, Japanese Government, 14, 99-102 (1973).