ON EXPERIMENTAL TAGGING OF DEMERSAL FISHES IN THE EAST CHINA AND THE YELLOW SEAS

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ABSTRACT

The paper deals with the history of the tagging experiments in these waters, types of tags used, and results obtained, summarizing recent experiments on tagging the demersal fishes in the East China Sea and the Yellow Sea. The experiments were made to survey the demersal fish stocks in these waters. The main purposes of the experiments are (1) to study the migration of the fish, (2) to investigate the growth rate and (3) to estimate the fishing mortality and stock size.

HISTORY OF THE TAGGING EXPERIMENTS IN THE EAST CHINA SEA AND THE YELLOW SEA

In the pre-war days, tagging experiments on the various demersal fishes in these waters were made, with no fishes recovered. After the war, although tagging experiments were carried out frequently by research vessels up to 1964, they proved unsuccessful excepting for a few recoveries (Table I).

The main reasons for the failures are that the research vessels were otter trawlers, the duration of towing was long, about 3-4 hours and unsatisfactory for securing large numbers of living fish.

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Through the experiences of these surveys, it is presumed that if large numbers of tagged fishes were released, more successful results must be obtained with some species, such as sea bream, *Pagrus major*, conger pike eel, *Muraenesox cinereus* and Korai shrimp, *Penaeus orientalis*, which were in good condition when taken out from the cod-end. Accordingly, a commercial bull trawler was used, the duration of towing the net being about 2.5 hours and hence the securing of living fish was easier than from an otter trawler. In 1963, 2,855 sea bream caught by bull trawlers were released at the offshore waters in Haichow Bay. The tags used in this test were strap brass tags. Contrary to expectations, only 13 recoveries were made, the recovery rate being 0.5 per cent. The scarcity of recoveries was due to (1) the frequent loss of tags from the fish, and (2) the difficulty of recovery by fishermen or fish dealers on account of the smallness of the disk and the similarity of the colour of the tag to that of the fish body, and (3) lack of general notification to the trawl fishermen and to the fish dealers. In spite of the poor results of this experiment, it was nevertheless confirmed that large numbers of living fish are obtainable by the use of the commercial bull trawlers, and that the some other aspects of the experiment could be improved.

In November, 1964, 13,342 sea bream caught by commercial bull trawler were tagged and released successfully in the offshore waters of Haichow Bay, using the Petersen disc tag made of the combination of red and yellow discs, which were more easily visible (Fig. 1). At the same time, 302 conger pike eel were also tagged and released. During the period from the release until June of the next year, 1,634 recoveries (12.2 per cent) were made. Since then 3,000 to 10,000 individuals of the three species mentioned above have been tagged and released annually in these waters. From 6 to 10 per cent have been recaptured.

On the other hand, much difficulty was experienced in the tagging experiments on yellow croaker, *Pseudosciaena polyactis* and hair tail, *Trichiurus lepturus*, the most valuable fishes in these seas. Yellow croaker caught by trawlers from the deep sea cannot adjust themselves to the rapid changes of water pressure, when they are brought up to the surface, and most of them have enlarged air-bladders and inverted stomachs. Moreover, their scales are easily removed by the jostling of each other in the cod-end.

In July 1961, the first test on yellow croaker was made, using a research vessel and commercial bull trawler, but no fish were recaptured. The experiment was conducted as follows: At first, the living fish caught by commercial bull trawler were transferred into holding cages made of twine net (2 meter cube) or canvas (1.3 meter cube) fixed in bamboo-frames. The fish were then transferred from the bull trawler to the research vessel, and thence into water tanks of canvas with steel frames on the deck, 108 yellow croaker which were swimming normally were tagged with arrow-shaped tags, and released.

The other yellow croaker which could not swim normally, for example, turning their abdomen upwards and drifting the surface owing to the expansion of the air-bladder, were put into a wire netting hanging cage (0.6 x 0.6 x 1, in cubic meter) for release at the sea bottom. Then, three different tests were made, that is, (1) after the hanging cage was sunk slowly to the sea bottom, the side shutter was opened and fish were released, this test being

repeated twice, (2) the hanging cage was sunk slowly to the sea bottom, and allowed to remain there for about 10 minutes to allow the fish to be restored to the normal physical condition, it was then, pulled up to the surface again, and fish released; this being repeated 6 times, (3) combined tests of (1) and (2) were made 6 times (Table II). The total number of fish used in these tests was 180, and of these, 36 individuals were released at the bottom and 46 at the surface. The remainder were withdrawn from the cage because they were in bad physical condition. In order to check whether the 36 individuals in test (1) were released effectively or not, 25 dead fish were put in a cage and lowered to the bottom using the same technique as (1). Of these, 11 individuals (44 per cent) were discharged from the cage by current. Therefore, it is not clear whether the 36 individuals could escape from the cage by themselves or they were discharged outside the cage by the current flow. However, as the 46 individuals released at the surface escape from the cage themselves, the effectiveness of the hanging cage seemed to be confirmed to some extent.

The second survey was made in July 1966 by the use of commercial bull trawler, and at this time, the releasing of the group in which the stomachs were seldom inverted because of the shallowness of the fishing grounds was tried. It was possible to successfully release 7,321 yellow croaker marked with Petersen disc tags.

At first, a hanging net-cage (Fig. 2), of which the lower end opened was used. However, as the majority of the fish escaped vigorously towards the sea bottom, it was not used again.

The result of this experiment was also unsatisfactory, only five tagged fish were recovered including one which was recaptured about 7 hours after release. The author summarizes the reasons of this failure as follows: i.e., (1) Shock due to the temperature gradient between surface and bottom waters, (2) Shock due to a sudden change of the water pressure in the hauling, (3) Shock due to the removal of scales, (4) Shock due to the tagging operation, (5) Shock due to the operation of extracting gas from the air-bladder by using a injection-needle (in this experiment, many of the yellow croaker caught by trawler had more or less expanded air-bladders, and were subjected to this operation), etc.

It is considered that further experiments on this species are essential because it is the most economically important fish in these seas. A new experiment on this fish is now being designed, in which the tagging will be made in winter season, when the vertical mixing of the waters by conversion takes place, and the shock due to the temperature gradient between surface and bottom waters will be avoided.

Finally, in the case of the hair tail, the fish is much more active than other fishes mentioned above and hence liable to injury in the cod end. Specimens caught by hand-line-angling have therefore been used. From 1961 to 1964, 270 hair tail were released for only one recovery. This fish however, travelled 195 miles in nine days. If the number of releases could be increased up to the order of thousands, a good result might be expected.

The recent results of tagging experiments, made during the period from 1964 to 1967, for the species mentioned above are summarized in Table III.

TYPES OF TAGS USED IN THE SURVEY

(1) Strap brass-tag: This tag was used for the conger pike eel in 1952 and was also used for the sea bream in 1963. Although it is easy to handle, there are some difficulties due to the loss rate of tags and the rate of recovery.

(2) Arrow-shaped tag: This one was used in 1961 for the yellow croaker. There are some difficulties due to the loss rate of tags, recovery rate and injury of the fish body due to the tagging operation.

(3) Atkins type tag: In the early days, a white celluloid disc (7 mm diameter) tied with silver wire was used for the conger pike eel, shark and Korai shrimps, etc. It was subsequently changed for the red celluloid disc (13 mm diameter) tied with a vinyl-tube. The latter one has some disadvantages; (a) it is not easy to pass the vinyl-tube through the body of fish and (b) the tube is somewhat difficult to tie.

(4) Petersen disc tag: In the early stage, the stainless steelpin passed through the two 7 mm discs was used. However, the operation is very trouble-some because it takes much more time, and in addition the cost is high. So, in consideration of these points, needles made of copper wire coated with resin containing formalin were substituted, the needles used for the conger pike eel and the sea bream being respectively, 1.0 mm diameter and 0.9 mm diameter.

Celluloid discs with a hole in the center, with return-address on one side and a number on the other were used, the discs being 13 mm diameter for the conger pike eel and 10 mm diameter for the sea bream, and colours of the discs were combinations of red and yellow or red and white. This new tag could be generally recognized more easily by the contrast of the two different colours and was hard to detach from the fish.

RESULTS OBTAINED UP TO THE PRESENT

(1) Sea bream:

In the previous studies on the geographical distribution and migration of the present fish in the East China Sea and the Yellow Sea, it is said that the main group appears at the fishing grounds from Haichow Bay and Pohai in autumn, and then migrate towards the southwestern waters off Cheju Island to winter. In the spring, they return to the spawning grounds, such as Haichow Bay and Pohai. The information was obtained from the analysis of the seasonal changes in the geographical patterns derived from catch per haul data which was computed from the catch-effort statistics.

The results of the tagging experiments definitely confirmed these previous studies, i.e., the sea bream which were released at the area off Haichow Bay in October or November, moved in various directions within 30 days after the release, but thereafter, most of them migrated east or south-east towards the south-western waters off Cheju Island, and wintered there, then in the spring they dispersed and moved back to the coastal waters of the Chinese Mainland (Fig. 3).

The recoveries indicated that a portion of this wintering population moved up to the west and south coast of the Korean Peninsula. Recent recoveries in the area off Barren Islands suggest that the Yellow Sea Group and the Southern East China Sea Group may be regarded as one population for the whole area of these seas. However, this is not conclusive.

The speed of the movement per days tended to increase at first and the maximum (5 miles) was noted after about 20 days after the release, then gradually decreased as the wintering grounds were approached.

Applying the Petersen's method, the population size of the sea bream in the Yellow Sea was estimated based on the tagging experiment made in November 1964 and the catch and effort statistics from September 1964 to August 1965. The present fish stocks in the Yellow Sea in the middle of November 1964 were estimated at 78.2 million individuals, and the rate of exploitation per year, from November 1964 to August 1965, was calculated at 0.25.

Also, the monthly changes in the composition of the body length data of the recovered fish definitely established the growth rate of this fish, and confirmed the accuracy of the age determination by the use of scales.

(2) Conger pike eel:

Using the monthly distribution of indices of population size by the longitudinal and latitudinal blocks and monthly distributions of catch per haul of this fish, the author found three migratory groups, namely, the group in the southern part of the East China Sea and another group in the middle part of the same sea, and the third group in the Yellow Sea and Pohai. The first group has a considerable range from the northern area of Taiwan to the northern part of the East China Sea and the southern part of the Yellow Sea. The second group is distributed between the south-western area off Cheju Island and the Barren Sea Area. The third group migrate between the south-western area off Cheju Island and Haichow Bay and Pohai.

As a result of tagging experiments with this fish in the area off Haichow Bay in Autumn (October or November), it was found that a proportion of the tagged fish moved towards the south-western area off Cheju Island, and another group moved towards the Barren Sea Area to the northern area off Taiwan in 6 months after the release. Then, in the next autumn they were recovered at the area of release.

The tagged fish released at the northern area of Taiwan in May stayed there for two months after the release. Thereafter, most of the fish moved to the north along the shore of Chinese Mainland, and reached the area off Haichow Bay in November, while a proportion of the tagged fish moved towards the southern area off Cheju Island from autumn to winter. They gradually moved back towards the original area of release from March to June.

Results mentioned above coincided with the earlier view concerning the migration of this fish. However, the accumulation of more recoveries will be necessary to identify the population.

Based on the analysis of monthly changes in the apparent straight-line-distance which they moved, the travelling distance of tagged fish released in the area off Haichow Bay in autumn gradually increased and showed maximum value (400-500 miles), in 6 months. This means that they migrate to the farthest area in the next spring.

In the other case, for those released in the northern area off Taiwan there was scarcely any migration during the first 50-60 days. Thereafter, one could not estimate their movements because of non-recovery till 140 days later. Recoveries after 140-190 days showed a maximum of 300-400 miles. Then the movements gradually decreased. This maximum time corresponds to the period from September to November, when they reach to the area off Haichow Bay.

The speed of the movement per day of the conger pike eel released offshore Haichow Bay tends to show more than 10 miles, which is the maximum, and the average was about 8 miles for the first 10 days, and in the next 10 days, it decreased to 2-4 miles. Thereafter, it increased again to 4-6 miles at one time, then gradually decreased to about 2 miles after 3 months.

While the speed of the movement per day of fish released in the northern area off Taiwan also tended to show the maximum (more than 10 miles) and the average was about 7 miles for the first 10 days, and it decreased quickly and kept about 1 mile. After about 5 months it showed 2 miles.

As described above, the speed of the movement per day of the conger pike eel is always fast immediately after release, regardless of the area and time of release, so it seems that this is a peculiar physicological reaction of this fish to tagging.

It cannot be definitely stated whether the reaction is one of escaping from the shock of the tagging operation or whether it is a natural one for the purpose of searching for a new shoal which they might join, or it may be both.

Besides, there are no differences in these reactions with sex or the body length.

The monthly increment in body length of the conger pike eels recovered coincided with Walford's growth transformation curve based on age determination by the use of the otolith.

(3) Korai shrimp:

By the analysis of the statistics, 2 migratory groups have been recognized; one, the so-called "Pohai Group", have their spawning and nursery grounds in Pohai, and during the latter 10 days of November, move down the Yellow Sea along the Shantung Peninsula, thereafter, they move towards the western waters off Cheju Island for wintering, and in spring, move back to Pohai Bay. The other group, the so-called "Korean Group", have their spawning grounds and nursery grounds in the west coast of Korea, whence they move off-shore and mix with the Pohai group, and in spring, move back to the west coast of Korea.

Tagging experiments were made twice a year, in December at the southern area of Shantung Peninsula, and in the next January at the central part of the Yellow Sea.

The tagged shrimp released in December gradually moved towards the western area off Cheju Island for wintering, and after March they moved back to Pohai Bay.

On the other hand, the tagged shrimp released in January moved towards the western waters off Cheju Island, thereafter, a portion of them moved towards the west coast of Korea and the others moved back to Pohai. Judging from the fact mentioned above, the information derived from the tagging experiments has definitely established the existence of the "Pohai and Korean Groups".

The wintering grounds of this shrimp tended to shift to the south-east, accompanied by a decrease in population size year by year. The reason for this phenomena is not clarified yet.

Until recently, it was considered that the span of life of the Korai shrimp is one year. However, there is clear evidence from the tagging experiments that some of them survive more than a year although the number of individuals recovered was rather small.

Using the recoveries per haul in each half month after the release, the total mortality coefficients were calculated, showing: 1.06 to 1.43 as regards the release in December and showing 0.19 to 0.25 as regards the release in January. Then, using the relation between the total mortality coefficients and the number of hauls, the rate of exploitation was obtained as follows, showing: 0.55-0.68 as regards the release in December and showing 0.46-0.74 as regards the release in January.

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Table I Results of tagging experiments by research vessels during 1952 to 1964.
number released : non bracket, number recovered : bracket

Species / Year	sea bream	Conger pike eel	Hair tail	Yellow croaker	Korai shrimp	Others	Total
1952		178(1)				73	251
1958		130	1			222	353
1959	1	32(2)				226	259
1960						1(1)	3
1961		19(1)	66	288		174	547
1962		55	3			29	87
1963	2,848*(13)	11	59		596*(13)	96	3,610
1964	40*	36*	141(1)				217
Total	2,889(13)	461(4)	270(1)	288	596(13)	823(1)	5,327(29)

*: used bull trawler

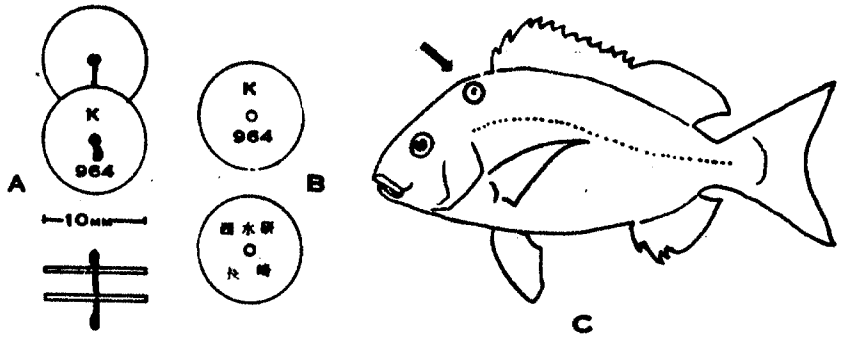

Fig. 1. PETERSEN disk tag used in the tagging experiments.
A: General appearance of tag, one disk is red and the other yellow. Both ends of the connecting wire are bent into knobs.
B: Surface and reverse sides of the red disk.
C: Arrow showing the position where the tag was fixed.

Table II Results of the tagging experiments on the yellow croaker, using the hanging cage.

Experiment No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Test 1	Test 2	Test 3
Date		July 17	17	17	17	17	17	18	18	18	18	19	20	20	20			
Depth		34	36	36	39	40	38	36	40	38	38	36	38	39	37			
Depth of cage		30	30	30	30	30	35	35	35	30	30	30	30	30	30			
Duration of lowering (min.)		2	2	2	2	1	2	2	2	0	4	4	4	3	2			
Duration of acclimation (min.)		6	5	5	7	5	10	10	20	10	5	10	5	13	11			
Duration of opening shutter (min.)		5	6	6	5	5	0	0	0	0	8	0	6	5	0			
Duration of recovery (min.)		1	2	4	2	-	14	2	20	15	-	31	11	10	13			
No. lowered		1	6	18	18	10	33	6	10	6	8	15	4	28	17	11	87	82
No. released at the bottom		0	4	9	7	6	-	-	-	-	0	-	2	8	-	6	-	30
No. of remainder after recovery		1	2	9	11	4	33	6	10	6	8	15	2	20	17	5	87	52
No. released at surface		-	1	4	5	-	8	5	4	3	3	5	1	5	2	-	27	19
No. of final remainder		1	1	5	6	4	25	1	6	3	5	10	1	15	15	5	60	33
Rate of escapement	Bottom	0	.67	.50	.39	.60	-	-	-	-	0	-	.50	.29	-	.83	-	.37
	Surface	-	.50	.44	.45	-	.24	.83	.40	.50	.38	.33	.50	.25	.12	-	.31	.37

Notes: Test 1; Exp. No. 1, 5 Test 2; 6-9, 11, 14 Test 3; Others

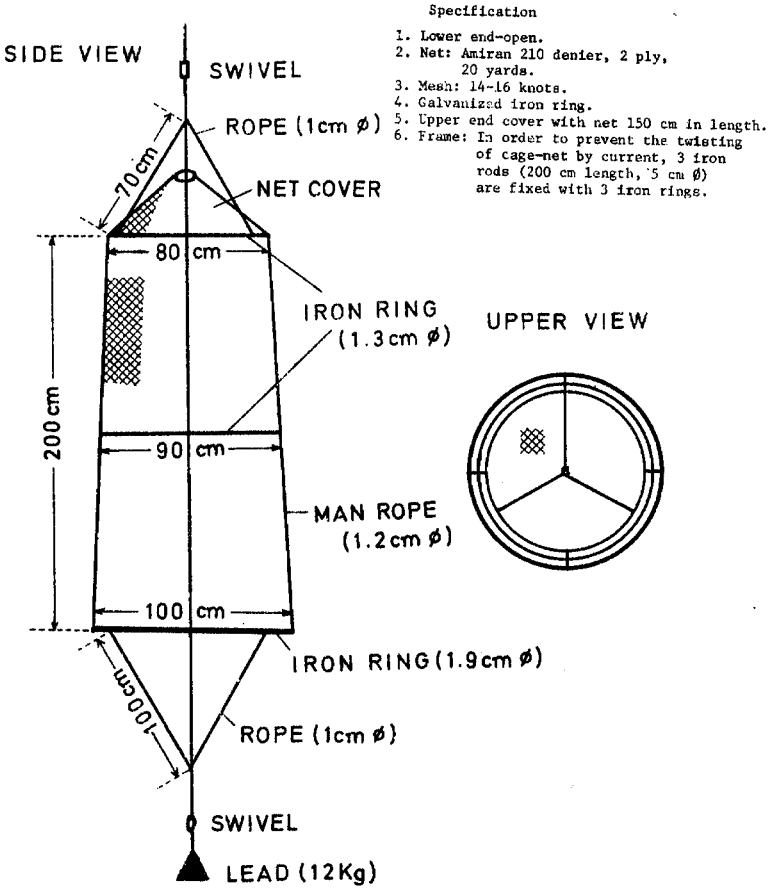

Fig. 2. Hanging net-cage for release.

Table III Recent results of tagging experiments by bull trawler.

Species \ Year / Month		1964 Nov.		1965 Oct.		1966 Nov.	1967 Oct.	
Yellow croaker	Released	13,342		4,850		4,523	5,055	
	Recovered	1,634		799		160	1,120	
	Rate (%)	12.2		16.5		3.5	22.2	
Conger pike eel	Released	302		3,497		4,899	5,042*	3,534
	Recovered	11		189		288	240	115
	Rate (%)	3.6		5.4		5.8	4.8	3.3
Korai shrimp	Released	999**	999****	999**	1,000***	1,500**	1,684**	
	Recovered	114	73	70	90	117	20	
	Rate (%)	11.4	7.3	7.0	9.0	7.8	1.2	
Sea bream	Released					7,321***		
	Recovered					5		
	Rate (%)					0.1		

*: May **: Dec. ***: Jan. ****: July

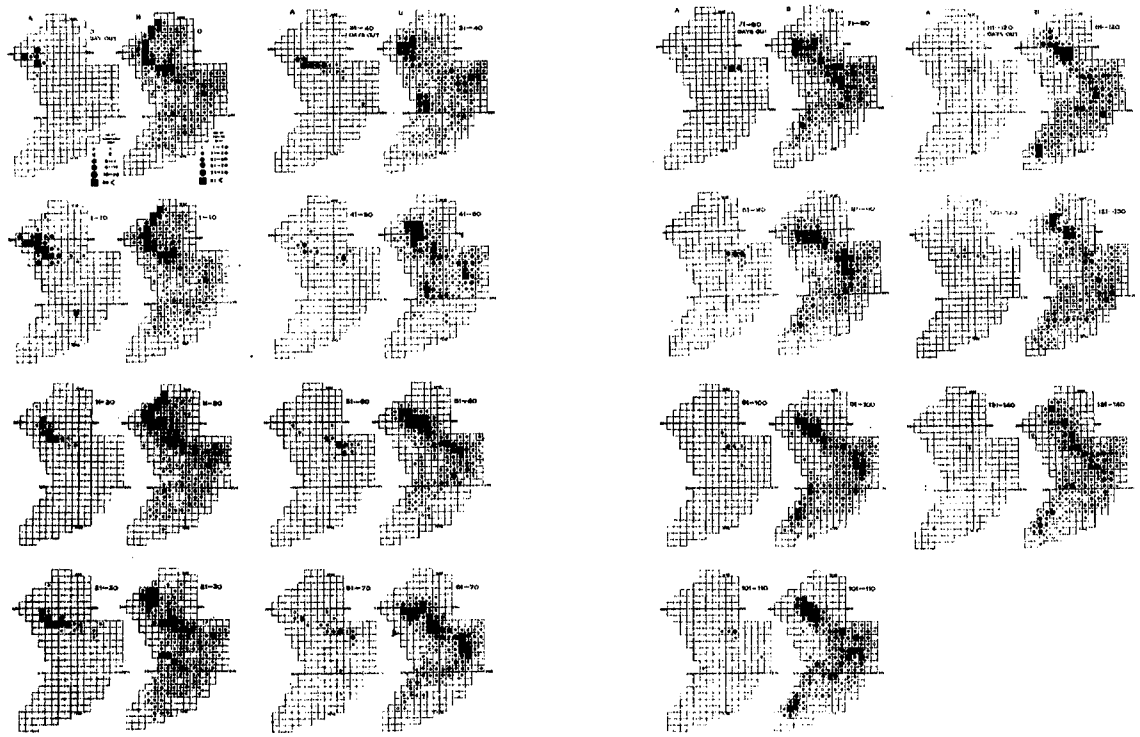

Fig. 8 A: Distributions of number of the sea breams recovered in each offcial block during the day of releasing and those found during the periods of ten days after the liberation.
B: Noon time distribution of the numbers of fishing boats in the offcial block during the same period for receveries shown in figures A.