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Line Fishing

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PREFACE

Fishing is classified into net fishing, line fishing and miscellaneous fishing.

Of the different types of net fishing, there are many which are operated on a large scale, such as trawl net fishing, purse seine fishing, gill net fishing for salmon, etc.

Line fishing is mostly operated on a small scale in coastal waters; the exceptions are tuna longline and skipjack pole-and-line fishing. This may be one of the reasons for there being relatively few studies on line fisheries.

The construction of gear and the methods of operation vary according to the fishing ground, fishing season and fishermen's preferences, even for the same kinds of fishing.

The fishing gears and fishing methods described in this book are the ones employed by the Japanese fishermen in coastal waters of Japan as well as in the pelagic sea water by Japanese fishing boats.

I hope that, with some modifications, the gear and fishing methods described in this book will be applicable to a different set of conditions in other countries.

This book also includes descriptions of studies which were done in order to improve catching efficiency of fishing gear and methods of operations. Such studies, especially those pertaining to habits (behaviour) of fish, environment of fishing ground, size of fishing vessels etc, are necessary in order to design appropriate fishing gear.

It is my hope that this book will be utilized as a textbook or a reference book on line fishing by the trainees of SEAFDEC, as well as other people engaged in fisheries education and training.

Finally, I would like to thank Mrs. Marijana Lee who helped me with the preparation of the present book.

Masatake Okawara

Bangkok
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INTRODUCTION

Line fishing has certain advantages over other methods of fishing, but there are also disadvantages. On the advantage side, fishing grounds where line fishing is carried out are less likely to be limited by environmental factors. For example, operation of line fishing gear is possible in very deep sea as well as in shallow waters, and in waters with strong currents and/or rough bottom. Furthermore, less damage is done to fish caught by line fishing, therefore preservation of freshness is good. On the other hand, a disadvantage of this type of gear is that the amount of catch is small because of its catching mechanism; one hook, one fish. Also, in most cases, a particular kind of bait is required for each species of target fish.

1. LINE FISHING GEAR

In comparison with the gear for net fishing, the line fishing gear is simple, being composed basically of a line and a hook. Other elements, such as pole, float, sinker, swivel and snap are added to the gear as required. The amount of catch is very much influenced by the efficiency of gear, therefore the choice of material and the construction of gear should be done carefully.

1.1 Hook

Hooks for line fishing exist in a variety of shapes and sizes. The materials of which hooks are made are mainly iron (galvanized or tinned for protection against rust), brass and stainless steel.

According to their shapes, hooks can be classified into three types: round, angular and long type. Besides, there are complex hooks, such as double and triple hooks, and hooks elaborately constructed as jigs for squid and for tuna pole-and-line fishing (Fig. 1).

A hook consists of five distinct parts, namely: head, shank, bend, point and barb (Fig. 2).

The function of the hook head is to allow the line to be fastened easily and securely to the hook. Figure 3 shows different forms of hook heads.

A hook with a long shank can be handled easily; it is easy to place the bait on the hook and to remove the fish from the hook. Furthermore, a long shank prevents the line from being cut by fish's teeth. However, the catching efficiency of such hooks is not high.

In order to prevent the captured fish from dropping from the hook, most hooks have a barb. In some cases when it is necessary to remove the fish from the hook quickly, as in the case of pole-and-line skipjack fishing, hooks without barbs are used.

The hook with the point bent inwards is the most suitable for use with bottom longline as it does not enter the fish's body very deeply and thus allows the fish to remain alive for some time after swallowing the hook.

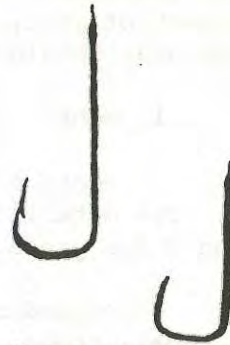
The hook twisted in the bend part is convenient because the bait can be placed on the hook easily and its catching efficiency is high.



(Round Hook)



(Angular Hook)



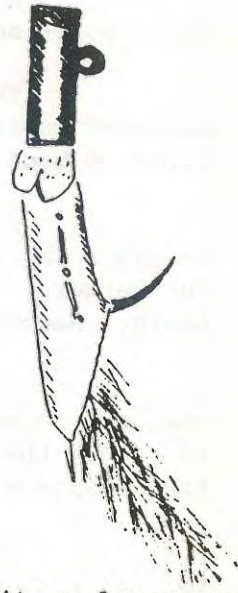
(Long Hook)



(Double Hook)



(Triple Hook)



Bonito and Tuna jig



(Squid jig)



Trolling jig



Fig. 1. Different types of hooks and jigs



Fig. 2. Parts of hook



Fig. 3. Forms of hook heads

Double and triple hooks are used for troll fishing; these hooks are effective to prevent the fish from dropping from the hook.

Squid jigs vary in shape, colour and materials. Body parts are made of plastics, vinyl, rubber, cloth, wood, lead, etc.

Bonito and tuna jigs also vary in colour and materials of the lure part (body part). Generally fish skin and chicken feathers are used to conceal the hook.

1.1.1 A study on hook selectivity

S. Takeuchi and A. Koike studied the catching efficiency and selectivity of hooks used in the longline spiny goby fishing. They carried out experiments using two different shapes of hooks, *Sodegata* and *Ryusen-sodegata*, and three sizes of hooks (Fig.4).

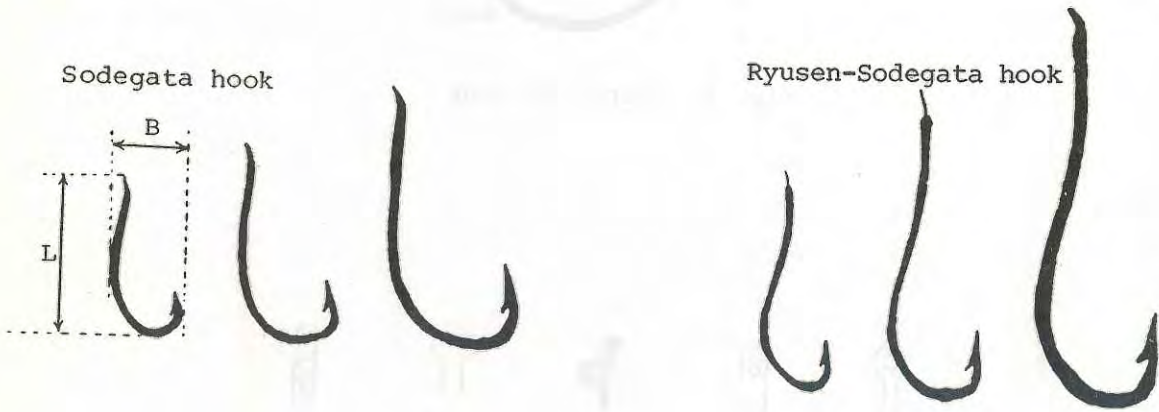


Fig. 4. *Sodegata* and *Ryusen-sodegata* hooks

It was found that the smaller the hook, the higher its catching efficiency, for both types of hooks. Table 1 shows the dimensions of different hooks used in the experiment and the amounts of catch.

Table 1. The size of hook and the number of captured fish

Shape	No.	Max. breadth	Max. length	Number of fish	Ratio
<i>Sodegata</i>	4	4.3 mm	5.3 mm	120	1.00
"	7	6.2	7.1	117	0.98
"	11	8.2	9.4	80	0.67
<i>Ryusen</i>	5	4.5	7.4	120	1.00
- <i>sodegata</i>	9	6.1	10.7	93	0.78
	13	8.1	14.0	56	0.47

The selection curves of *Sodegata* hook No.4 and *Ryusen-sodegata* hook No.5 are shown in Fig. 5. The graph in Fig. 5-a shows that the maximum relative catch efficiency of *Sodegata* hook No.4 was obtained between 10.5 - 16.0 cm in the total length of spiny goby. Its class mark was 13.5 cm.

Similarly, the class mark was 19 cm for *Sodegata* No.7 and 25.0 cm for *Sodegata* No.11.

In the case of *Ryusen-sodegata*, the class marks of No.5, No.9 and No.13 were 14.0 cm, 19.0 cm and 25.0 cm respectively.

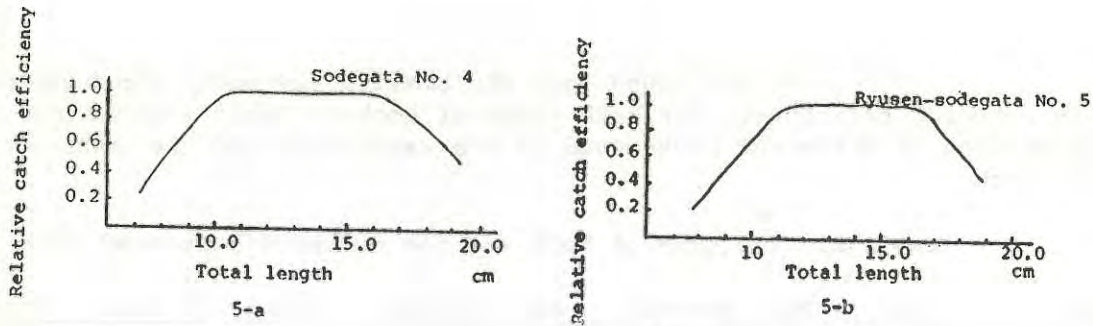


Fig. 5. Selection curves of *Sodegata* No.4 and *Ryusen-sodegata* No.5

Figure 6 shows the relationship between the mean selection length of fish and maximum breadth of the hook. From this figure, it appears that there is no difference in the length of fish caught by hooks of different shapes if the maximum breadth of hooks is almost the same.

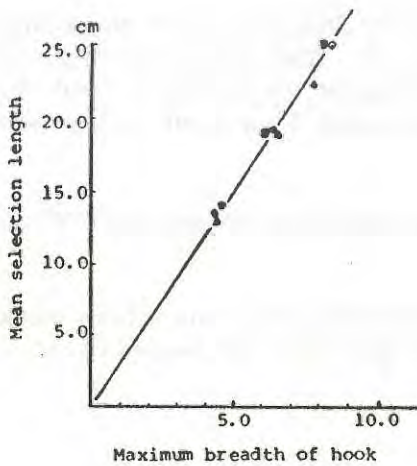


Fig. 6. Relation between the mean selection length of fish and the maximum breadth of hook

- ⊙ Sodegata
- Ryusen-sodegata
- ▲ Sodegata (1968)

1.2 Line

The material and thickness of the line depend on what kind of fishing it is used for. For example, in the case of tuna longline, the main line is 6 mm in diameter and it is made of vinylon, nylon, polyester, etc. Branch lines are somewhat thinner and are also made of nylon, vinylon, or polyester, whereas the hook line is made of steel wire. In the case of handline and pole-and-line fishing, the main line is not as thick as that of tuna longline. Nylon or polyethylene are used for both the main line and the hook line.

Generally, lines for line fishing should be as thin and as strong as possible, particularly branch lines and hook lines. Therefore nylon monofilament is the best material for line fishing. Table 2 shows the standard of nylon monofilament.

1.2.1 Thickness of monofilament nylon line and the size of fish

Y. Ishida estimated the relation between the size of fish and the thickness (go ^{1/} standard) of nylon line in the following way:

- 1) Spindle shape fish

$$N(go) = 6.2 \times W \text{ (kg)}$$

- 2) Flat shape fish

$$N(go) = 4.2 \times W \text{ (kg)}$$

N: go standard

W: Weight of fish (kg)

^{1/} go is the Japanese standard for thickness of monofilament nylon line. The metric equivalents of different go values are given in Table 2.

Table 2. Strength of nylon monofilament line

No. of go	Diameter	Breaking strength	Knot strength
3	0.29 mm	4.2 kg	2.7 kg
5	0.37	7.3	4.1
7	0.44	10.7	5.9
10	0.52	14.4	8.0
12	0.57	17.0	8.1
16	0.66	21.9	10.4
18	0.70	24.0	10.9
20	0.74	27.1	12.2
24	0.81	30.7	13.5
28	0.87	36.4	16.6
30	0.90	38.1	17.8
35	0.97	41.4	19.8
40	1.04	46.9	21.5
50	1.17	56.9	27.6
60	1.28	65.1	28.4
70	1.38	74.5	30.0
80	1.47	82.0	35.0
100	1.65	101.0	47.0
120	1.81	115.0	57.2

1.3 Pole

Generally, angling pole is used to catch the fish swimming near the surface. There are several advantages in using a pole;

- a) The hook can be moved to the desired position easily,
- b) The shock caused by the fish can be mitigated thus preventing the line from breaking,
- c) The fish captured is taken on board easily and quickly.

Bamboo used to be the most popular material for the pole, but recently, fiberglass pole has been developed and is now widely used.

On the other hand, in order to catch the fish swimming in deep waters by handline, a special device is used. This is called "Tenbin" in Japanese or "Balance" in English. A piece of thin stainless steel wire with a strong spring attached to the end of the line has the function of a pole. Figure 8 shows some poles for pole-and-line fishing.

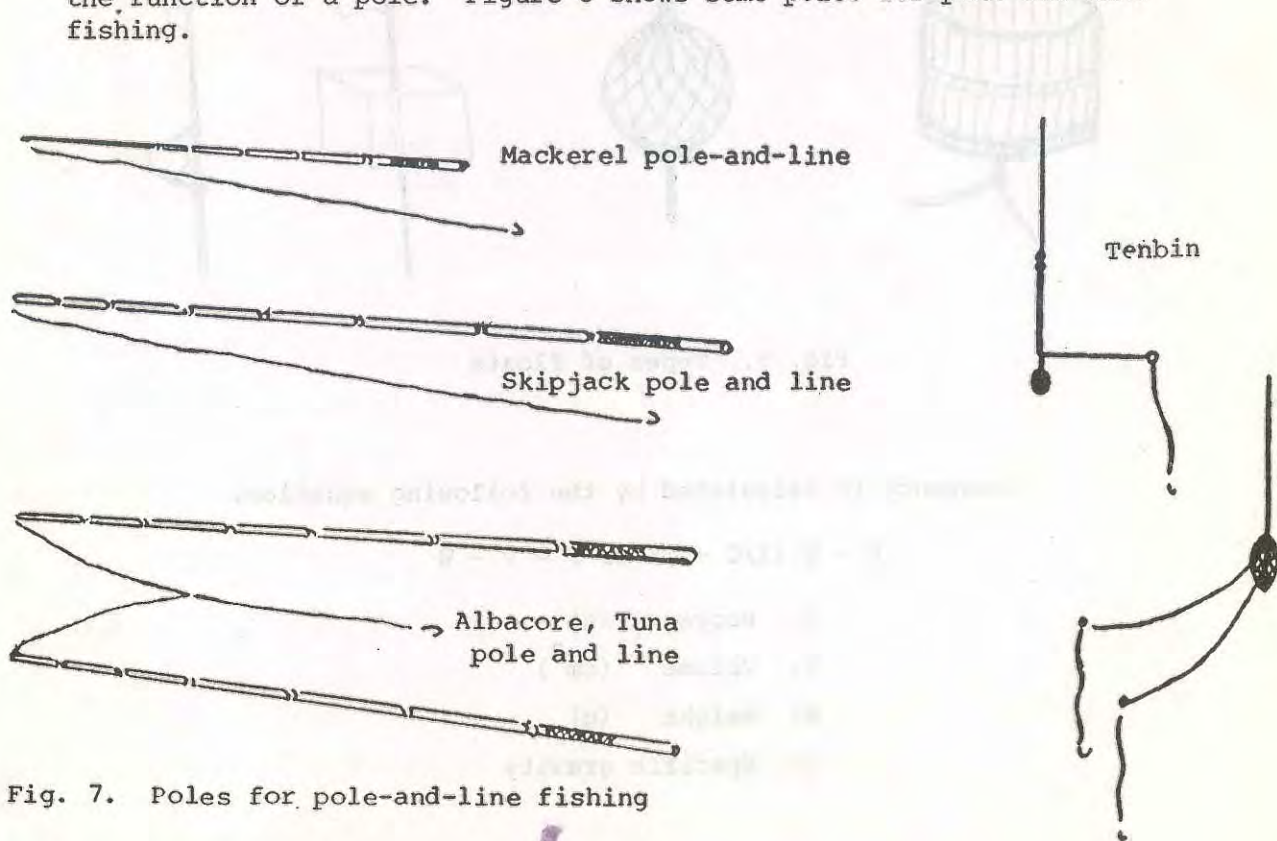


Fig. 7. Poles for pole-and-line fishing

1.4 Float and sinker

The float serves several purposes:

- To place the hook at the desired position (depth),
- To indicate whether the fish is hooked,
- To mark the location of gear.

In commercial fisheries, float is used mainly for longline fishing. A barrel, a block of wood, an empty pot etc, are still commonly used in small-scale coastal fishing, but glass or polyethylene floats are used in large-scale fishing, such as tuna longline in deep waters. Some floats are shown in Fig. 8.

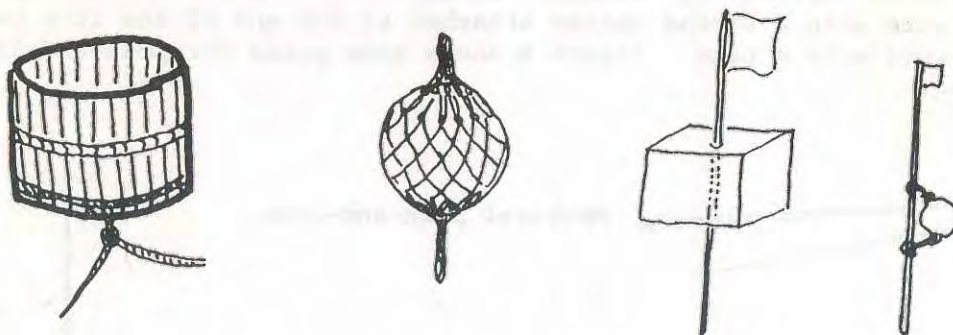


Fig. 8. Types of floats

Buoyancy is calculated by the following equation:

$$F = W (1/C - 1) \text{ or } F = V - W$$

F: Buoyancy (g)

V: Volume (cm³)

W: Weight (g)

C: Specific gravity

Sinker has the following roles:

- To sink the hook to the required depth quickly,
- To prevent the hook and line from drifting away by current.

Stone, iron, lead etc. are used. Fig. 9 shows some sinkers.

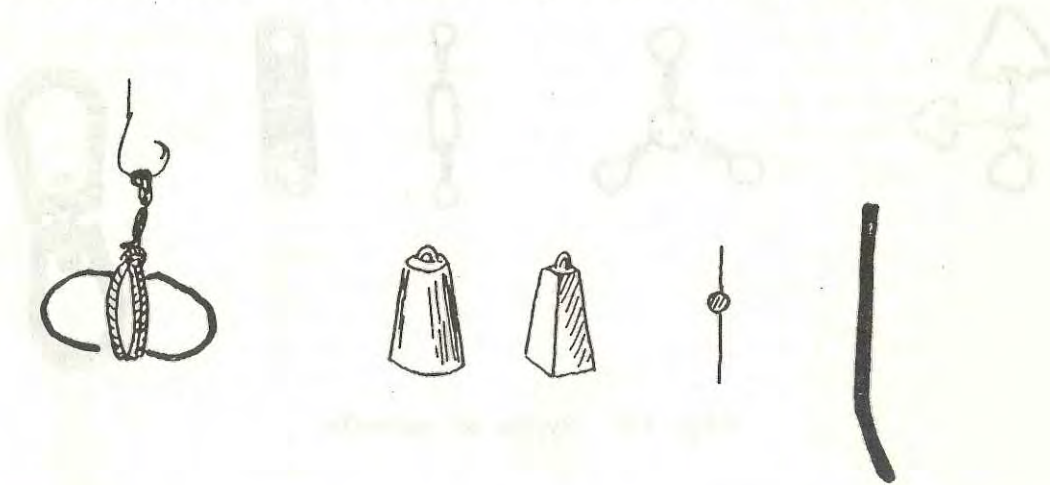


Fig. 9. Types of sinkers

Sinking power can be calculated by the following equation:

$$S = W - (W/C) = \{ W 1 - (a/C) \}$$

S: Sinking power (g)

W: Weight (g)

C: Specific gravity

1.5 Swivel and snap

Swivel is used in joints, for example between the main line and the branch line, or the branch line and the hook line, to prevent the line from twisting.

There are many types of swivels, but the type and the size are decided according to the kinds of fishing and size of fishing gear. Figure 10 shows the most commonly used types of swiveles.

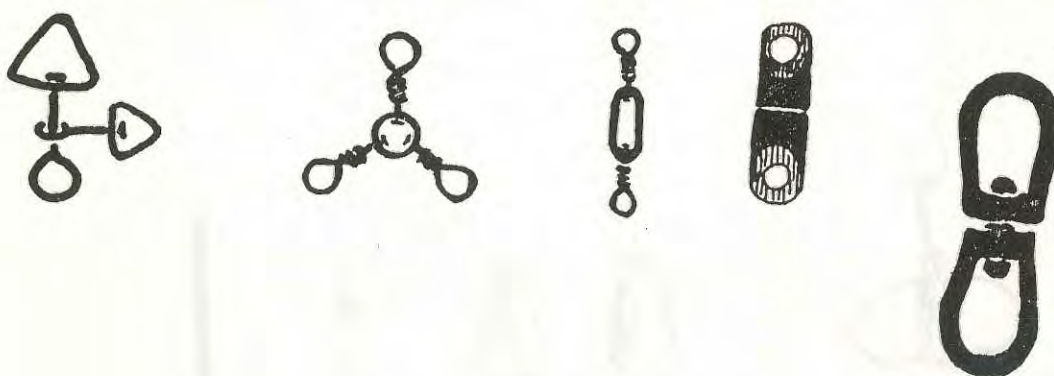


Fig. 10. Types of swivels

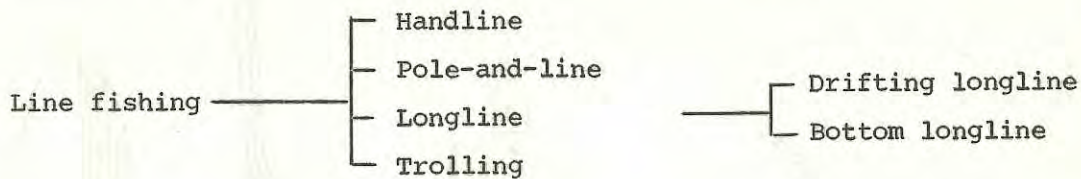
Snap has been developed for tuna longline fishing to join the branch line to the main line easily (Fig. 11). Nowadays the snap is used widely not only for tuna longline but also for some other kinds of fishing such as trap-net fishing.



Fig. 11. Snap

2. CLASSIFICATION OF LINE FISHING METHODS

Line fishing is classified according to the type of gear construction as follows:



2.1 Handline fishing

Handline gear is very simple. It is composed of the main line, branch lines, hook and lead. Some types of handline gear have several hooks; for example, a main line with an end-lead may have hooks on branch lines so that vertical long lines are formed. Fishing with a "Balance" which is a kind of pole, is also considered a variation of handline fishing. Handline gear is used to catch the fish dwelling in midwater and near/on the sea bottom. Sea bream, mackerel, jack-mackerel and other bottom fish are caught by handline fishing.

2.1.1 Handline fishing for demersal fish

Fishing gear

The gear is shown in Fig. 12a and its specifications are given in Table 3.

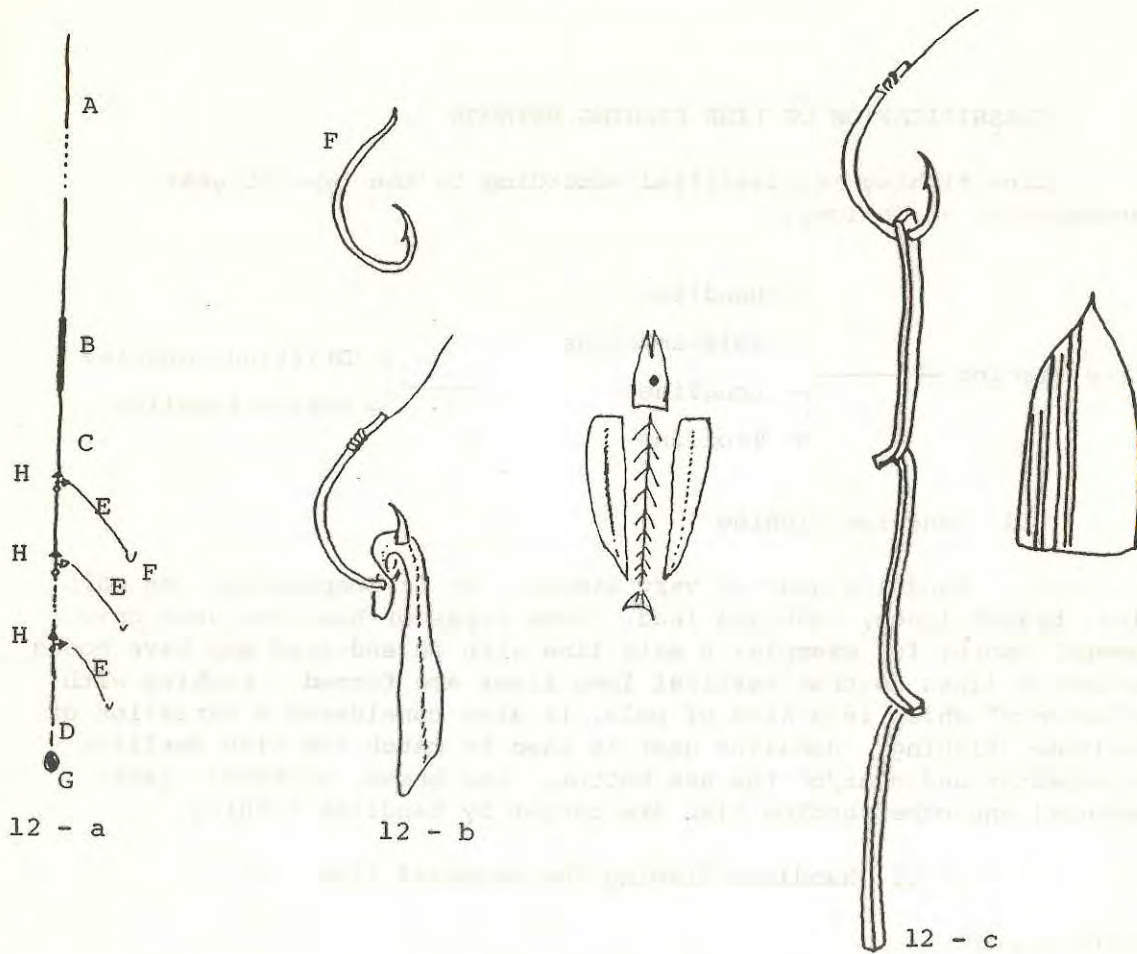


Fig. 12a, b, c : Handline fishing gear and bait

Table 3. Specifications of handline gear for demersal fish

Mark	Name	Material	Dimensions	Amount
A	Main line 1	Wire #20	450-600 m	
B	- " - 2	Vinyon	48-ply 20 cm	
C	- " - 3	Nylon	30 go 40 m	
D	- " - 4	Nylon	20 go 2.3 m	
E	Branch line	Nylon	30 go 1.5-3.0 m,	12-15
F	Hook		23-25 go	12-15
G	Sinker	Iron	1 kg	
H	Two-way swivel			

Fishing method

Saury fish, squid, etc are used as bait. In the case of saury fish, it is cut as shown in Fig. 12b and one piece is placed on the hook through the tail part. Squid is cut into strips of about 30 cm in length, as shown in Fig. 12c

For this method of fishing, a 3-5-ton boat is used, with engine capacity of 15-45 h.p., and 2-4 crew on board. A fish finder is used to locate the school of fish and the fish bank. When the school of fish or the fish bank is found, the boat should be sailed above the school of fish, against the current, and the gear is shot. After the boat has drifted across the school of fish, it should be brought to its initial position above the school of fish before the fishing operation is repeated.

2.1.2 Handline fishing for mackerel and jack-mackerel

Fishing gear

Fig. 13 shows the fishing gear for jack-mackerel and mackerel, and the specifications are shown in Table 4.

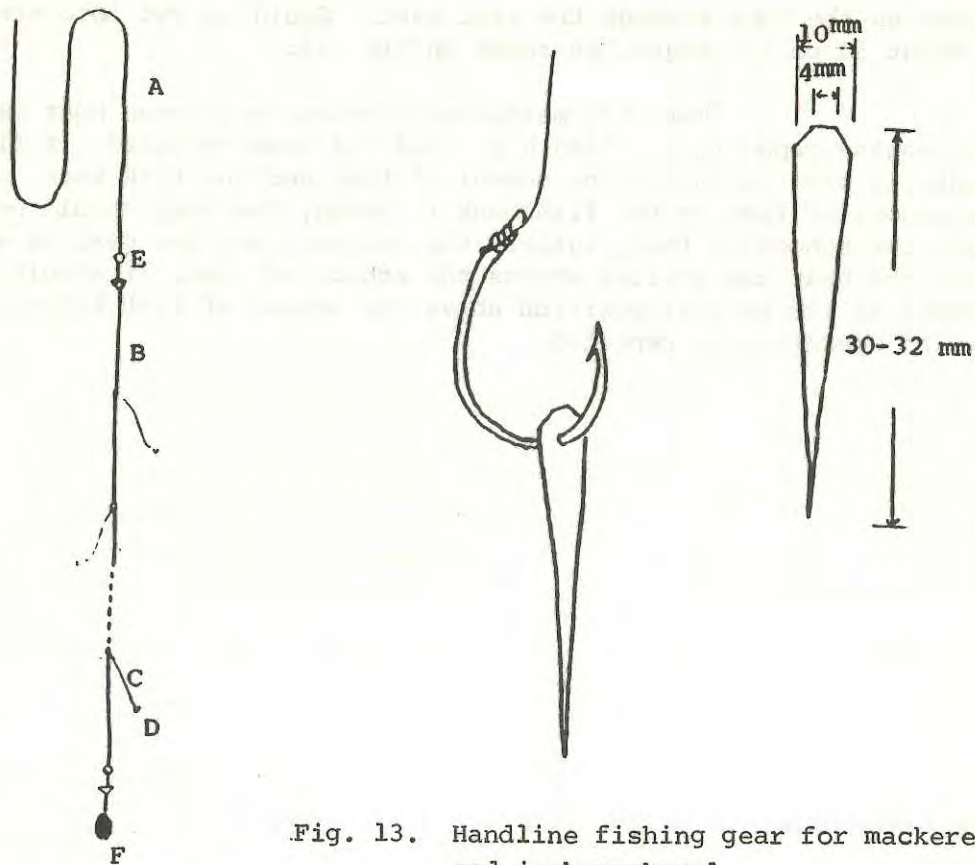


Fig. 13. Handline fishing gear for mackerel and jack-mackerel

Table 4. Specifications of handline gear for jack-mackerel and mackerel

Mark	Name	Material	Size	Amount
A	Main line 1	Nylon	8-10 go	50 m
B	- " - 2	Nylon	5 go	9-14 m
C	Branch line	Nylon	5 go, 20-25 cm	8-10
D	Hook (Round type)		6-7 go	8-10
E	Swivel		12 m	2
F	Sinker	Iron, lead	225 g	

Fishing method

Cat skin, trigger-fish skin, thin strips of rubber, etc are used as bait.

A 1-3-ton boat is used for operation, with one fisherman on board. The boat is equipped with fish luring lamps powered by a 24 V, 1 kW generator. The boat is anchored above the fish bank after sunset; two fishing lamps of 100-300 W are hung above the water, one on either side of the boat. The fisherman operates handline gear and pole-and-line gear. The operation is carried out until sunrise. This type of fishing is suspended for three days during the full moon period.

2.1.3 "Balance" handline for mackerel and jack-mackerel fishing

The balance functions as a pole under water. It is usually made in the shape of a crescent, as seen in Fig. 14a. With the up-and-down movement of the fishing line, the balance vibrates causing vibration of the hooks. Fig. 14b shows the other type of balance of which the sinker parts and bag net parts for bait are combined. The specifications of the mackerel and jack-mackerel handline gear with balance are shown in Table 5.

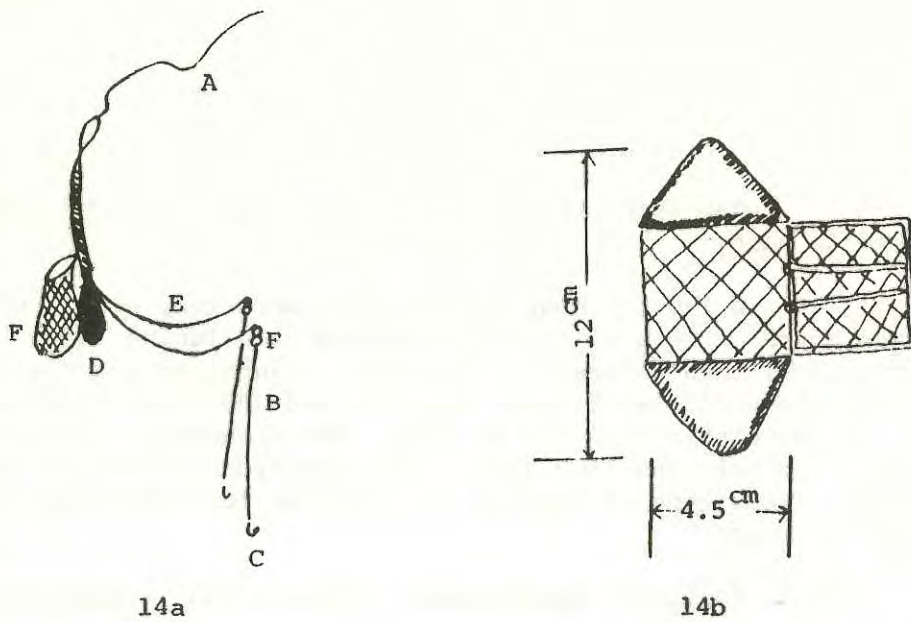


Fig. 14-a, b : "Balance" handline fishing gear

Table 5. Specification of "Balance" handline for mackerel and jack-mackerel

Mark	Name	Material	Size	Amount
A	Main line	Polyester+Nylon	40-50 go	
B	Branch line	Nylon	12-14 go	1.8 m
C	Hook (Round type)		15 go	
D	Sinker	Lead	375-563 g	
E	Balance	Stainless steel or brass		30 cm
F	Bait bag			
G	Swivel			

2.1.4 Handline fishing for squid

Fishing gear

Handline fishing gear for Japanese common squid is shown in Fig. 15 and its specifications are given in Table 6.

Fishing method

Fishing operations are conducted on board a 0.5-3-ton boat, by 1-3 crew. The boat is equipped with a fish luring lamp which hangs in the centre of the boat and which is usually powered by a battery, or sometimes by a generator as in the case of larger boats. There are two fishing methods; one is for night-time fishing and the other is for daytime fishing. As squid fishing is generally done in the night time.

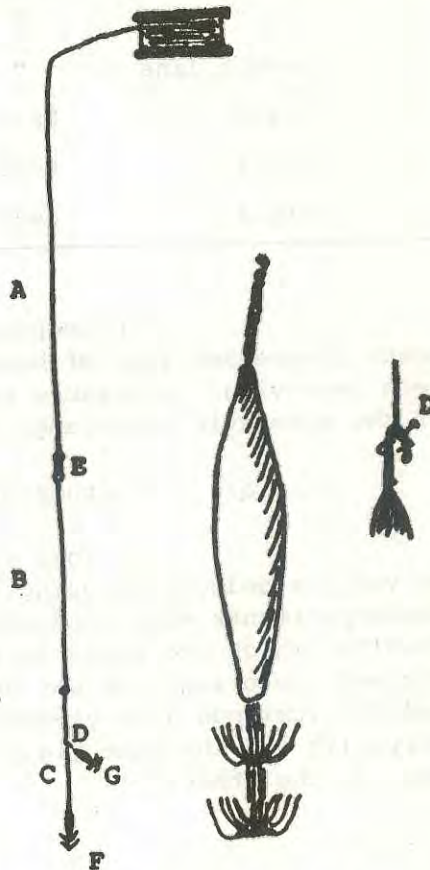


Fig. 15. Handline gear for squid fishing

On arriving at the fishing ground, the boat is anchored. The hooks are at first shot near the sea bottom but gradually, as the squid are lured to the surface the fishing line should be shortened and the hooks brought close to the surface.

Table 6. Specifications of squid handline

Mark	Name	Material	Size	Amount
A	Main line	Tetron	18 <i>go</i>	100 m
B	"	Nylon	10-12 <i>go</i>	15-20 m
C	"	"	7-8 <i>go</i>	3 m
D	Branch line	"	7-8 <i>go</i>	10 cm
E	Swivel	Brass	Box type	
F	Jig 1	Lead with cloth	8-10 cm	
G	Jig 2	Lead with wood	8-10 cm	

In keeping with general modernization of fishing boats (increased size of boats, mechanization, etc), the gear has also been improving. A notable recent development has been the introduction of the automatic squid angling machine.

a) A study on squid fishing jigs

K. Yoza studied catching efficiency of squid jigs of various colours by using the automatic squid angling machine. The experiments were conducted at two different fishing grounds. The results, which are given in Table 7, show that the catch by the red jig and the orange jig was good at both fishing grounds, the green and the luminous jigs yielded comparatively poor catch, whereas the white jig and the blue jig gave better results at one fishing ground than at the other.

Table 7. Number of squid caught by jigs of various colours

Colour of jig	Dattan sea		North Yamato Tai	
	Number of catch	Ratio	Number of catch	Ratio
Red	57	1.04	55	1.35
Orange	62	1.13	42	1.03
Luminous	44	0.80	31	0.76
Green	53	0.96	33	0.81
Blue	62	1.13	36	0.88
White	52	0.95	49	1.20
Black	-	-	39	0.96
Mean	55	1.00	41	1.00

The Japan Marine Fishery Resource Research Center carried out an experiment in the waters around New Zealand, in order to test catching efficiency of different types of squid jigs which are shown in Fig. 16. The results indicate that the plastic triple-decker jig (see Fig. 16, C) has the highest catching efficiency. A disadvantage of this type of jig is that it can easily damage the angling line with its long hooks. It was found that its long body could also be damaged easily, if the diameter of the drum of the automatic squid angling gear is small.

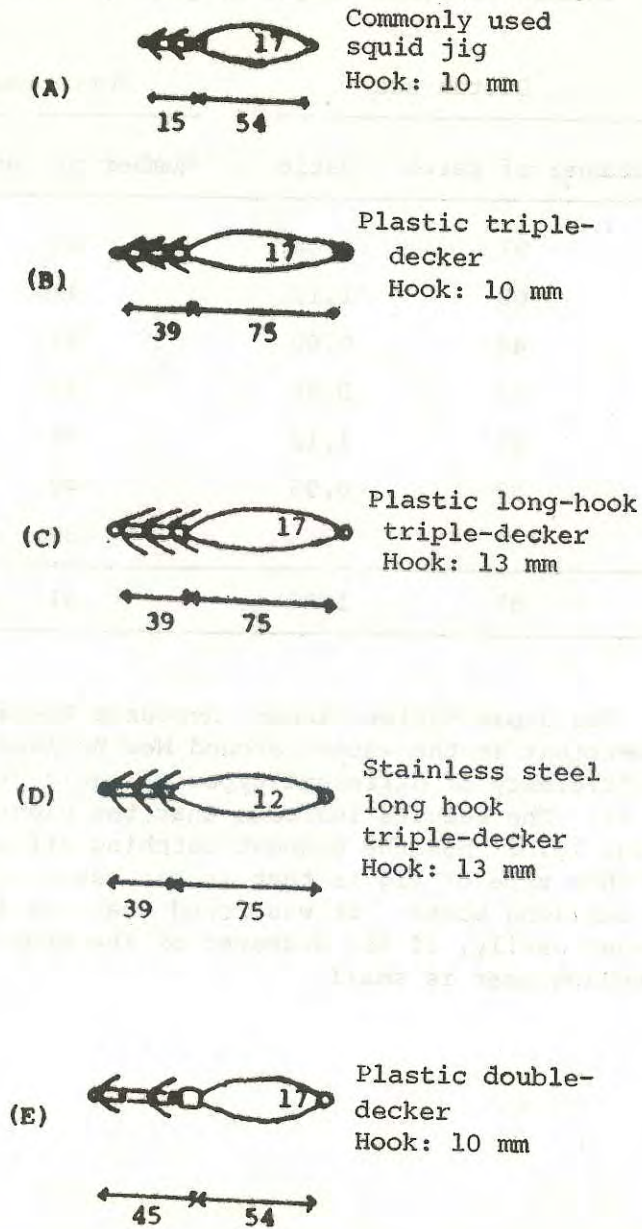


Fig. 16 Types of squid jigs

b) Studies of fish luring lamp

M. Ogura measured luminosity of fishing lamps whose total power was 13.5 kW (1-2 kW x 9) and which were arranged along the centre line of a 5-ton boat. Distribution of luminosity is shown in Fig. 17, the values shown in the figure were obtained by actual measurement while the iso-illumination lines were arrived at theoretically.

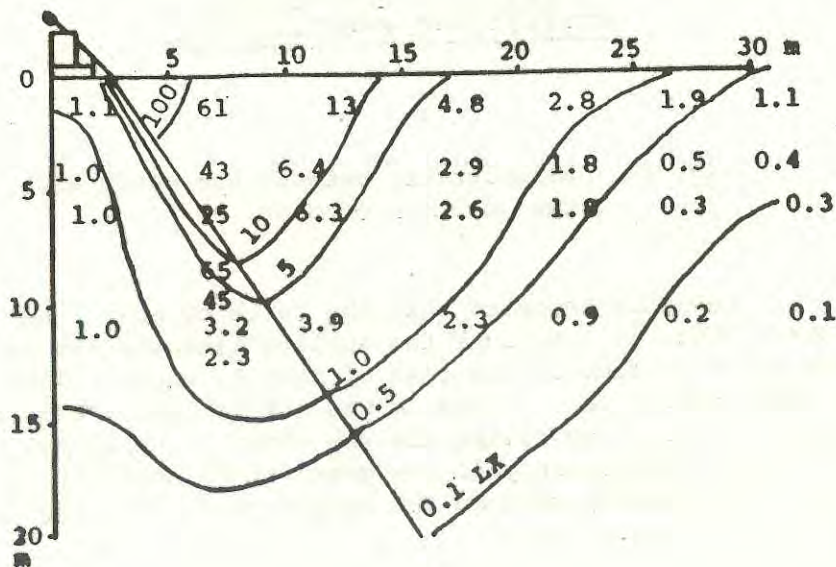


Fig. 17. Fish luring lamp: distribution of luminosity in water

M. Noda carried out an experiment on the relation between the catch and the position of angling gear. According to the results of this experiment, the best catch was obtained when the gear entered the sea at the borderline between the areas of light and darkness (B in Fig. 18).

The angling gear placed in the dark area (A in Fig. 18) obtained better catch than the gear which was submerged in the lit-up area (C in Fig. 18)

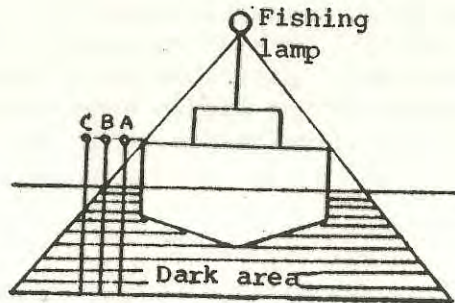


Fig. 18. Relationship between the catch and the position of gear

K. Kawamura reported that the catch by boat B was better than by boat A (Fig. 19), because the angling line was set in the light area on the water surface in the case of boat A, whose roller arm was too long. The angling line of boat B was set in the dark area on the water surface, because the roller arm was short. Therefore, in order to improve catching efficiency of the gear, it is necessary to consider the relationship between the height of the fishing lamp and the length of the roller arm.

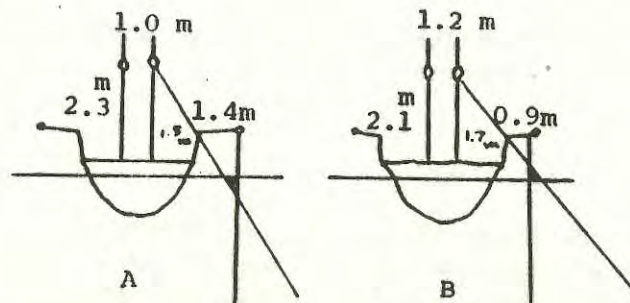


Fig. 19. Relationship between the height of the fishing lamp and the catch

2.2 Pole-and-line fishing

Pole-and-line fishing gear is used mostly to catch the fish swimming near the water surface.

The advantages of pole-and-line fishing, in comparison with other line fishing methods, are as follows; taking the captured fish into the boat is done easily and quickly and the shock caused by hooked fish is lessened.

Pole-and-line fishing on a large scale is carried out mainly for skipjack and mackerel. Skipjack pole-and-line fishing is described below, as skipjack is an important species in commercial fisheries in tropical areas.

2.2.1 Skipjack pole-and-line fishing

Skipjack distributes widely in the warm waters of the world and is caught mainly by purse seine, pole-and-line and gill net.

A school of skipjack can be located by means of a fish finder, trolling with lure and by visual observation. Skipjack forms schools around drifting objects, whale sharks and baleen whales. Flocks of birds often circle above schools of skipjack and feed on the small fish. It is therefore possible to detect the presence of skipjack by spotting large drifting objects, whales, sharks or a circling flock of birds, all of which are easily observed by naked eye.

When the school of skipjack has been found, the boat should approach the school and live bait fish is thrown from the bow to attract the school toward the boat. Water is also sprayed around the boat, so as to conceal the shadows of fishermen from the fish.

Live bait fish is indispensable for skipjack pole-and-line fishing. The next section deals with the fishing for live bait fish.

2.2.2 Live bait fishing

Anchovy, sardine, pilchard and herring are used as live bait fish for skipjack pole-and-line fishing. Anchovy is the most suitable bait fish, but its mortality is very high.

Live bait fish are caught by means of purse seine, stick-held dip net, lift net and *Oikomi* net.

When a Lampara net is used for fishing, an underwater lamp of 200 W is set 1-3m below the water surface after sunset. When the bait fish are attracted around the underwater lamp, the lamp is moved away from the mother boat by the lamp boat, while extending the electric cord. At 50 m distance from the mother boat, the underwater lamp of the lamp boat is switched on, and the underwater lamp of the mother boat is turned off. The lamp boat then moves further away from the mother boat so that the purse seiner is able to operate. Figure 20 shows the method of operation.

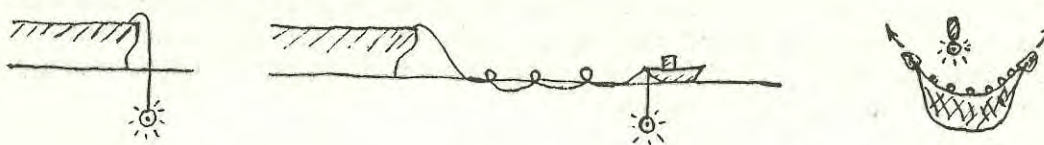


Fig. 20. Live bait fishing by purse seine

In the case of the lift net, the net is set on the sea bottom and an underwater lamp of 200 W is hung above the centre of the net. In addition, two fishing lamps of 500 W each are hung above water (Fig. 21). When the bait fish are attracted, the fishing lamps are turned off and the net, together with the underwater lamp, is pulled to the side of the boat. The boat has to be anchored for this method of fishing, therefore the operation is difficult at the fishing ground where the water depth exceeds 20 m or the current is strong.

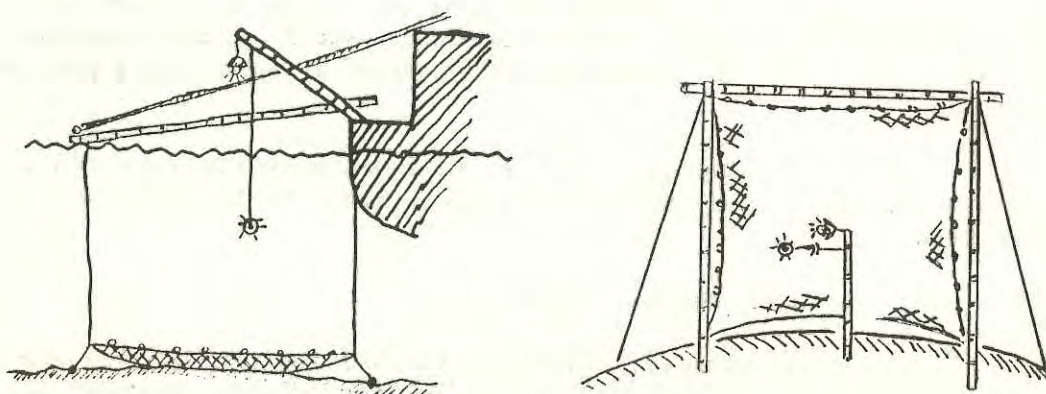


Fig. 21. Live bait fishing by lift net

Fishing with *Oikomi* net is carried out in the daytime in waters of 1-1.5 m depth. Bait fish form schools in the shade near rocks or corals in the daytime. The fishermen disturb the fish by noise and splashing and drive the school into the net. (Fig. 22)

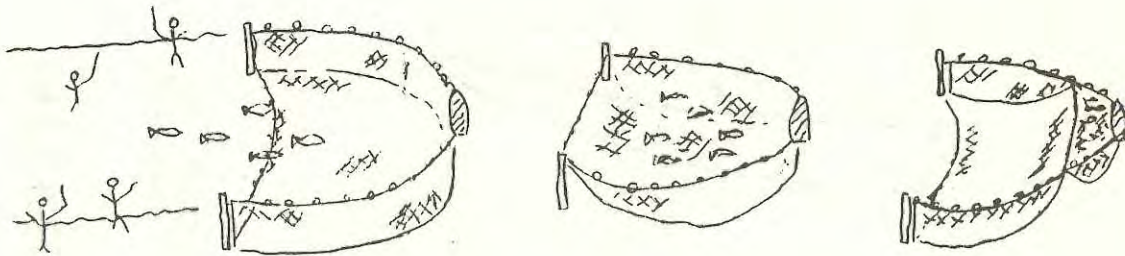


Fig. 22. Live bait fishing by *Oikomi* net

2.2.3 Skipjack pole-and-line fishing with a 40-ton boat

Fishing gear

The gear is shown in Fig. 23 and its specifications are given in Table 8. Fishing for skipjack often means catching tuna and albacore as well as skipjack. For this reason each boat usually carries 5-8 types of poles, varying in size as well as in construction. For different sizes of fish and schools of different characteristics, fishermen use the appropriate type of pole.

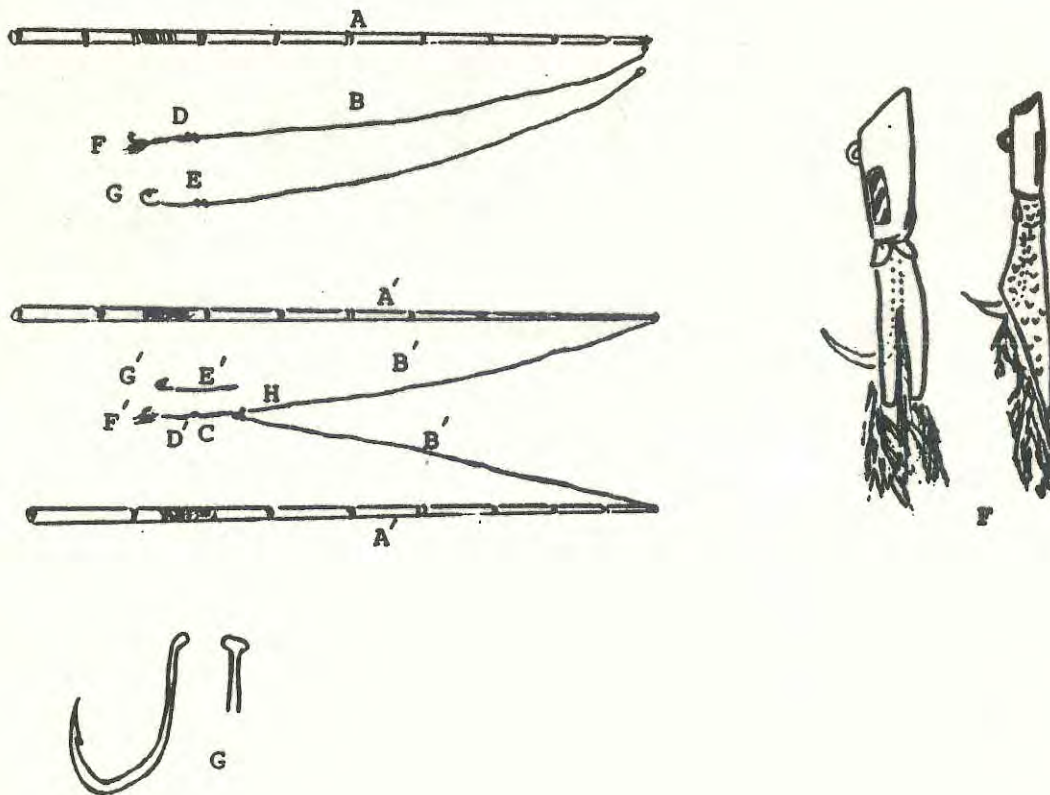


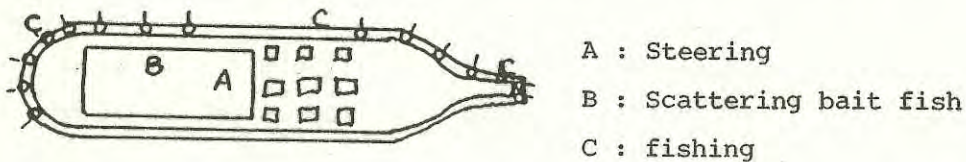
Fig. 23. Skipjack pole-and-line gear

Table 8. Specifications of gear for skipjack pole-and-line fishing

Mark	Name	Size of fish	Material	Dimensions of gear
A	Pole	Small	Bamboo	3-4 m
"	"	Medium	"	3-3.7 m
"	"	Large	"	3-3.7 m
A'	"	Albacore	"	3-3.6 m x 2
B	Main line	Small	Nylon	40-50 go 2.4-3.4 m
"	"	M	"	50-60 go 2.4-3.1 m
"	"	L	"	60-70 go 2.4-3.1 m
B'	"	Albacore	"	150 go 2.1-2.7 m x 2
C	"	Albacore	"	150 go 30-40 cm
D	Hook line	S	Nylon	26-30 go 25-35 cm
"	"	M	"	30-40 go 25-35 cm
"	"	L	"	50-70 go 25-35 cm
D'	"	Albacore	"	150 go 15-25 cm
E	Hook line	S	Nylon	16 go 25-35 cm
"	"	M	"	16-26 go 25-35 cm
"	"	L	"	26 go 25-35 cm
E'	"	Albacore	"	26 go x 2, 15-20 cm
F	Jig	S		Small size
"	"	M		Medium size
"	"	L		Large size
F'	"	Albacore		Albacore jig
G	Hook	S	Stainless steel	13 go
"	"	M		14 go
"	"	L		15 go
G'	"	Albacore		18 go
H	Three-way swivel	Albacore	Stainless steel	

Fishing method

Boats of 30-50 tons have 20-25 crew members on board. At the fishing ground, the crew first have to find the school by means of a trolling line or by watching for drifting objects, whales, sharks, jumping skipjack and birds. When the school of skipjack has been found, the boat approaches it, live bait fish is scattered from the bow while water is sprinkled from the sides of the boat. If the school of skipjack is attracted around the boat, boat is stopped and the operation begins. Generally, operation is done at the port side of boat, and this side should be kept on the lee side. The position taken by crew during operation is shown in Fig. 24.



Figs. 24. Position of crew during pole-and-line fishing operation

Generally, jigs are used for skipjack pole-and-line fishing by *Tatakizuri* method, because the operation is done more quickly than with a live bait hook.

2.2.4 Studies on skipjack pole-and-line fishing

T. Kariya studied the time required to catch skipjack by three methods; *Kakaezuri* with jig, *Kakaezuri* with live bait hook and *Tatakizuri* with jig. The results are shown in Table 9.

Table 9. Time required to catch fish by *Kakaezuri* and *Tatakizuri* method

Type of fishing	Name of boat	Mean time (sec)	Min. time (sec)	Max. time (sec)
L	Mie	4.43	3.0	9.0
	Ibaragi	7.95	3.5	15.3
	First Chokyu	6.24	3.0	11.5
Li	Mie	17.0	-	-
	First Chokyu	16.3	9.0	29.0
T	Ibaragi	1.7	1.0	3.0
	First Chokyu	1.7	1.2	2.5

L : *Kakaezuri* with jig (fisherman holds the fish under his arm while removing the hook)

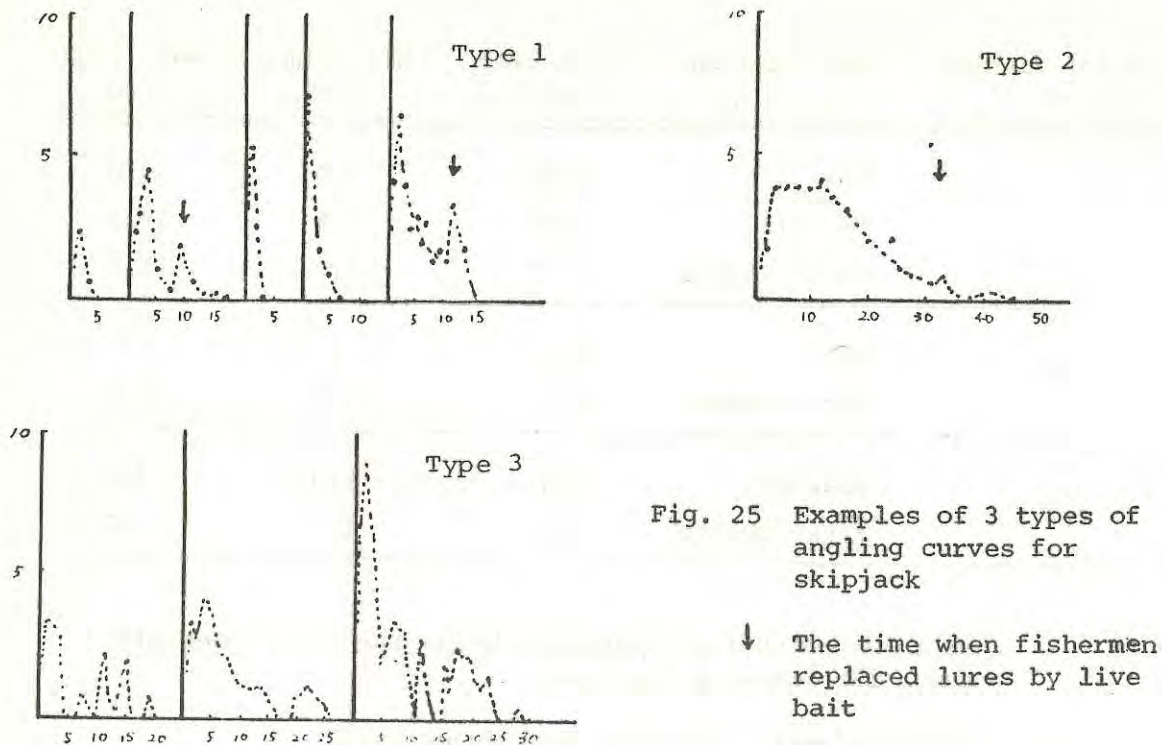
Li : *Kakaezuri* with live bait hook (same as L)

T : *Tatakizuri* with jig (the captured fish drops off the hook automatically when the line slackens)

In the case of *Tatakizuri*, the captured fish should drop on deck automatically, therefore the jig has no barb as shown in Fig. 23. Jigs with white chicken feathers are good for catching skipjack and jigs with white and brown chicken feathers are used for albacore pole-and-line fishing.

On the other hand, when the boat finds a school of skipjack which cannot be caught by jigs, live bait hooks are used. Sometimes, skipjack is caught by jigs as long as the catch is good, but when the catching rate decreases live bait hooks are used instead of jigs.

T. Kariya studied the angling mechanism for skipjack pole-and-line. His three types of angling curves reproduced below (Fig. 25), show how after the initial decrease in the catch rate by jig, the fishermen boost the catch rate by switching over to live bait hook.



Live bait fish is placed on the hook as illustrated in Fig. 26. Anchovy, 6-10 g (6-10 cm) in size, is suitable as the bait fish for skipjack pole-and-line. Larger anchovy, 8-15 g (8-13 cm) in size, is used for albacore pole-and-line fishing. A 40-ton boat uses 80-120 buckets of live bait fish (capacity of a bucket is 18 litres) in the course of one fishing trip.

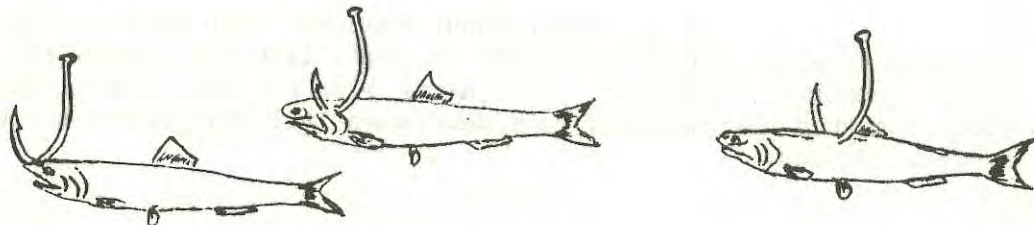


Fig. 26. Methods of hook baiting

2.3 Longline fishing

Handline and pole-and-line fishing is movable fishing, operations are done at the place where the school of fish is found. On the other hand, longline fishing is passive, that is, the gear is set at the place where the school of fish is expected to be found. Therefore the scale of gear is comparatively larger than the gear of handline and pole-and-line fishing.

Longline is classified into two types of fishing, one is drifting longline and the other is bottom longline.

2.3.1 Drifting longline

Drifting longline which is the largest in the size of boat, size of gear etc., is tuna longline.

Tuna longline fishing is operated in any sea water between the latitudes of 40° south and 40° north. The number of units of gear used is different according to the size of the boat, but the construction of gear is almost the same in all cases.

a) Tuna longline fishing with a small boat

Tuna longline fishing originated as a small scale fishery in coastal waters of Japan. Gradually, with the mechanization and modernization of fishing vessels, new fishing grounds have been developed and expanded from coastal waters to off-shore and pelagic waters.

Tuna longline fishing is still operated in the coastal and off-shore waters on a small scale with small boats of under 20 tons. Generally, tuna caught by small boats and preserved by means of ice and sea water is more expensive than tuna caught and frozen for long periods on board large vessels which operate in pelagic waters.

i) 10-ton boat

Gear is shown in Fig. 27 and its specifications are given in Table 10.

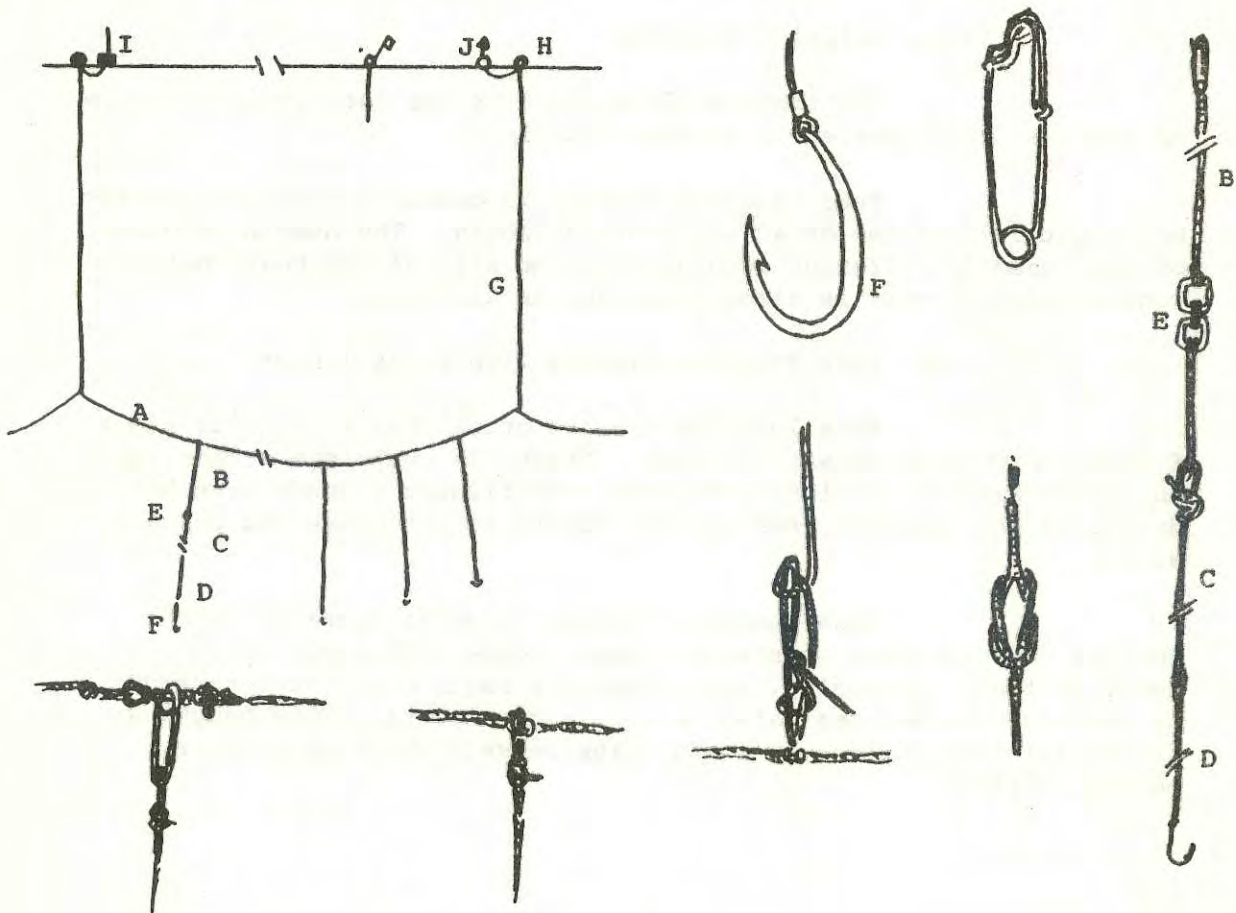


Fig. 27. Tuna longline fishing gear (10-ton boat)

Table 10. Specifications of tuna longline fishing gear

a) Bigeye and albacore

Mark	Name	Material	Size/Quantity
A	Main line	Vinylon	∅ 5.5 mm 37.5 m 14 ps
B	Branch line	Vinylon	∅ 5.5 mm 10.5 m Bigeye 5 ps Albacore 13 ps
C	Sekiyama	Wire with cotton	3 m
D	Hook line	Wire	2 m
E	Swivel		
F	Hook		
G	Float line	Polyethylene	∅ 5.5 mm 12 m
H	Float	Glass	∅ 24 cm
I	Radio buoy		3-4 ps
J	Light buoy	Battery	12 V 6-7 ps every 15-20 baskets

b) Yellowfin and marlin

Mark	Name	Material	Size
A	Main line	Vinylon	∅ 5.5 mm, 52.6 m 6 ps
B	Branch line	Polyethylene	∅ 3.5 mm, 12 m 5 ps
C	Sekiyama	Nylon	4.5 m 5 ps
D	Hook line	Wire	3 m 5 ps
E	Swivel		
F	Hook		
G	Float line	Polyethylene	∅ 3.5 mm 10.5 m
H	Float	Glass	∅ 18 cm
I	Radio buoy		3 ps
J	Light buoy	Battery 12 V	6-7 ps every 20 baskets

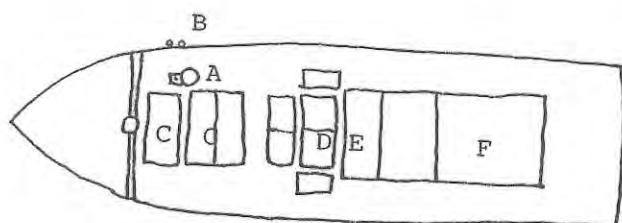
One unit (one basket) of the main line for catching bigeye and albacore is composed of 14 lines, each one 37.5 m long. Branch lines are joined to the joining parts of the main line.

In case of yellowfin tuna longline and marlin longline, the main line consists of 6 parts, each one 52.6 m long. The yellowfin tuna longline has five branch lines, whereas the marlin longline has 4 branch lines and the float line is attached to the centre part of the main line.

The way of joining the branch lines and the float line to the main line is shown in Fig. 27.

A branch line is composed of three parts: the branch line proper, sekiyama and the hook line. A swivel is used between the branch line and sekiyama to prevent the hook line from twisting and entangling with the main line. Sekiyama and the hook line are joined as shown in Fig. 27. A hook is fixed to the hook line by means of a snap.

Fishing boats of less than 10 tons, 70-100 h.p., with 6-7 crew, are used. Each boat has a live bait preservation hold, a fish hold with ice, line hauler, side roller, fish finder, wireless, and loran. Fig. 28 shows the facilities of a small tuna longline boat.



- A: Line hauler
- B: Side roller
- C: Fish hold
- D: Live bait fish preservation hold
- E: Bridge
- F: Fishing gear store (upper deck)

Fig. 28

Live jack-mackerel is used for yellowfin and marlin longline fishing mainly, but frozen saury, squid and mackerel are also commonly used. The way of placing bait on hooks is shown in Fig. 29. In the case of live bait fish, the hook pierces slightly the front part of the first dorsal fin, but when frozen bait fish is used, the hook pierces the head of the fish from top downwards.

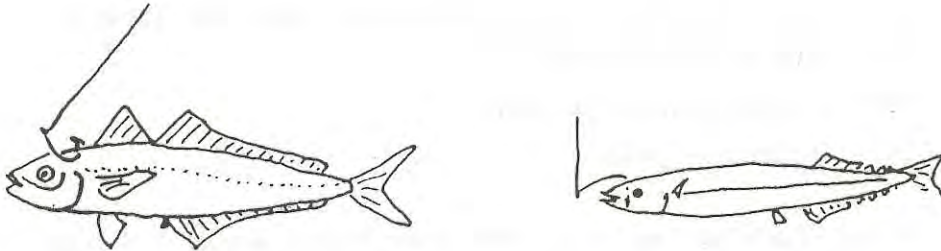


Fig. 29. Method of baiting longline hooks

The choice of fishing ground is made before departure of the boat, according to the data obtained from the fishing information centre or other boats in the port, but the exact operation position is dictated by sea conditions such as water temperature, water colour etc., and the presence of other boats operating in the area.

Lines are shot around sunrise from the stern part of the boat while the bait fish are placed on the hooks. The position of crew during shooting is shown in Fig. 30.

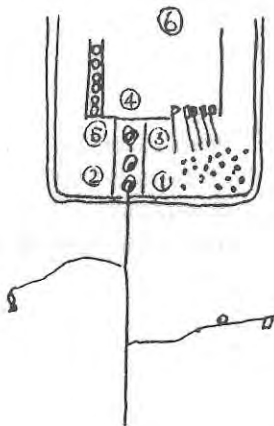


Fig. 30 Position of crew during longline shooting operation

It takes about 3 hours to shoot 170 baskets.

Duties of the crew shown in Fig. 30 are as follows:

- (1) shoots the main line and hands over the branch lines to (2),
- (2) places the bait fish on the hooks and shoots the branch lines,

- (3) joins the float line to the main line and shoots,
- (4) carries the baskets,
- (5) prepares the bait fish,
- (6) steers the boat.

After shooting the line, the boat drifts about 4-5 hours near the end of the line. While the boat is drifting, the crew take a rest and/or prepare for hauling. Hauling starts around 5 p.m.; it is done with the help of the line hauler. It takes about 7-8 hours to haul all lines. Duties of the crew during hauling (Fig. 31) are as follows:

- (1) handles the line hauler and processes the catch,
- (2) hauls the branch lines, coils them and places them with the main line,
- (3) manages the main line,
- (4) makes the baskets and carries them to the stern part for next shooting,
- (5) manages the floats,
- (6) steers the boat.

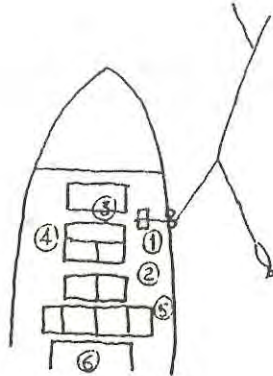


Fig. 31. Position of crew during longline hauling operation

(ii) 20-ton boat

Gear is shown in Fig. 32 and its specifications are given in Table 11.

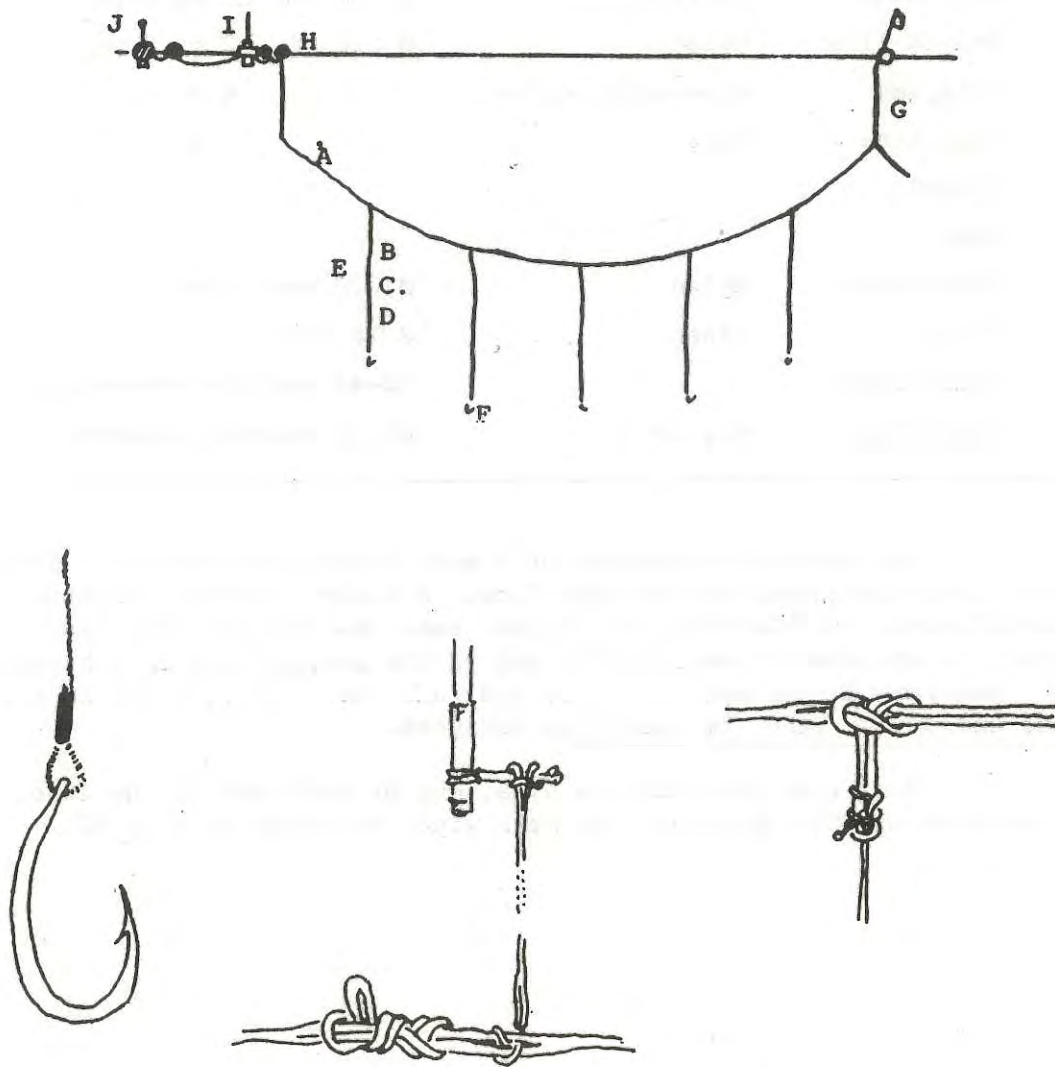


Fig. 32 Tuna longline fishing gear
(20-ton boat)

Table 11. Specifications of tuna longline fishing gear

Mark	Name	Material	Demensions/Quantity
A	Main line	Vinylon	Ø 5.5 mm, 50 m, 6 ps
B	Branch line	Nylon	Ø 2.8 mm, 12 m, 5 ps
C	Sekiyama	Wire with cotton	4 m
D	Hook line	Wire	3 m
E	Swivel		
F	Hook		
G	Float line	Nylon	Ø 3.0 mm, 12 m
H	Float	Glass	Ø 18 cm
I	Radio buoy		42-48 baskets intervals
J	Light buoy	6V, 3W	21-24 baskets intervals

One basket is composed of 6 main lines, each one 50 m long. Branch lines are joined to the main line. A branch line is composed of three parts: the branch line proper, sekiyama and the hook line. A swivel is attached 20 cm from the end of the branch line on sekiyama side. Sekiyama has an eye at either end, and the hook line has an eye at one end of the line, to join with sekiyama.

The float line has two eyes, one at each end of the line, to join with the flag pole and the main line, as shown in Fig. 32.

Fishing boat of 20 tons, 120-130 h.p., with 6 crew is used. Facilities and their arrangement are shown in Fig. 33.

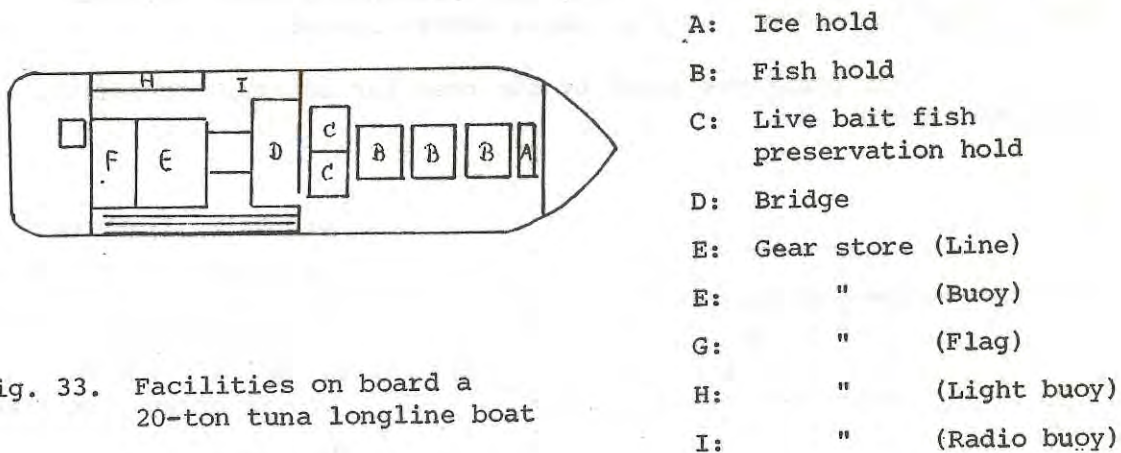


Fig. 33. Facilities on board a 20-ton tuna longline boat

The boats of this size has a radar, direction finder, Loran, wireless and fish finder.

Live jack-mackerel or mackerel is generally used as bait; the optimum size of bait is 50-80 g per fish. Frozen saury and squid are used when live bait fish is not available.

The hook pierces slightly the front part of the first dorsal fin, as shown in Fig. 34. The amount of bait fish necessary for 7-10 operations in one trip is kept on board.

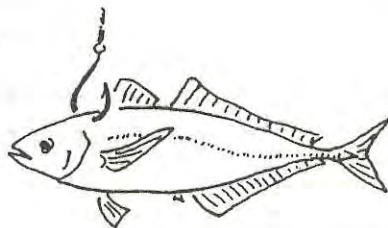
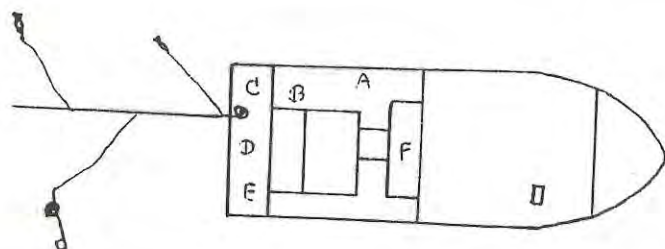


Fig. 34. Method of baiting tuna longline hooks

Shooting begins after dawn while bait fish is being placed on hooks. Light buoys are shot every 21-24 baskets, and a radio buoy is shot with every second light buoy. It takes three hours to shoot 150 baskets. After the shooting of line, the boat drifts near the end of the line until before sunset.

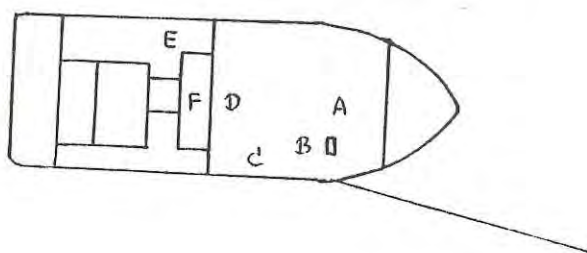
The positions taken by the crew for shooting operation is shown in Fig. 35.



- A: Bait, light buoy
- B: Line
- C: Placing bait, shooting branch line
- D: Shooting main line
- E: Float
- F: Steering

Fig. 35. Position of crew during tuna longline shooting operation

Hauling starts shortly before sunset. It takes 6-7 hours to haul 150 baskets. The position of the crew is shown in Fig.36.



- A: Main line
- B: Line hauler
- C: Branch line
- D: Catch
- E: Line, float, buoy
- F: Steering

Fig. 36. Position of crew during tuna longline hauling operation

b) Large-scale tuna longline fishing

Tuna longline boats of 200-400 tons operate at the pelagic tuna fishing grounds all over the world. These boats are undergoing rapid modernization of facilities and mechanization of fishing equipment in the face of increasing demand for fish as well as rising cost of labour. With the introduction of power equipment such as the line winder system and the reel system, it has been possible to reduce the number of crew of a tuna longliner from 27 or 28 to between 17 and 21. There has been a considerable development in the processing and the catch-preservation facilities on board tuna longliners. In modern vessels the temperature of the freezing chamber is -55° to -60°C and that of the fish hold is -45° to 50°C , thus allowing excellent preservation of catch for very long periods. At present, tuna longliners operate for 8-12 months continuously, storing their catch on board, only stopping at a port once every 2-3 months to renew their supplies of water and provisions.

Fishing gear

Gear is shown in Fig. 37 and its specifications are given in Table 12.

The main line can be a single line up to 150,000 m long. When not in operation, it is either wound on the reel on the stern part of the boat which is equipped with the reel system, or it is coiled in the storage box in case of boats equipped with the line winder system.

Branch lines are attached to the main line, at suitable intervals, by means of a snap which is shown in Fig. 37.

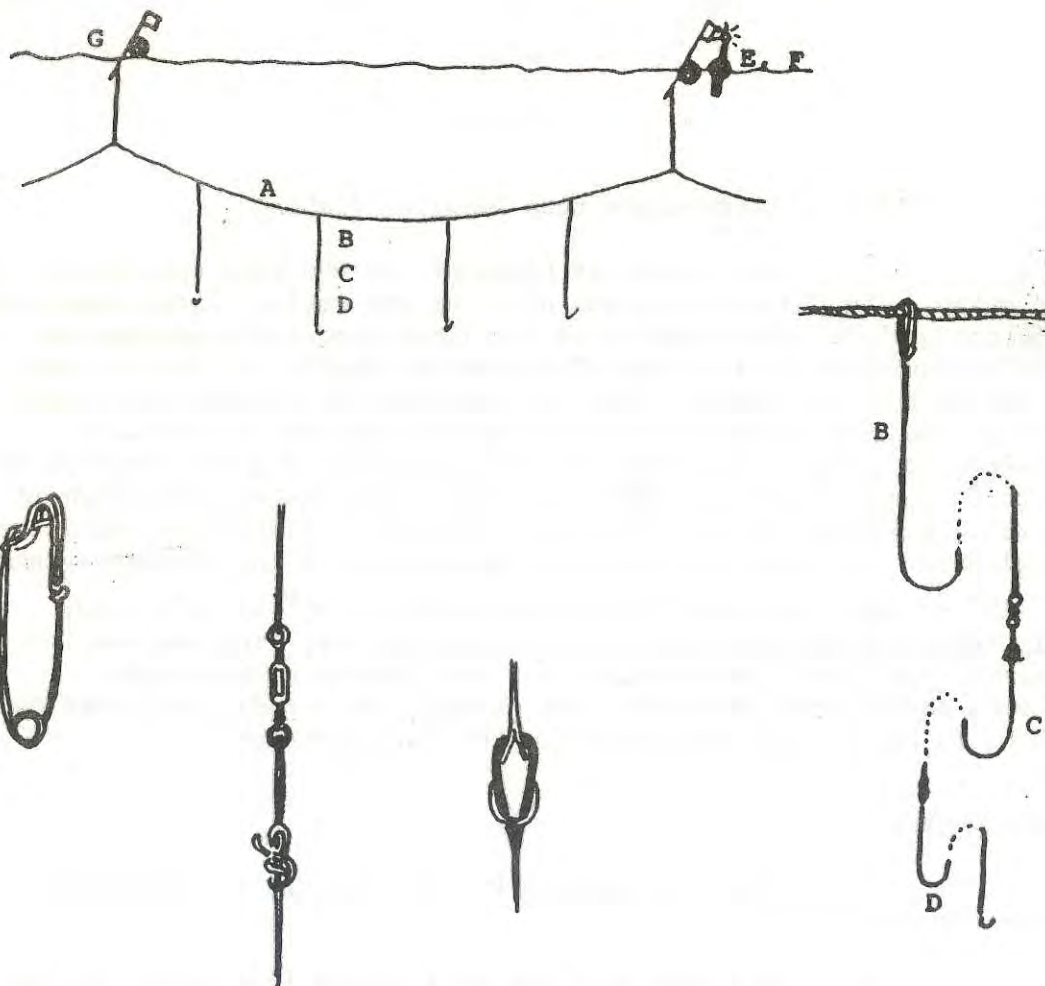


Fig. 37. Gear for large-scale tuna longline fishing

Table 12. Specification of tuna longline gear

Mark	Name	Material	Size/Quantity
A	Main line	Vinylon	Ø 6.2 mm, 150,000m
B	Branch line	Vinylon	Ø 5.5 mm, 11-14 m, 2000-2500 ps
C	Sekiyama	Wire with cotton	7-10 m, 2000-2500 ps
D	Hook line	Wire	2-4 m, 2000-2500 ps
E	Radio buoy		2-4 ps
F	Light buoy		10-20 ps
G	Float	Glass or plastic	Ø 30 cm

Fishing method

All tuna longline boats over 100 GT are built with a long poop deck. Such a deck has certain advantages, for example, protecting the ship from the following wave or beam wave during shooting of the line. Also, when the line is hauled against the wind at an angle, it is easy to keep this angle because the resistance of wind in bow part of the boat is less than in the stern part.

Frozen saury, squid and mackerel are used as bait. There have been some attempts to introduce artificial bait, so far without significant results.

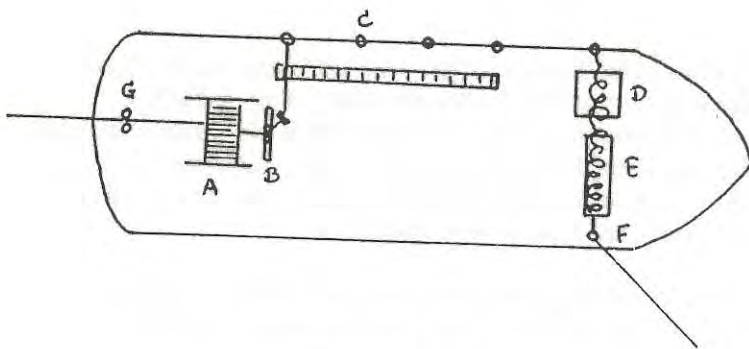
The main line of the old type, which consists of many parts, is shot while the line is being joined by baskets, at speed of boat of 5 knots or more. The modern main line is a single piece of line to which branch lines have to be attached while shooting is done, at the speed of boat about 10 knots.

Shooting generally begins before sunrise. The boat runs with a constant course following the direction of the wind.

Hauling begins in the early afternoon with the help of the line hauler. Ideally, the course of the boat should be kept at the starboard bow wind. It takes about 10 hours to haul the entire line. Fig. 38 shows the facilities on board boats equipped with the reel system and line winder system.

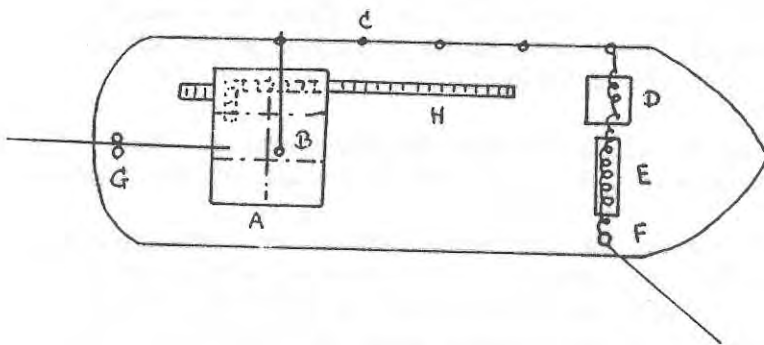
Table 13a, b and c shows the specifications of the main line, branch line and wire for hook line respectively.

Table 14 shows the specifications of the line hauler.



(Reel system)

- A: Reel
- B: Traverse
- C: Guide roller
- D: Water tank
- E: Slow conveyer
- F: Line hauler
- G: Shooting machine
- H: Conveyer



(Line winder system)

- A: Main line store
- B: Line winder
- C: Guide roller
- D: Water tank
- E: Slow conveyer
- F: Line hauler
- G: Shooting machine
- H: Conveyer

Fig. 38. Facilities on board boats equipped with the reel system and the line winder system

Table 13.

a) Specifications of main line for tuna longline

Vinylon F (1500 D/120 F)

<u>Diameter (mm)</u>	<u>g/m</u>	<u>Breaking strength (kg)</u>		<u>Weight of 200 m (kg)</u>
		Dry	Wet	
3.28	7.2	175	148	1.40
4.16	11.7	260	230	2.34
4.60	14.0	304	272	2.80
5.00	16.3	350	312	3.26
5.68	20.7	440	394	4.14
5.98	22.9	484	435	4.58
6.36	25.2	530	477	5.04

b) Specifications of branch line for tuna longline

	<u>Diameter (mm)</u>	<u>Breaking strength (kg)</u>
Nylon (55%) Polyester (45%)	4.4	300
Nylon (55%) Polyester (45%)	4.8	350
Nylon (60%) Polyester (40%)	5.2	400

c) Specifications of hook wire for tuna longline

No.	Diameter (mm)	Breaking strength (kg)
26	2.2	220
27	2.0	180
28	1.8	155
29	1.6	130
30	1.5	115
31	1.4	100

Table 14. Optimum size of the line hauler for different sizes of fishing boats.

Height (m)	Weight (kg)	Hauling speed (m/min), h.p.		Size of boat
1.5	400	High speed	252	10 over 90 tons
		Low "	168	
1.4	280	High "	216	7.5 over 30 tons
		Low "	144	
1.3	280	High "	216	7.5 over 20 tons
		Low "	144	
1.2	190		75	5 over 10 tons
0.8	106		63	2 under 10 tons

c) A study of tuna longline fishing

The Japan Marine Fishery Resource Research Center (JAMARC) carried out an experiment in tuna longline fishing in higher latitudes of the Southwest Pacific, in the area shown in Fig. 39. The purpose of the experiment was to investigate the fishing grounds vertically, i.e. below the depths where tuna is normally caught with the existing tuna longline gear.

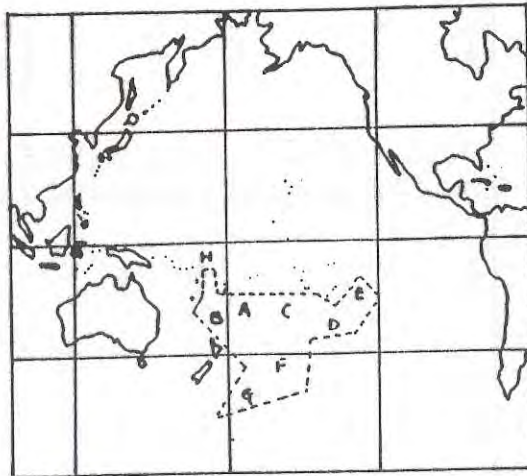


Fig. 39. Location of the JAMARC tuna longline experiment

In order to examine vertical distribution of tuna and marlin, various types of tuna longline gear were used. Fig. 40 illustrates how the gear was used. The curves are obtained assuming that the main line in each case makes a catenary curve. The depths of branch lines obtained from this figure, as well as the depth of branch lines measured by depth meter, are given in Table 15.

Table 15. Tuna longline experiment: relationship between the fishing method and the depth of hook

Fishing ground	No. of hooks per basket	Length of float line (m)	Length of main line (e)	Per basket Distance between floats (f)	Shrinkage (g=e/f)	Hook position	Depth by meter	Depth by catenary curve (m)	Target fish	
										86-93
A and B	10	20 m	572 m	315	0.55	1, 10	86-93	90	Bigeye, Marlin	
						2, 9		138		
						3, 8		186		
						4, 7		227		
A and C	11	20	624	331	0.53	5, 6	210-264	256		
						1, 11	90-93	90		
						2, 10		140		
						3, 9		187	Bigeye, Marlin	
C	5	20	468	249	0.53	4, 8		232		
						5, 7	293-302	268		
						6		286		
						1, 6		139		
D and E	14	20	780	447	0.57	2, 5		184	Marlin	
						3, 4	212-218	218		
						1, 14		90		
						2, 13		138		
H	12	20	676	366	0.54	3, 12	173-178	186	Bigeye	
						4, 11		232		
						5, 10	268-279	274		
						6, 9	320-323	310		
						7, 8	307-364	332		
						1, 12	70	90		
						2, 11	110	140		
						3, 10	180	188	Yellowfin	
						4, 9	200	233	Bigeye	
						5, 8	220	272		
6, 7	280	300								

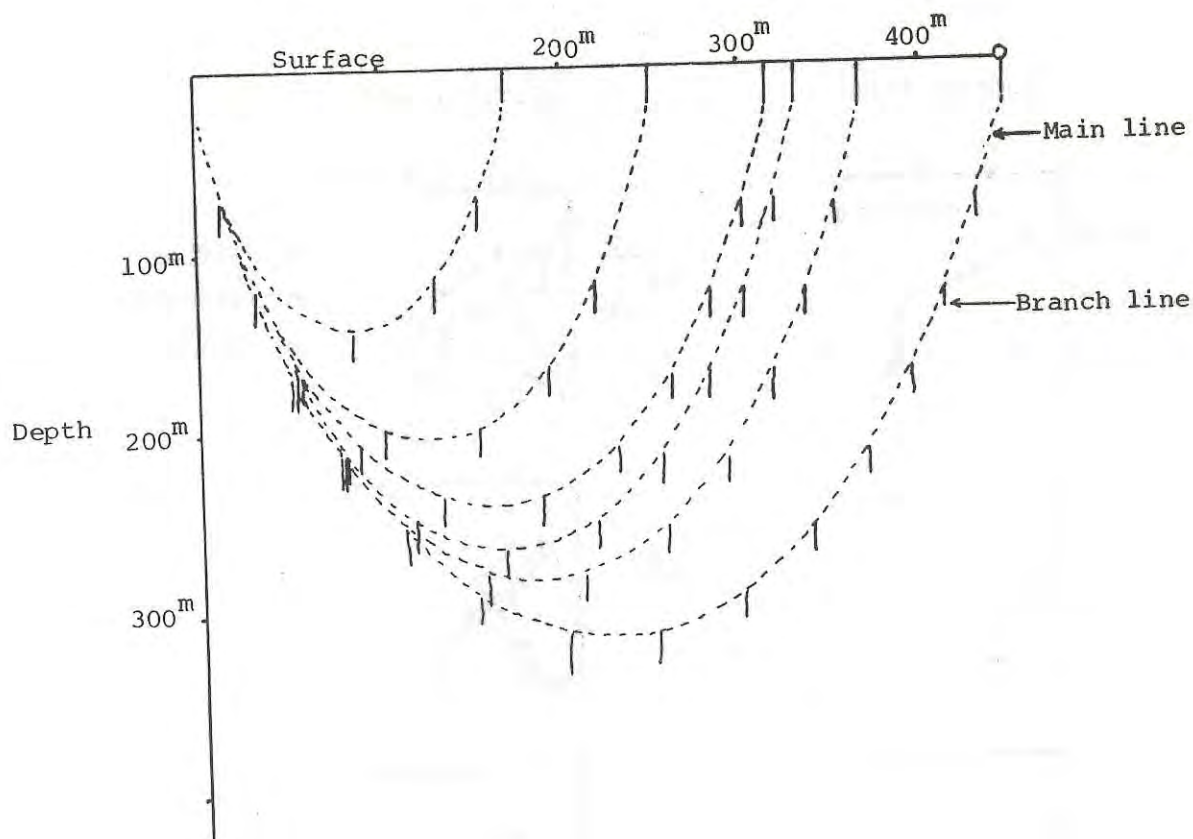


Fig. 40. Catenary curve

Hook rates by species and by depth at fishing grounds A, C, D and H are shown in Fig. 41. In the case of bigeye, higher hook rate was obtained at the fishing ground D when deep long-line with 14 branch lines in a basket was used. The depth where the hook rate showed over 0.5 was between 275-330 meters. From this, it was known that the bigeye's dwelling depth is about 300 m or more. Albacores were caught a lot at the fishing ground A with the gear constructed with 11 branch lines in a basket. Hook rate was more than 4.7 at the depth of 185-285 meters. In the case of yellowfin and marlin, good hook rate was obtained at almost the same depth. The depth where the hook rate was over 0.4 for yellowfin and for marlin was 140-235 meters.

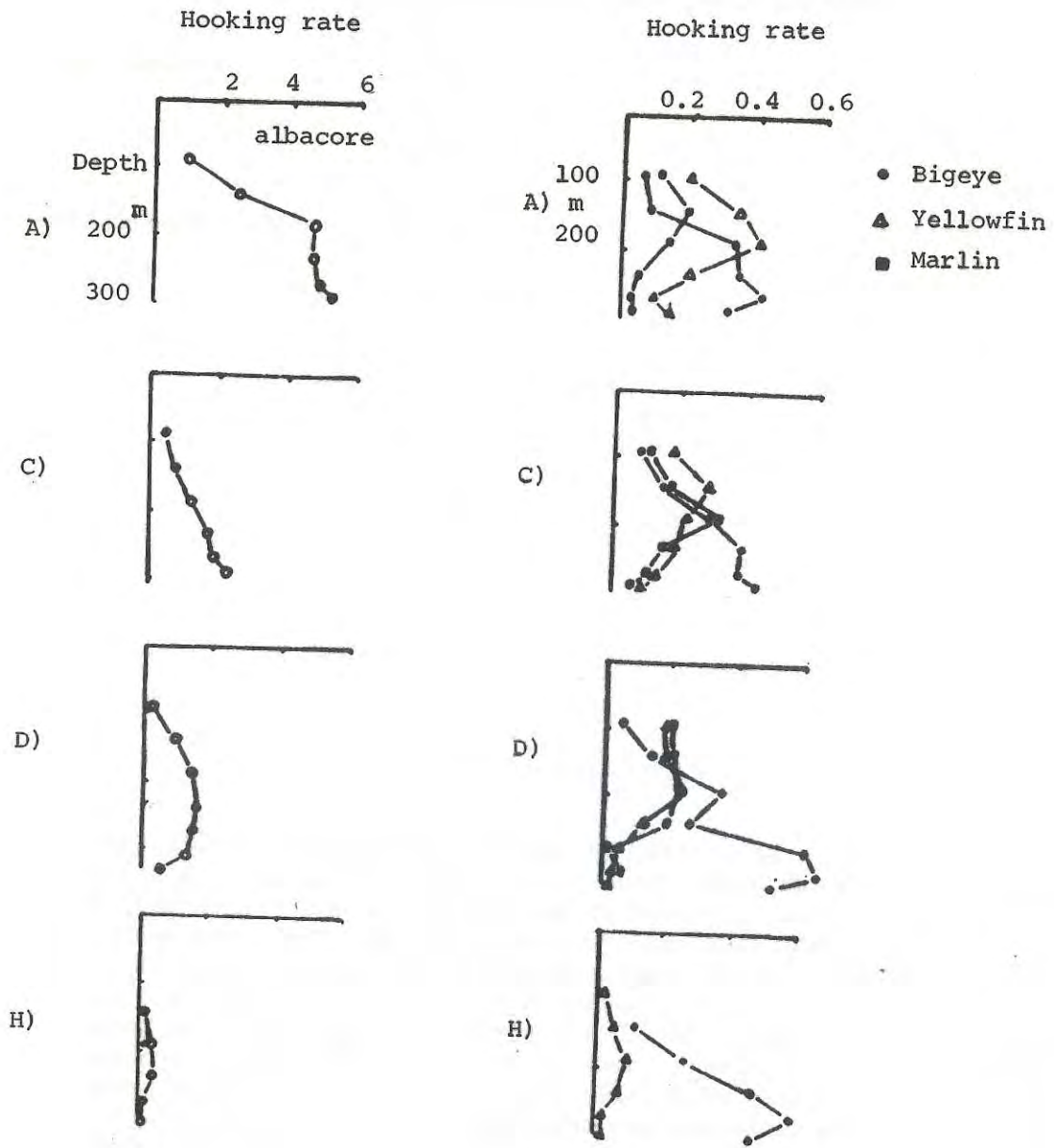


Fig. 41 Hook rate by depth of hook

2.3.2 Bottom longline fishing

Bottom longline is used widely throughout the world. There are many types of bottom longline, but many of them are operated only on a small scale, generally in coastal waters.

a) Materials and structure of bottom longline gear

(i) Main line

Cotton and vinylon are widely used because these materials have high specific gravity which gives them high sinking speed and reduces the effect of current upon gear. Thickness is determined by many factors such as character of the bottom, speed of current, depth of water, size of fish, pulling power of fish, number of branch lines and size of the fishing boat. Generally, thickness of the main line used by small boats (1-3 tons) in waters of less than 100 m depth, is about 1.5 mm in diameter. Boats of 3-10 tons use a thicker main line whose diameter ranges from 1.5-2.2 mm.

When fishing is done in waters with strong current, a main line thicker than 2.3 mm in diameter is used, regardless of the size of the boat. In most cases, length of one unit (basket) of main line ranges from 200-700 m.

(ii) Branch line

Branch line should be moved by current and should have low visibility. Nylon with its high flexibility, good breaking strength, elongation and durability is the most suitable material for branch lines. Thickness and length of branch lines are determined by the size and power of fish and the speed of current. Length will also have to be chosen so as to allow easy handling of gear.

Length of branch lines and intervals between branch lines are determined by the size of fish and density of school. Generally, the length of interval between the branch lines is from double to triple the length of a branch line. Fig. 42 shows the relation between the length of a branch line and intervals between branch lines for different kinds of fish.

Fig. 43 shows the relation between the thickness of the main line and the thickness of branch lines.

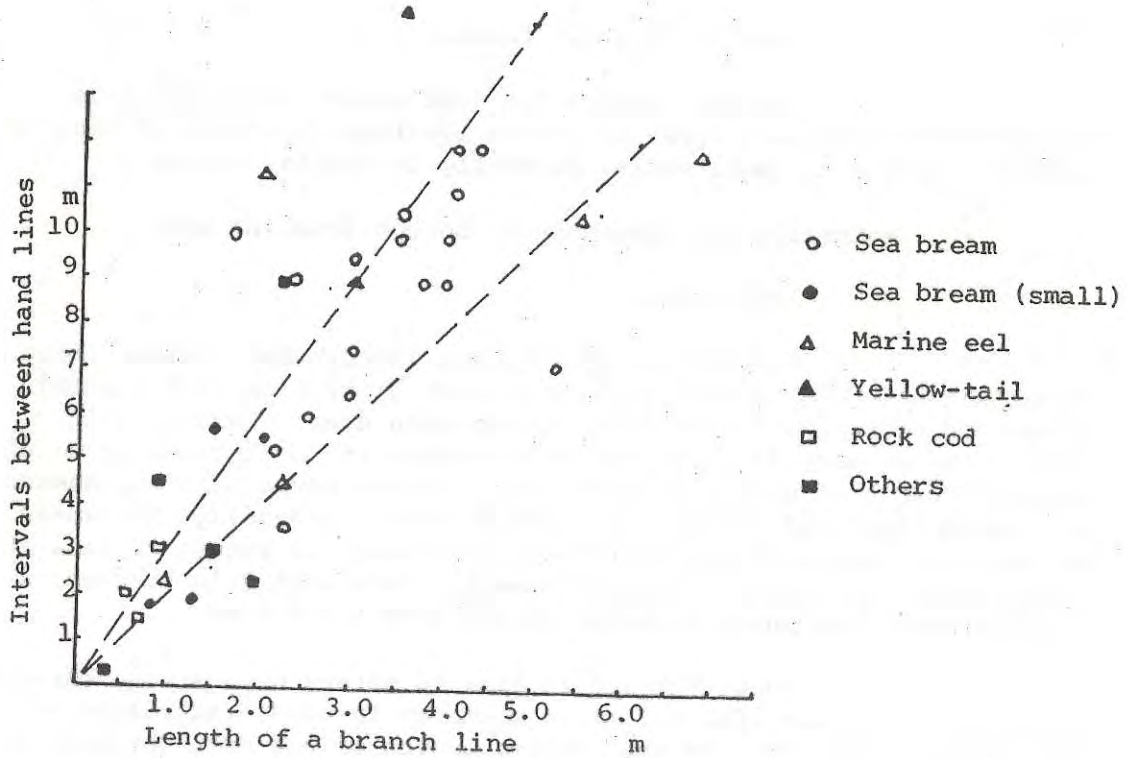


Fig. 42. Length of branch lines and intervals between branch lines

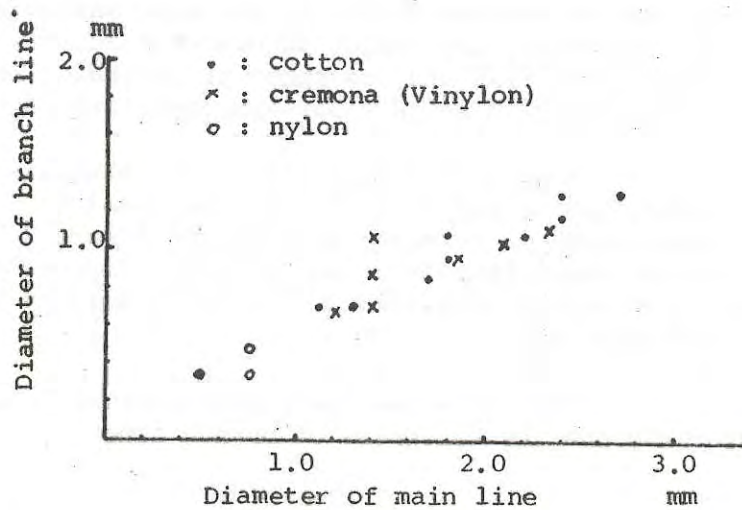


Fig. 43. Thickness of the main line and branch lines

b) Types of bottom longline and respective characteristics

Three main types of bottom longline fishing gear may be distinguished; we shall call them here Type A, Type B and Type C. Type A (Fig. 44): This is the most commonly used type of bottom longline gear. Its structure is very simple making it also easy to handle. A disadvantage of this type of gear is that since the main line or branch lines sometimes get caught by rocks, which may result in damage or loss of gear. Also, bait may be taken from the hooks by bottom dwellers such as starfish or crab.

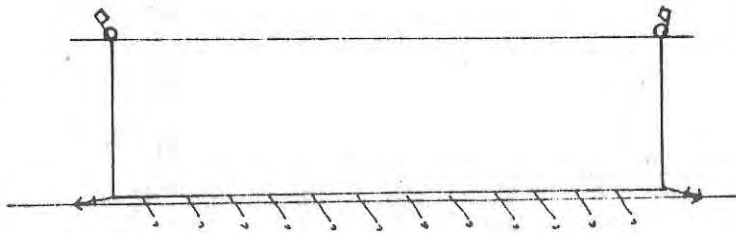


Fig. 44. Bottom longline, Type A

Type B (Fig. 45): The structure of gear is more complicated. The main line, branch lines and hooks do not touch the sea bottom. Therefore the risk of the gear getting caught by rocks or other obstacles at the bottom is not so great. Fish which dwell near the bottom are caught by this gear.

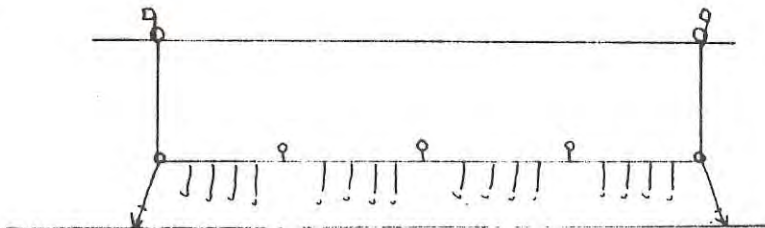


Fig. 45. Bottom longline Type B

Type C (Fig. 46): This gear has the most complex structure. The main line is suspended at some distance above the bottom, depending on the length of branch lines. Thus the main line does not touch the bottom whereas the branch lines do. If a branch line gets caught by some obstacle at the bottom, only that particular line would get damaged or lost, without a risk to the rest of the gear. In this type of gear, hooks are placed between the sea bottom and the main line so that the fish which dwell near or at the bottom are caught.

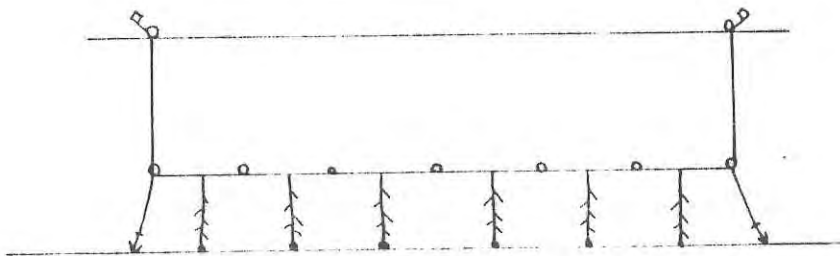


Fig. 46. Bottom longline, Type C.

(i) Sea bream bottom longline (1)

Fishing gear

Gear is shown in Fig. 47 and its specifications are given in Table 15.

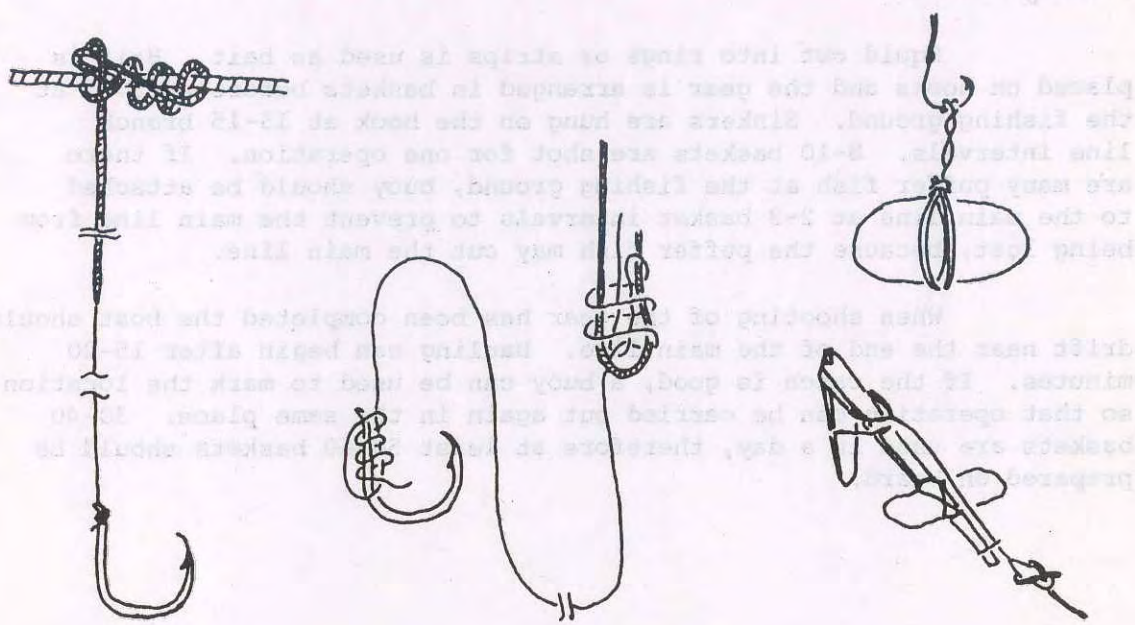
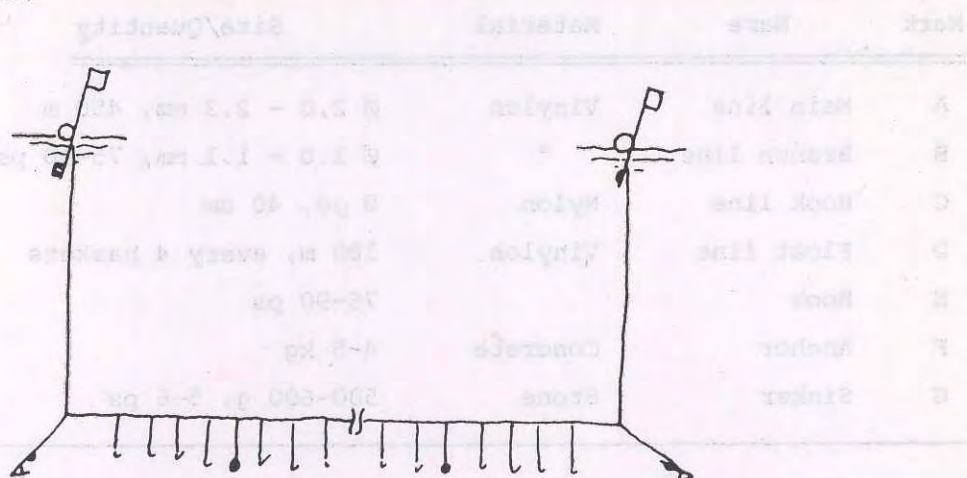


Fig. 47. Sea bream bottom longline (1)

Table 16. Sea bream bottom longline (1)

Mark	Name	Material	Size/Quantity
A	Main line	Vinylon	Ø 2.0 - 2.3 mm, 450 m
B	Branch line	"	Ø 1.0 - 1.1 mm, 75-90 ps
C	Hook line	Nylon	8 go, 40 cm
D	Float line	Vinylon	180 m, every 4 baskets
E	Hook		75-90 ps
F	Anchor	Concrete	4-5 kg
G	Sinker	Stone	500-600 g, 5-6 ps

Fishing method

Squid cut into rings or strips is used as bait. Bait is placed on hooks and the gear is arranged in baskets before arrival at the fishing ground. Sinkers are hung on the hook at 13-15 branch line intervals. 8-10 baskets are shot for one operation. If there are many puffer fish at the fishing ground, buoy should be attached to the main line at 2-3 basket intervals to prevent the main line from being lost, because the puffer fish may cut the main line.

When shooting of the gear has been completed the boat should drift near the end of the main line. Hauling can begin after 15-20 minutes. If the catch is good, a buoy can be used to mark the location so that operation can be carried out again in the same place. 30-40 baskets are used in a day, therefore at least 50-60 baskets should be prepared on board.

A 3-4 ton boat is used for operation, with the crew of one or two fishermen. In the case of a one-man boat, the line hauler is set at the stern, but if there are two fishermen on board, it is set on the bow part of the boat (Fig. 48). The line hauler is driven by the main engine through the countershaft.

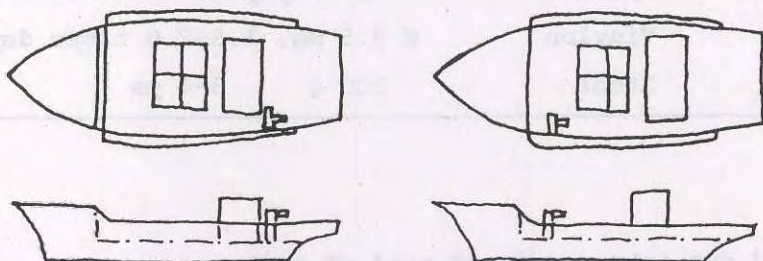


Fig. 48. Position of the line hauler

(ii) Sea-bream bottom longline (2)

Fishing gear

Gear is shown in Fig. 49 and its specifications are given in Table 17.

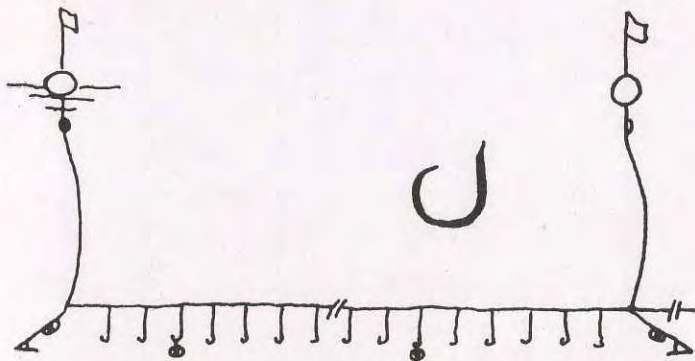


Fig. 49. Sea bream bottom longline (2)

Table 17. Sea bream bottom longline (2)

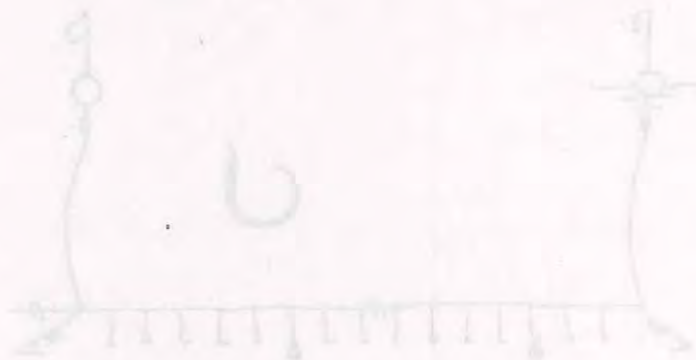
Mark	Name	Material	Size/Quantity
A	Main line	Cotton	Ø 1.5-2.3 mm, 276-366 m
B	Branch line	Nylon	10-22 go, 3.4-4.5 m, 30-40 lines
C	Buoy line	Vinylon	Ø 2.5 mm, 1.5-2.0 times depth
D	Sinker	Stone	300 g 3-4 ps

Fishing method

Squid cut into rounds is used as bait.

Shooting is done from the stern part of the boat while bait is put on hooks. The boat should be operated across the current in order to prevent branch lines entangling with the main line.

Hauling begins 30-60 minutes after shooting, by means of a line hauler which is driven by the main engine. Operation is carried out in the daytime, from sunrise to sunset. 10-15 baskets are used for one operation and 2-3 operations are done in a day.



(iii) Rockfish bottom longline

Fishing gear

Fishing gear is shown in Fig. 50 and its specifications are given in Table 18.

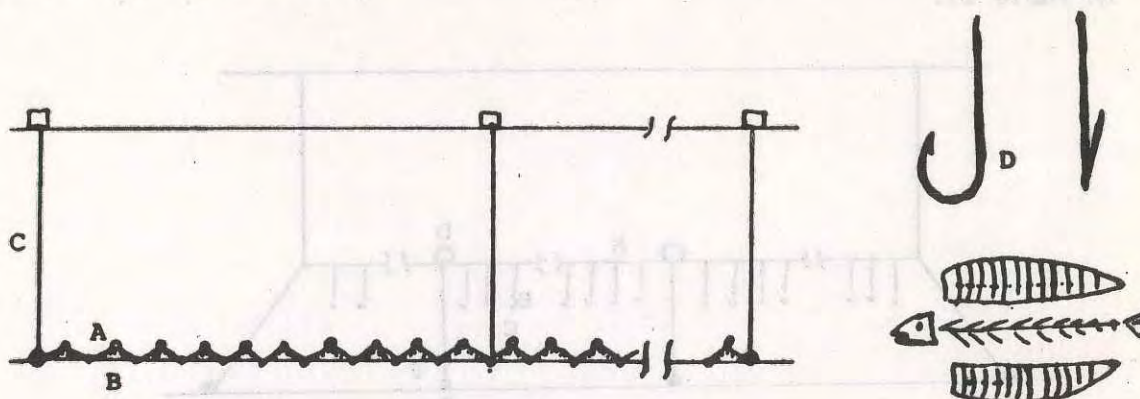


Fig. 50. Rockfish bottom longline

Table 18. Rockfish bottom longline

Mark	Name	Material	Size/Quantity
A	Main line	Cotton	∅ 1.5 mm, 68 m
B	Branch line	Nylon	5 go, 1 m, 2.6 m interval
C	Buoy rope	Vinylon	∅ 2.3 mm
D	Hook		

Fishing method

Saury fish is used as bait, cut into strips as shown in Fig. 50.

Two thirds of all branch lines in one basket should be laid on the sea bottom and the rest of the branch lines are hung above the sea bottom. Shooting is done while placing bait on hooks. After shooting the boat returns to the position from which it started and hauling begins.

(iv) Sea bass bottom longline

Fishing gear

Gear is shown in Fig. 51 and its specifications are given in Table 17.

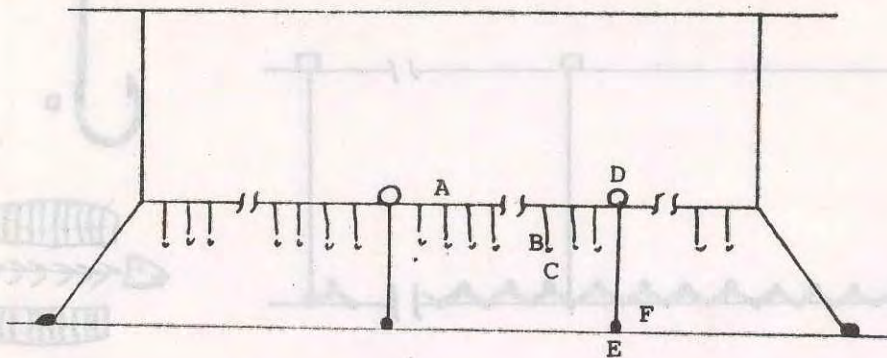


Fig. 51. Sea bass bottom longline

Table 19. Sea bass bottom longline

Mark	Name	Material	Size
A	Main line	Nylon	∅ 1.04 mm, 240 m
B	Branch line	Nylon	∅ 0.5 mm, 0.8 m 100 ps
C	Hook (Round type)		
D	Float	Glass	∅ 6-9 cm 4 ps
E	Sinker	Stone	300 g 4 ps
F	Sinker line	Vinylon	∅ 1.1 mm 10 m, 4 ps

Fishing method

Salted sardine is used as bait.

Operation is done in the early morning; 10 baskets are prepared and shot at ten places separately in order to cover a wide area of the fishing ground.

(v) Rockfish vertical bottom longline

Fishing gear

Gear is shown in Fig. 52 and its specifications are given in Table 20.

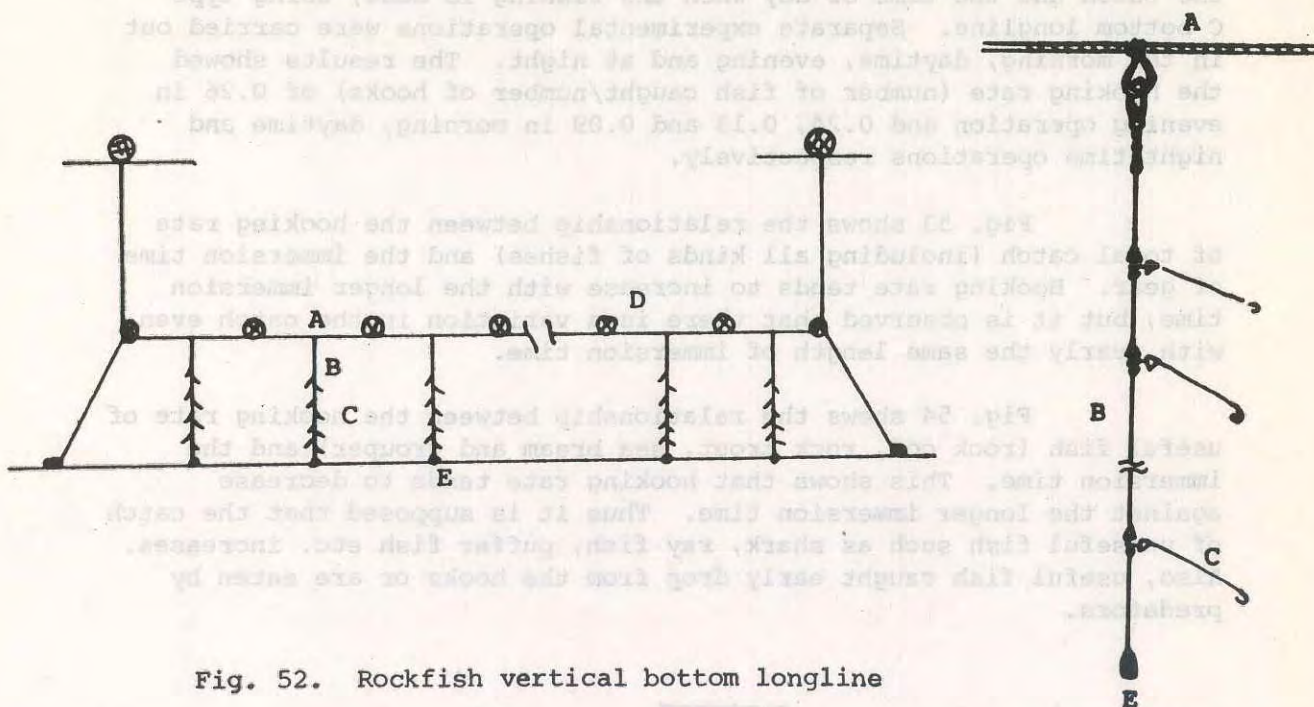


Fig. 52. Rockfish vertical bottom longline

Table 20. Rockfish vertical bottom longline

Mark	Name	Material	Size/Quantity
A	Main line	Vinylon	∅ 2.7 mm 960-2160 m
B	Branch line	Nylon	∅ 0.6 mm, 15 m, 40-90 ps
C	Hook line	Nylon	∅ 0.4 mm 0.8 m, 320-720 ps
D	Float	Glass	∅ 9 cm 24 m intervals
E	Sinker	Stone	40-90 ps

Fishing method

Squid is used as bait in night-time operation and mackerel, saury, sardine etc., are used in daytime operation.

Shooting is done just before sunrise; hauling begins from the starting point of the line as soon as shooting is finished.

c) A study of bottom longline

M. Ogura conducted a study on the relationship between the catch and the time of day when the fishing is done, using type C bottom longline. Separate experimental operations were carried out in the morning, daytime, evening and at night. The results showed the hooking rate (number of fish caught/number of hooks) of 0.26 in evening operation and 0.24, 0.13 and 0.09 in morning, daytime and night-time operations respectively.

Fig. 53 shows the relationship between the hooking rate of total catch (including all kinds of fishes) and the immersion time of gear. Hooking rate tends to increase with the longer immersion time, but it is observed that there is a variation in the catch even with nearly the same length of immersion time.

Fig. 54 shows the relationship between the hooking rate of useful fish (rock cod, rock trout, sea bream and grouper) and the immersion time. This shows that hooking rate tends to decrease against the longer immersion time. Thus it is supposed that the catch of unuseful fish such as shark, ray fish, puffer fish etc. increases. Also, useful fish caught early drop from the hooks or are eaten by predators.

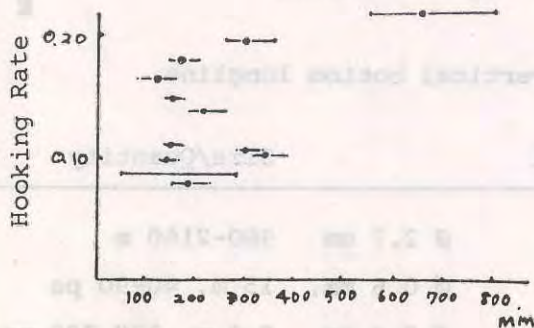


Fig. 53. Relationship between the hooking rate of total catch and the immersion time of the gear.

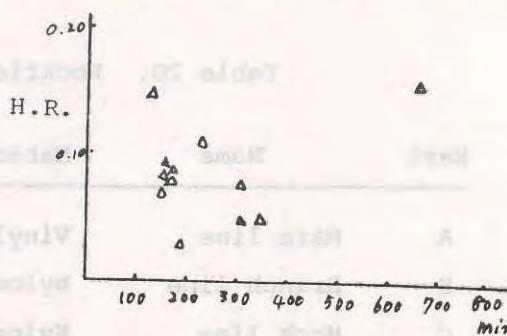


Fig. 54. Relationship between the hooking rate of useful fish and the immersion time of the gear.

It was observed that grouper were caught by hooks on the upper part of branch lines in morning operation, but in evening fishing they were caught by lower hooks. Rock trout were always caught by lower hooks. Rock cod were caught by lower hooks in morning, evening and night-time operations, but in the daytime they were caught by both lower and upper hooks.

2.4 Troll line fishing

Troll fishing gear is composed of a line, a trolling jig, and a diving board or splashing float whose function is to submerge or to move the jigs. The trolling jig moves like a small fish so that large fish are lured and captured. Boats used in troll fishing are generally small in size. Each boat tows several lines at a speed of 3 to 8 knots. The main species of fish captured by trolling are the pelagic ones, such as bonito, tuna, yellow-tail, etc.

2.4.1 Gear used for trolling

a) Diving board

There are many shapes of diving boards, but they all have basically the same function:

- to submerge the trolling jigs to the aimed depth,
- to move the jigs so as to simulate live bait fish,
- to indicate whether the fish are hooked; when this happens, the board comes up to the water surface.

Some types of diving boards are shown in Fig. 55.

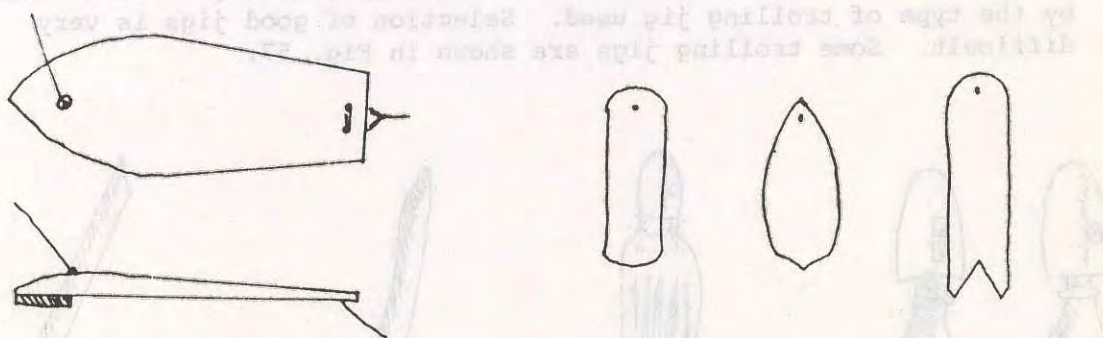


Fig. 55. Diving boards

b) Splashing float

There are many shapes of splashing floats; the purpose of these floats is as follows;

- to move the trolling jigs as if these jigs were real bait fish,
- to create waves and noise similar to those made by small fish,
- to indicate whether fish are hooked; generally, when fish are hooked, the float will submerge. Fig. 56 shows some splashing floats.

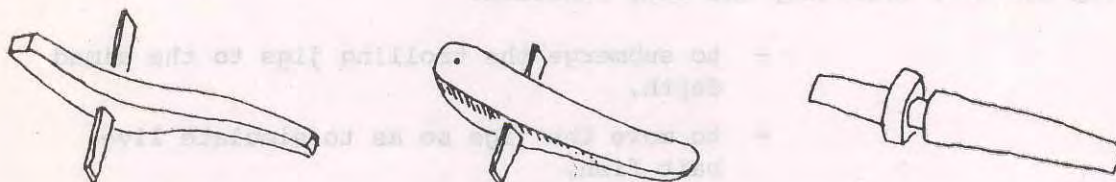


Fig. 56. Splashing floats

c) Trolling jig

The amount of catch by trolling is influenced by the type of trolling jig used. Selection of good jigs is very difficult. Some trolling jigs are shown in Fig. 57.

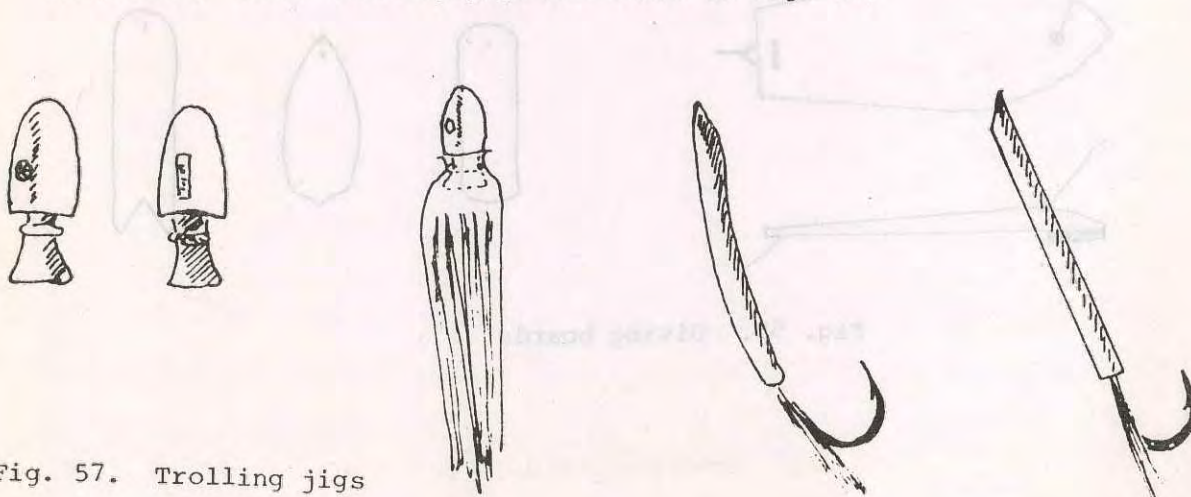


Fig. 57. Trolling jigs

2.4.2 Skipjack trolling

Fishing gear

Gear is shown in Fig. 58 and its specifications are given in Table 21.

The arrangement of different parts of gear is shown in Fig. 58. A special device is used to join the main line and the diving board in order to facilitate the removal or replacement of the diving board when necessary. The joint of the pole-tip line and the main line should come to the stern part of the boat when the main line is taken in by using messenger line.

Pole Tip line

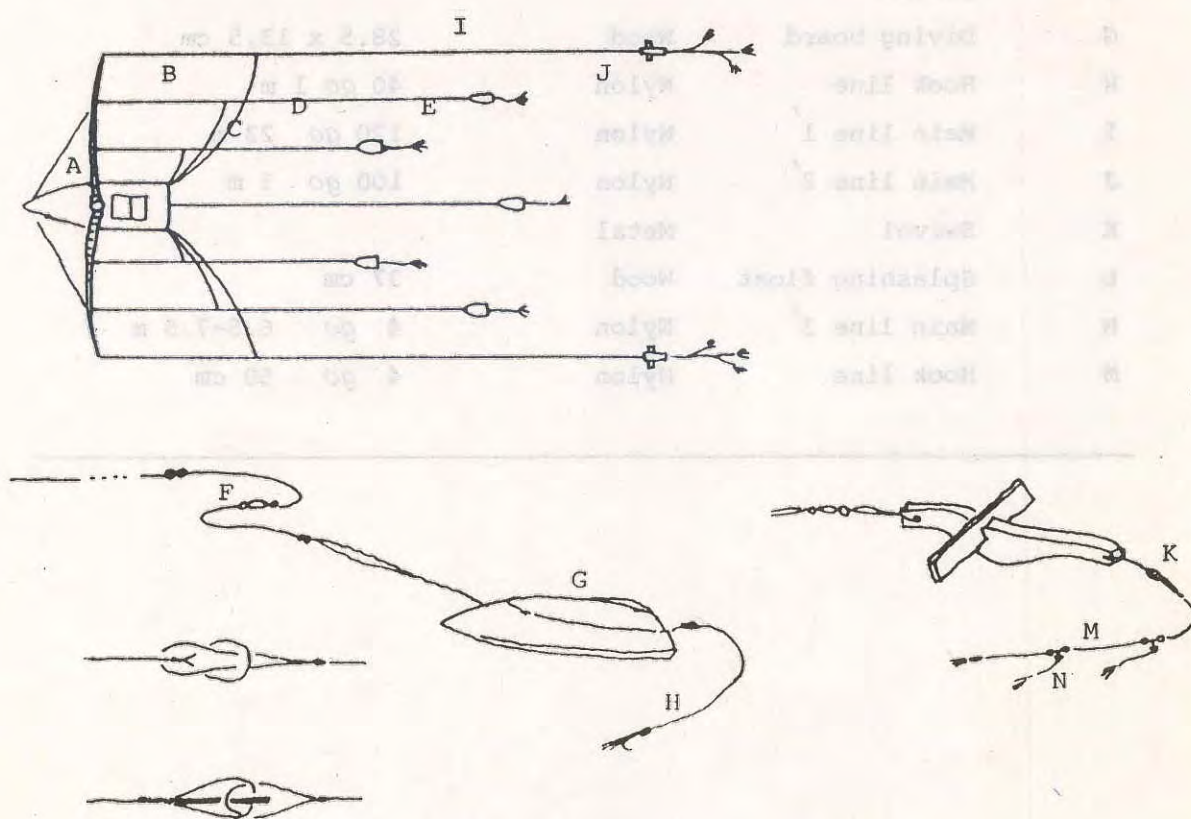


Fig. 58. Skipjack trolling gear

Table 21. Skipjack trolling gear

Mark	Name	Material	Size
A	Pole	Bamboo	8-10 m
B	Pole-tip line	Vinylon	∅ 6 mm, 4-12 m
C	Messenger rope	Vinylon	∅ 6 mm, 6-12 m
D	Main line 1	Nylon	120 go 6-13.5 m
E	Main line 2	Nylon	100 go 3 m
F	Swivel		
G	Diving board	Wood	28.5 x 13.5 cm
H	Hook line	Nylon	40 go 1 m
I	Main line 1'	Nylon	120 go 23 m
J	Main line 2'	Nylon	100 go 3 m
K	Swivel	Metal	
L	Splashing float	Wood	37 cm
M	Main line 3'	Nylon	4 go 6.5-7.5 m
M	Hook line	Nylon	4 go 50 cm

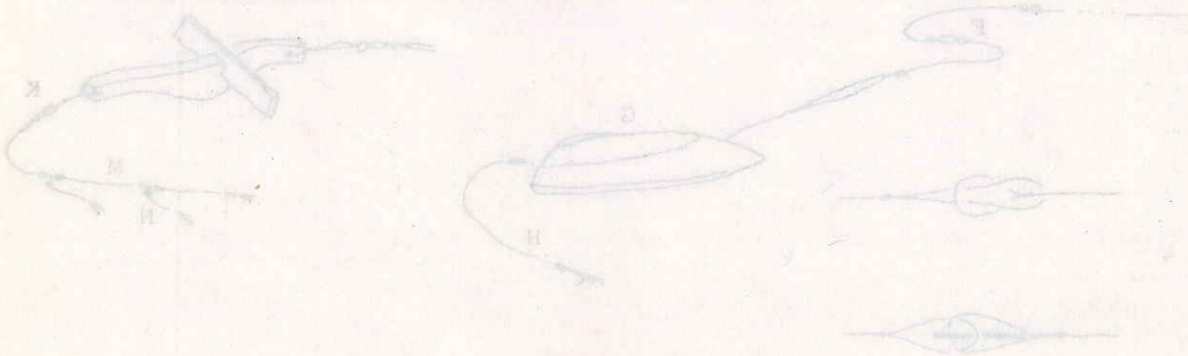


Fig. 58. Skipjack trolling gear

Fishing method

Squid-shaped or octopus-shaped lures are used for skipjack troll fishing. The lures are made of vinyl, chicken feathers, fish skin, etc. The head of the lure is made of lead or lead inlaid with shell, cow horn, animal bone, ivory or plastic. The hook is fastened to the line as shown in Fig. 59.

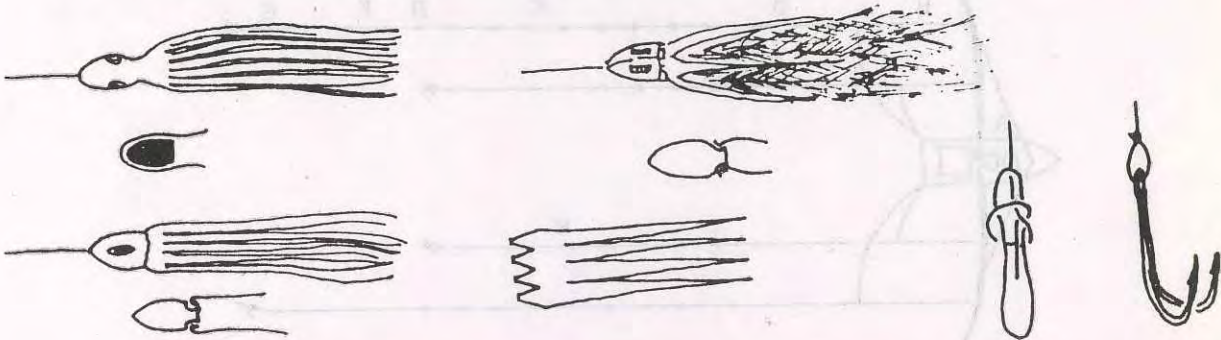


Fig. 59. Lures for skipjack troll fishing

1-8 ton boats are used, but the number of crew are one or two only. There is a device on board to hold the bamboo pole, shown in Fig. 60.

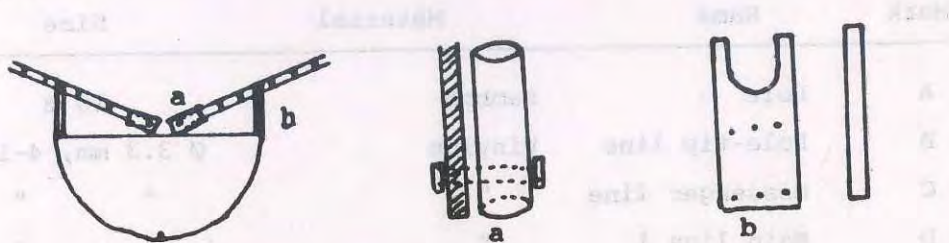


Fig. 60. Holding device for bamboo pole

When the first fish is hooked, it is not taken in; it is left on the hook to lure other fish. Generally, if the fish are hooked by the lines on only one side of the boat, the boat will change its course to that direction.

2.4.3 Spanish mackerel trolling

Fishing gear

Gear is shown in Fig. 61 and its specifications are given in Table 22.

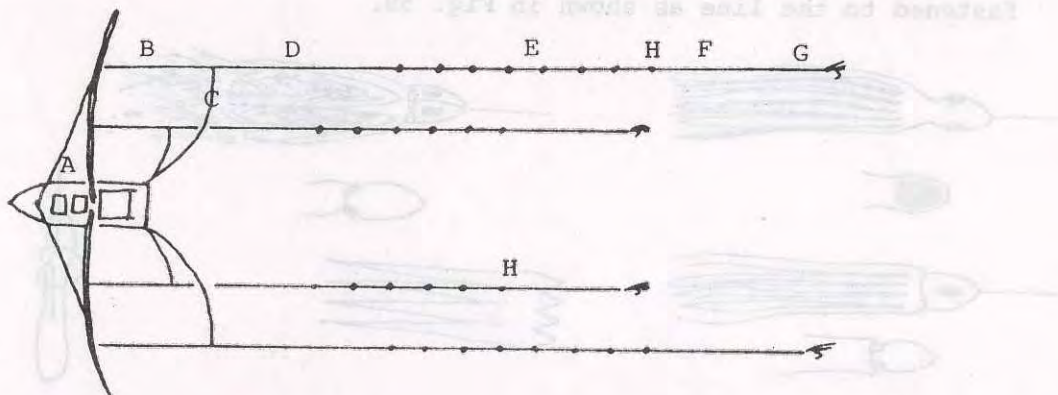


Fig. 61. Spanish mackerel trolling gear

Table 22. Spanish mackerel trolling gear

Mark	Name	Material	Size
A	Pole	Bamboo	10 m
B	Pole-tip line	Vinylon	∅ 3.3 mm, 4-12 m
C	Messenger line	"	" "
D	Main line 1	"	" "
E	" 2	Wire with cotton	30 m
F	" 3	Stainless steel	4 m
G	Hook line	Wire	3 m
H	Swivel		

25 pieces of lead are attached along the main line 2 at intervals which become shorter the nearer they are to the hook. The weight of each piece of lead is 45 g.

Fishing method

Four pieces of some shiny, light-reflecting material, such as abalone shell, are inlaid in the head of the lure. (Fig. 62). This is believed to increase effectiveness of the lure.

The teeth of spanish mackerel are sharp and can easily damage the line. Therefore, the hook line should be carefully examined every time when spanish mackerel is caught. Engine revolution is kept to 70% of normal operation while fishing.



Fig. 62. Lure for spanish mackerel troll fishing

2.4.4 A study on trolling

H. Sakazume studied the pulling force of fish caught by trolling, and obtained the following regression equation:

$$T = 3.31 W + 0.52$$

T: maximum tension of hook line (kg)

W: body weight of fish (kg)

Figure 63 shows the relationship between the maximum tension exerted by the fish on the hook line and the body weight of the fish.

Furthermore, the breaking strength of hook lines used actually was estimated for different fishing methods and for various body weights of fish. These are shown in Fig. 64. From this figure, it was found that the breaking strength of the line actually used by fishermen is large enough to catch the target fish, in the case of fish under 12 kg in body weight.

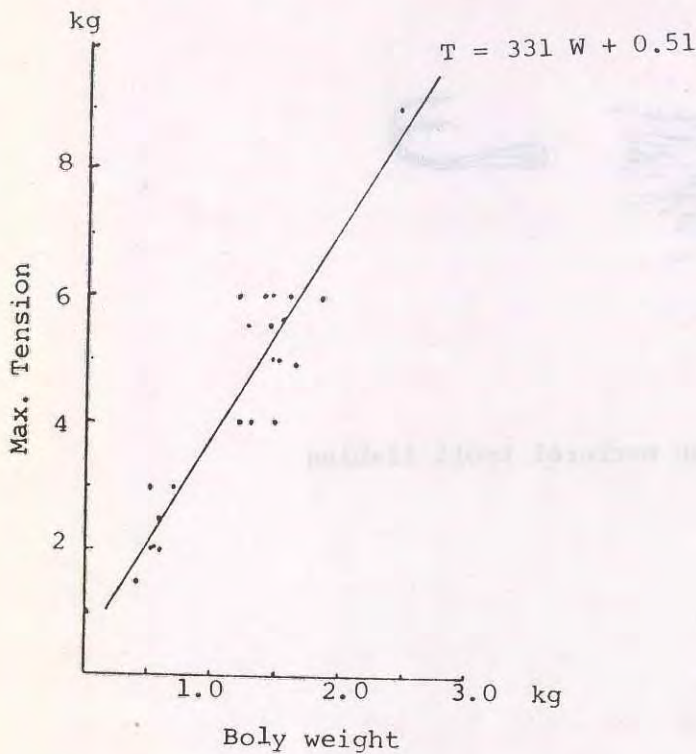


Fig. 63. Relationship between the maximum tension exerted by the fish on the hook line and the body weight of the fish.

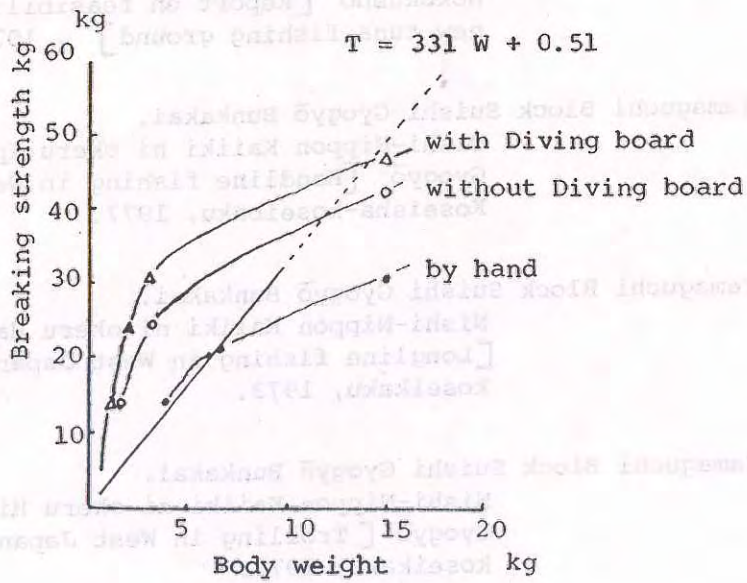


Fig. 64. Breaking strength of hook line for various body weights of fish.

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