サザエ刺網(在来型と改良型)の漁獲性能の比較

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A Comparison of the Catch Efficiency between Existing Topshell Trammel Nets and Improved Nets*1

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Fishing experiments were conducted using topshell trammel nets and bottom fish tramme nets as a control in the west of Yamaguchi Prefecture form October 1990 to June 1991. The topshell trammel nets were grouped into two types, one being the ordinary type and the other a pilot type proposed for test purposes. The latter, as compared with the former, is smaller in the height of the net and thus plays, in effect, a role in reducing fishing mortality caused by lost gear, even if the gear escapes during fishing operation, because it has the least possible amonut of netting. This kind of fishing mortality is called ghost fishing. Each of the two types was grouped into three subtypes by the mesh size of the inner net. Of a total of 391 topshells *Turbo cornutus*, 139 were caught by the ordinary type, 169 by the pilot type and 84 by the control nets. The mean CPUE, the catch per unit of net per average of soaking hours, was used in a statistical comparison between the catching power of the ordinary type and that of the pilot type. As a result, the topshell cathing power of these two types were nearly equal.

There are three major methods for catching topshell: trammel net, diving, and a simple plucking tool that has been traditionally employed in coastal waters around Japan. The topshell *Turbo cornutus* one of the important key species in Yamaguchi Prefecture, is notably abundant on natural reef seabeds from the littoral zone to 10 m or more. However, there has been insufficient data on catch efficiency according to catching method. Topshell trammel net fishery is seasonal, but takes place mainly within the period from April to December in southern Japan, because of rough sea conditions during the winter.

Six kinds of trammel nets and two control nets, which differed in the mesh size of their inner net, were used in field tests from October 1990 to June 1991. The main objective of this study was to examine the catching power of the trammel nets presently used in Yamaguchi Prefecture and that of improved trammel nets trially desgined for reducing fishing mortality caused by lost gear. Secondary objectives are to show one way of improving the trammel net design and to present basic information on complex catching processes based on the data obtained through the field tests.

Materials and Methods

Topshell Trammel Nets and their Characteristics

There are some local variations in the construction of trammel nets currently used in Yoshimo, Yamaguchi Prefecture, but no appreciable difference exists in their size. The length of floatline is 24.46 m and the leadline, 26.27 m, is about seven per cent longer than the floatline, thus setting the gear well on an uneven bottom. The mesh size for a single inner net ranges from 68 to 94 mm, but for the two outer nets it is 300 mm only. The trammel nets used for the field tests can be grouped into two types, one being the original type in Yoshimo while the other was a pilot type proposed for test purposes. The latter, as compared with the former, is smaller in the height of the net and thus plays, in effect, a role in reducing fishing mortality caused by lost gear or loss of fragments of trammel nets even if they escape during fishing operation. This kind of fishing mortality is called ghost fishing.[1] This is based on the premise that the smaller the use of netting materials, the smaller the fishing mortality, thus the pilot type to some extent plays the role

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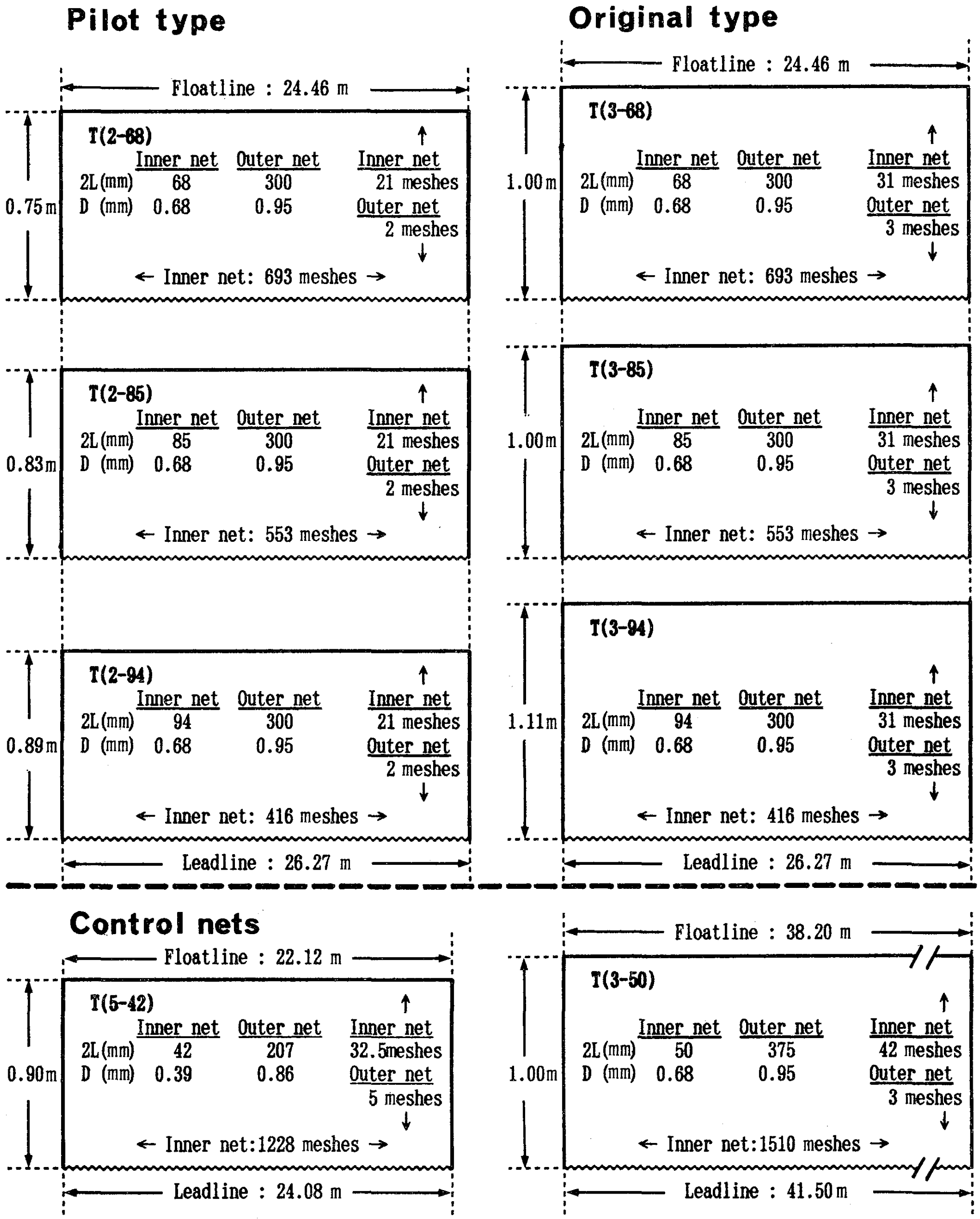

Fig. 1. Composition details of the topshell trammel nets and control net used for the field tests.

of saving netting materials.

For the mesh size of the inner net, each of these two types was grouped into three subtypes: Small, 68 mm; medium, 85 mm; and large, 94 mm. They are denoted as follows: the original subtypes (0-S types) T (3–68), T (3–85), and T (3–94), and the pilot subtypes (P-S types) T (2–68), T (2–85) and T (2–94). The parenthesized figures indicate, respectively, the number of meshes deep hung for the outer net and the mesh size of the inner net.

In addition to these six subtypes, two control nets were used, one being a type with a smaller mesh of 42 mm in the inner net, with 51 meshes deep, and the outer net of 207 mm mesh with 51 meshes deep, while the other was a type of 50 mm mesh in the inner net, with 50 meshes deep, and a 375 mm outer net mesh 3 meshes deep. The control nets, which are denoted as T (5–42) and T (3–50), are used to catch bottom fish in deeper

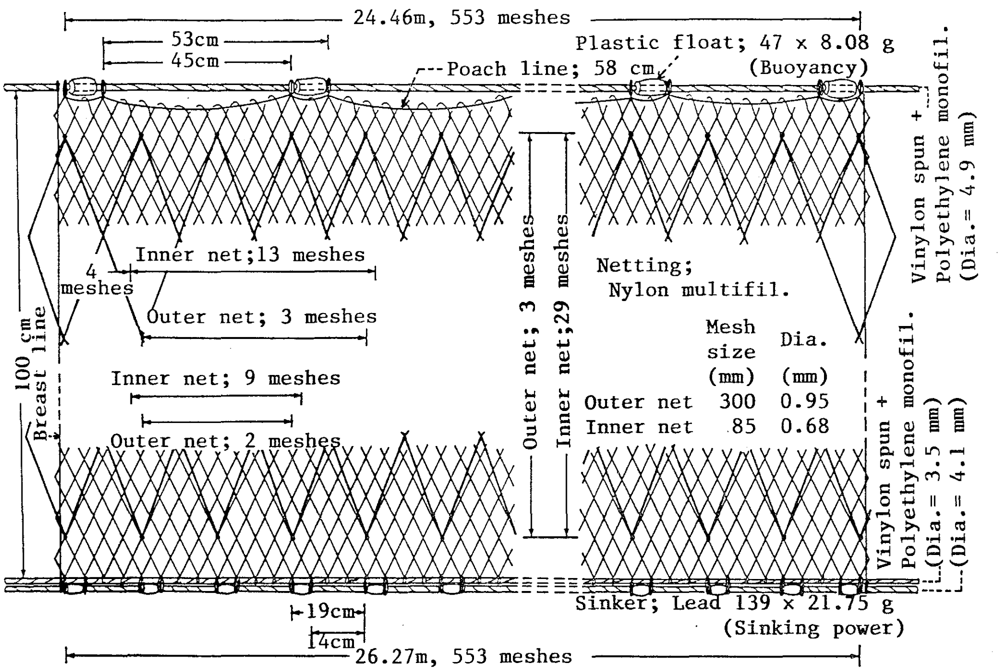

Fig. 2. Dimensions and composition characteristics of one of the existing trammel nets, T (3–85) type.

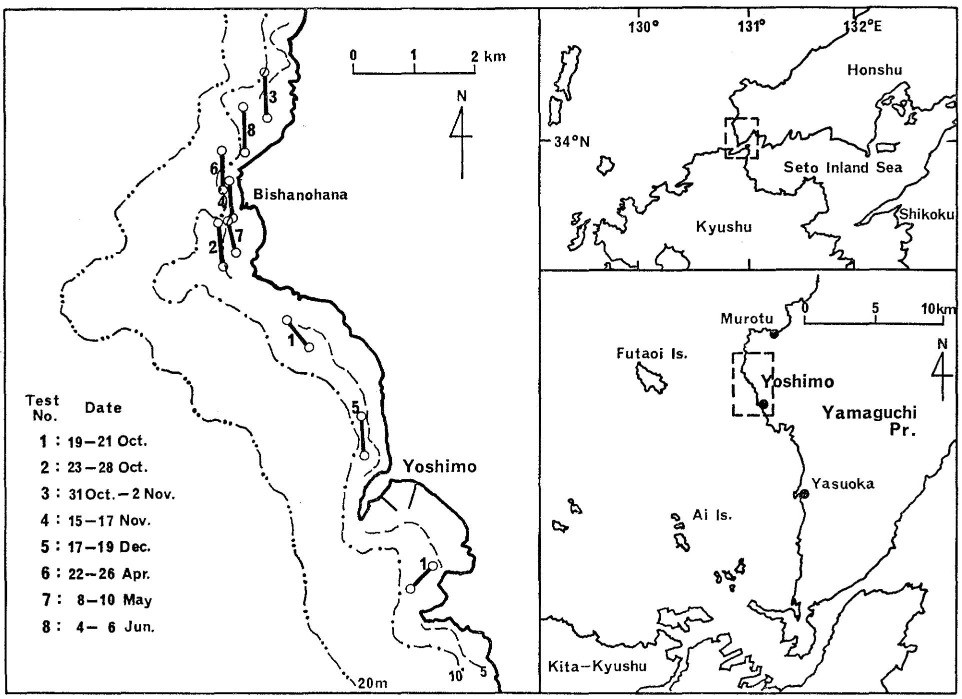

Fig. 3. The study area and bottom topography.
Note: The test gear divided into two parts were set separately in Test No. 1.

Table 1. Specification and materials of topshell trammel nets used

Type of net	Outer net				Inner net						
	Color	Material	Const.	Dia. (mm)	Color	Material	Const.	Dia. (mm)	Deep [A] (m)	Breast line [B] (m)	Vertical slack [A/B]
Pilot subtypes											
T (2–68)	Dark brown	Nylon multifil.	210d/3×6	0.95	Dark brown	Nylon multifil.	210d/3×3	0.68	1.22	0.75	1.63
T (2–85)									1.52	0.83	1.83
T (2–94)									1.54	0.89	1.73
Original subtype											
T (3–68)	Dark brown	Nylon multifil.	210d/3×6	0.95	Dark brown	Nylon multifil.	210d/3×3	0.68	1.80	1.00	1.80
T (3–85)									2.25	1.00	2.25
T (3–94)									2.27	1.10	2.06
Control nets											
T (5–42)	Dark	Nylon	210d/3×4	0.86	Dark	Nylon	210d/3×2	0.39	1.23	0.90	1.37
T (3–50)	brown	multifil.	210d/3×6	0.95	brown	multifil.	210d/3×3	0.68	1.81	1.00	1.81

zones. Composition details of all test nets used are shown in Fig. 1. Dimensions and construction characteristics of the T (3–85) are shown here only in Fig. 2, as a sample, while there is no difference in other specifications such as total buoyancy and sinking power, or hanging ratio among subtypes. Table 1 gives netting materials for the test nets.

Field Tests and Treatment of Data

These trammel nets were arranged in a combined test gear consisting of two units to every six subtypes and two control nets in random order. This test gear was generally set on shallow reef seabeds at depths ranging between 4 and 10 m for two nights continuously on a normal commercial basis of fishing operations, if weather permitted. When the weather was bad, the gear would remain set until it was safe to retrieve it. Fig. 3 shows the study area and bottom topography. The length of time the gear is soaked averaged about two nights among fishermen, who usually set 25–30 units of trammel net per opration in Yoshimo. The tests were conducted from a chartered fishing boat during a 29-day period. Table 2 shows details of the test fishings from October 1990 to June 1991.

The mean CPUE (catch per unit of net per average of soaking hours) was used, both as a means of adjusting the catch data biased by different soaking times, and as a measure for comparing the topshell catching power between subtypes. The numbers of topshells and main species of bycatch caught were recorded for every test fishing by type of net.

For all topshells taken, the following length characteristics were measured in millimeters: shell height, and shell width, which have an effect upon the catching process, as yet unspecified. Fig. 4 shows the length characteristics measured. As morphological differences exist in the shape of shell, which also affects the cathing power, they were grouped into two shapes, shell with spines and spineless.[2,3]

Results

A total of 391 topshells were caught during the present tests, of which 169 were taken by P-S types, 138 were by O-S types, and 84 were by the control nets. Table 3 gives a summary of topshells and bycatch caught in terms of numbers and weights by type of net, in which little difference is

Table 2. Details of fishing tests and number of topshell trammel nets used by type

Test No.	Date Year (1990–1991)	Hour of soaking	Number of unit of nets by mesh size*1									Water temp. (°C)
			Pilot type			Original type			Control		Total	
			68	85	94	68	85	94	42*2	50*2		
1	19/Oct. –21/Oct.	41	2	2	2	2	2	2	2	—	14	—
2	23/Oct. –28/Oct.	112	2	2	2	1*3	2	2	2	—	13	—
3	31/Oct. – 2/Nov.	42	2	2	2	2	2	2	1	—	13	—
4	15/Nov. –17/Nov.	40	2	2	2	2	2	2	1	—	13	—
5	17/Dec. –19/Dec.	40	2	2	2	2	2	1	1	—	13	16.0
6	22/Apr. –26/Apr.	86	2	2	2	2	2	2	—	2	14	14.4
7	8/May –10/May	40	2	2	2	2	2	2	—	2	14	16.0
8	4/Jun. – 6/Jun.	40	2	2	2	2	2	2	—	2	14	19.0
Total	29 days	441	16	16	16	15	16	16	7	6	108	

Notes: *1 Mesh size of inner net. *2 Trammel nets for bottom fish.
*3 A unit of net washed away during test fishing.

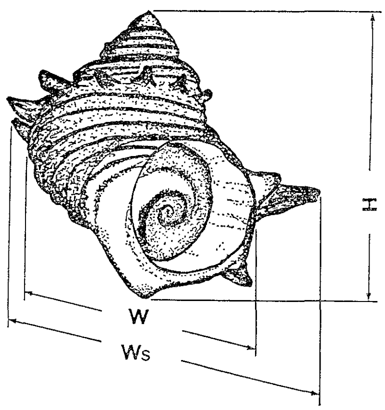

Fig. 4. The length characteristics measured.
Notes: H, shell height; W, shell width; and Ws: shell width between two opposite spines.

seen between the subtotal of topshells caught by type of net, except for the control nets. However, the number of topshells taken depends mainly on the mesh size of the inner nets. During the eight test fishings, 12 species of bycatch were caught, predoninantly filefish *Stephanolepis cirrhifer* which accounted for over 51 percent of the tatal weight. Of the 92 individuals in the bycatch, 56 (60%) were taken by the control nets in spite of the smaller soaking time and fewer units of nets used, while the remaining 40% was taken by the six subtypes. One reason why the control nets were superior to the six subtypes in the capture of fish is that they have the smaller meshes necessary to catch many species of fish of various sizes, including squid and crabs. On average, of the three mesh sizes, the O-S types caught

Table 3. Topshell and by-catch caught by type of net

Type of net	Catches by species					
	Topshell		File fish		Other fish	
	No.	Weight (g)	No.	Weight (g)	No.	Weight (g)
Pilot subtypes						
T (2–68)	107	6105.7	4	126.5	4	400.0
T (2–85)	41	2705.9	1	37.0	0	0.0
T (2–94)	21	1670.3	0	0.0	0	0.0
Sub total	169	10481.9	5	163.5	4	400.0
Original subtypes						
T (3–68)	55	3612.7	14	469.5	5	3426.0
T (3–85)	55	3535.7	2	53	3	659.5
T (3–94)	28	2250.0	1	32.0	2	1239.5
Sub total	138	9398.4	17	554.5	10	5325.0
Control nets						
T (5–42)	51	1966.7	20	428.7	4	246.3
T (3–50)	33	1933.0	5	104.5	27	3136.0
Sub total	84	3899.7	25	533.2	31	3382.3
Grand total	391	23780.0	47	1251.2	45	9107.3

Table 4. The values of CPUE, catch per average hour of soaking per unit of net

Type of net	No. of topshells caught	Average hour of soaking	Total units of net	CPUE (mean)
Pilot subtypes				
T (2–68)	107	55.1	16	6.69
T (2–85)	41	55.1	16	2.56
T (2–94)	21	55.1	16	1.31
Sub total	169		48	3.52*1
Original subtypes				
T (3–68)	55	55.1	15	3.67
T (3–85)	55	55.1	16	3.44
T (3–94)	28	55.1	16	1.75
Sub total	138		47	2.94*1
Control nets				
T (5–42)	51	55.0	7	7.28
T (3–50)	33	55.3	6	5.50
Sub total	84		13	6.46*2
Grand total	391		108	3.62

Notes: *1 No statistical difference at the 1% significant level.
*1,*2 There is a statistical difference at the 5% significant level between control nets and other subtypes.

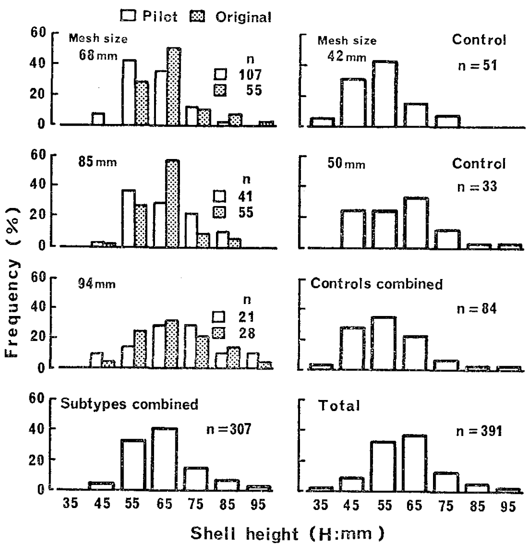

Fig. 5. Shell height compositions of topshell taken by type of net.
Note: n indicates the samples measured.

slightly more bycatch than did the P-S types.

For primary evaluation of the topshell catching power, the mean values of CPUE by type of net are given in Table 4, ranging from 1.31 to 7.28. The mean CPUE for the P-S types was 3.52, with the highest value (6.69) for the smallest inner mesh, T (2–68), and the lowest value (1.31) for the largest inner mesh, T (2–94). Meanwhile, the mean CPUE for the O-S types was 2.94, with the highest value (3.67) for the smallest inner mesh, T (3–68), and the lowest value (1.75) for the largest inner mesh, T (3–94). Compared with the mean CPUE values for the P-S and O-S types, there is little difference, if any. By mesh size, there is little difference in the CPUE values within the same mesh size category. The highest mean CPUE occurred in the control net with the smallest inner mesh. Statistical analysis indicated few differences in the mean CPUE values at the 1% significant level between the P-S and O-S subtypes, which suggested that the topshell catching power of these two was nearly equal. However, there is a statistically significant difference at the 5% level in the mean CPUE values between the control nets and the other six subtypes.

Shell height compositions were investigated by type of net and mesh size of inner net because the shell height or shell width, or both, were considered to be important factors affecting the catching power. The result obtained is shown in Fig. 5. The shell height ranged from 32 to 96 mm, with a mean shell height of 62 mm. The shell height compositions are generally unimodal and quite broad, and the smaller the mesh size, the steeper the mode. A slight difference existed in steepness and relative positions of mode between P-S types and O-S types; the former types show a higher mode around 65 mm, larger than the latter types at 55 mm. As for the height compositions of control nets, T (5–42) is different from T (3–50);

the former shows a steeper mode occurring at a height of 55 mm, while the latter shows a flatter mode at 65 mm. When comparing the combined height composition of the six subtypes and that of the control nets, they were also unimidal, with a low mode at a height of 55 mm for the control nets and with a high mode at 65 mm for the six subtypes. Each of them shows a gradual drop and then a sharp decrease in frequencies with shell height. The majority of smaller individuals less than 45 mm in height were caught by the control nets with smaller meshes. For larger individuals over 85 mm in height, a similarity was found in the height frequencies between six subtypes and control nets. It would appear from the above comparisons that the test gear is considered to be size-selective,[4,5] like other trammel nets for fish, even for topshells, with a very complicated shape. Details of mesh selectivity for topshell will be reported at a later opportunity.

Discussion

The results of the present work show that, during a limited season and in the study area, the topshell catching power of the P-S types is very similar to that of the O-S types. Statistical analysis shows no significant difference in mean CPUE by O-S and P-S types, despite considerable differences in the height of net between the two. This means that the majority of the topshells taken probably became entangled and ensnared into the smaller meshes of the lower part along the leadline. K. Yoza *et al.*[6] have reported that many topshells were ensnared in the down side of a lobster gillnet. Considering the above, it is not necessary to keep the floatline unduly high, but little is known about how low to set the floatline height properly for any type of trammel net. The design of O-S types, improved low-height versions of existing designs, gives a clue to keeping the lowest possible floatline height without any reduction of topshell catch. It is of some interest that a fair number of topshells were sometimes caught by holding a mesh bar or two bars inside their operculum, other than by gilling and entangling. From this fact, the main catching elements can be basically divided into gilling, entangling, and holding. The first two elements of the above three commonly occurred at least once in many cases.

From a different viewpoint, the P-S types will play a still more important role in the mitigation of reverse effects on resources by ghost fishing, even if they accidentally escape during fishing. The loss by ghost fishing decreases according to economy of netting materials, and the P-S types achieve this aim to some extent. For example, the T (2–68), as compared with the T (3–68), affords a saving of about 30 per cent in terms of the whole quantity of nettings used in the inner and outer nets, *i. e.* it is a type of netting material saving gear which subsequently reduces plastic debris on fishing grounds.[7] One of the leading causes of plastic pollution is to be found in synthetic fishing gear and its fragments which are often lost or carelessly discarded. It would appear from this that the P-S types answer a double purpose, though against this they have the obvious disadvantage that the bycatch decreases, as shown in the right column in Table 3.

Although the results obtained in this study suggest that the catching power was directly affected by the mesh size of the inner net, it would be unwise to overlook the extent of the vertical slack along the down side of the inner net. This slack forms a loop[8,9] and the topshell are gilled and entrapped. As the topshell is a kind of crawling animal, the slack should be properly maintained so that they cannot escape from the net, but a slight amount of slack is presented in the two outer nets which are constructed from slightly thicker twine than the inner net. If the slack is expressed in terms of the ratio of the height of the inner net to that of the outer net, then we obtain the calculated values of slack as shown in Table 1. The amount of slack for six subtypes is larger than that for control nets. However, within the extent of slack for the test gear, it appeared to have little effect on catching ability between the P-S and O-S types. This suggests that it is desirable to eliminate slack to the least extent for further improvement of net design.

To what extent slack is allowable is not known in relation to choosing the proper mesh size for resource control. In this regard, the shape of topshell, the existence and the size of spines are further parameters to consider, and are probably some of the most important. Of a total of 391 topshells, the majority (315) consisting of shell height classes 25–85 mm had spines, with an approximate ratio of 4 : 1 between shells with spines and spineless ones. This ratio is smaller than M. Amio's[2] result of 2 : 1, and such a large difference may be due to the different sampling areas, *i. e.* his specimens collected from three fishing grounds. However, the total numbers of topshells examined are too low for a firm conclusion to be drawn about the relation between catch size and spine size. Further field tests throughout the year are necessary in order to come to definite conculusions about the development of even more effective designs in relation to the catching process and the least possible amount of slack.

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