Preliminary report of Japan-U.S. joint survey on reducing incidental catches of low quota species in the North Pacific in 1986.

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Preliminary report of Japan-U.S. joint survey on reducing incidental catches of low quota species in the North Pacific in 1986.

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Trawling is one of the most important parts of fishing operation conducted by the U.S. and Japan within 200 nautical miles of the Bering Sea. However, since the bottom trawl may not selective for ground fishes larger than the mesh size of the trawl net, it would be extremely beneficial for the fisheries of both countries to develop trawling gear that would fish the target species exclusively.

Since 1982, the Fisheries Agency of Japan has been conducting four-year surveys on selective trawling gear and alternative methods for reducing incidental catches of prohibited species and species with low TALFFs. The survey showed that modified gear with hanging ropes or chains between fishing line and ground lope is the most promising among other equipment experimented with to date.

However, due to a lack of information on effective lengths of the hanging chains and distances between them, the 1986 survey was aimed at finding the detailed effects of them to reduce incidental catches of prohibited species and those with low TALFFs as well as to discover an effective way of fishing only the target species. Therefore, we planned to continue surveys on the selective trawling gear using two types of hanging chain and to make underwater observations of the gear using a movie camera.

1. Survey objectives

1) The objective of the survey was to develop selective trawling gear that permit sufficient catches of target species such as pollock, while minimizing the incidental catches of prohibited species and those with low TALFFs.
2) In the 1986 survey on pollock fishing, emphasis was placed on the reduction of incidental catches of sablefish and Pacific cod.

3) A movie camera was used in the production of a film investigating the condition of net directly and how the species evades the net using the modified gear.

2. Survey methodology

1) Survey implementation

The Fisheries Agency of Japan defrayed all expenses for the implementation of the survey and commissioned the project to the Japan Marine Fishery Resource Research Center (JAMARC). The survey was done as a joint U.S.-Japan project, and a U.S. scientist participated in the survey.

Scientific personnel on board was as follows.

From JAMARC:	Tadashi Inada	Scientist
	Shin-ichi Miyakawa	Scientist
	Hiroshi Kawagishi	Research assistant
	Masuhiro Oda	Research assistant
	Akisato Sakamoto	Cameraman
From U.S.:	Robert Loghry	Scientist

2) Survey areas

Two areas were selected for the purpose; one southwest area off Pribilof Islands and another northern area of Unimak Pass (Fig. 1). As different levels in the abundance of sablefish and Pacific cod might affect the rate of incidental catch of the species, it was preferable to have at least two survey areas. Shallow and relatively flat bottom areas were selected for shooting the gear with the movie camera because depths of over 200 meters preclude such activities.

3) Survey period and itinerary

The cruise plan is shown in Table 1. The period of charterage of the vessels was 53 days altogether and allowed 30 days' research activity in the survey area. The period was chosen from summer seasons in order to avoid to have inclement weather which might not allow effective survey.

4) Survey vessels

Two 350 ton-class commercial fishing trawlers were chartered for the survey. Major specifications of these vessels are as follows.

Name of vessel:	Shoshin maru No.20	Shin-ei maru No.63
Type:	stern trawler	stern trawler
Length:	49.76m	51.00m
Tonnage:	349.03 tons (by old tonnage)	279 tons (by new tonnage)
Hull color:	grey	grey
Radio call sign:	7JEJ	8LWF
Captain:	Yoshiji Takayashiki	Satoshi Shiino
Number of crew:	22	23

5) Survey methodology

Conventional commercial fishing gears were adopted as the basis for the modifications of nets to make an easy application of the result of experiments to actual commercial fishery.

(1) Fishing gear used

The following types of modified nets were used. In order to evaluate the performance, two unmodified conventional nets were also used for control.

(a) Conventional trawling net

Of the various conventional trawling nets used by the Land-based Drag net Fishery (Hokuten trawler) in the North Pacific, the small type with a mouth opening height of 5 to 6 meters and an overall length of 61.3 meters (Fig. 2, Table 2) were used as the conventional net for

comparison with the modified nets. Hereafter they are referred to as C1 net and C2 net, and together referred as C nets.

(b) Hanging chain net

Ten of 1.5 meters chain were hung between the ground rope and fishing line of conventional trawling nets to widen the distance between rope and line in order to prevent fish near the sea-bottom from entering the net (Fig. 3). Hereafter this is known as X1 net.

(c) Other hanging chain net

The same type net described in paragraph (b) with hanging chains of 2.0 meters instead of 1.5 meters chains (Fig. 3). Hereafter this is known as X2 net.

(2) Towing details

Tows were made simultaneously from two vessels running parallel with one using a conventional net (C1 or C2), and the other using the modified net (X1 or X2). Towing speed of the vessels was about 3.5 knots, and towing was conducted six times a day in principle. Tows were made in parallel with the isobath. When the first tow was completed, the vessels moved toward deeper or shallower positions not to duplicate the wake of the first tow, and repeated the procedure moving parallel with the isobath. The two vessels changed relative positions so as to eliminate any possible errors caused by the depth deviation between two vessels. Towing depth ranged from 150 to 400 meters. Among 6 tows per day, 3 tows were made deeper than 250 meters and another 3 tows were made shallower than 250 meters.

Towing was a 30-minute period in principle from the time the net recorder confirmed contact of the net with the sea-bottom until the warp started to reel in the net. The distance between the two vessels was maintained at about 0.2 miles by constant monitoring on rader. The height of the net opening was constantly checked and recorded. The wingspread was estimated by the method of warp divergence measurements. To detect the effective length of hanging chains from the bottom, marking of chains by paint and measurements of shining chains were made.

(3) Catch measurements

Every fish caught was weighed or counted by species in the following manner. In principle, the entire catch was sorted by species, with each species weighed and counted. If the catch was large, calculation by fish bin content was carried out, then partial sampling was conducted to determine average density. From these values, the total volume of the catch was estimated. 30 baskets with a known capacity were used for partial samplings. The catch volume by species was based on these values.

Animals other than fish and crabs, such as starfish and shellfish, were excluded from the total catch volume.

(4) Body length measurements

For major species, such as pollock, sablefish and Pacific cod, as well as for prohibited species, body lengths of around 100 specimens per tow were measured. Measurement boards and punching cards were used for this purpose. Length was measured as either total or fork length, whichever was shorter, along the body axis of the fish.

6) Experimental design

The following is a list of factors which may affect the catch of each species of fish:

Net	:	Conventional type C1 and C2 which were the same size and shape and modified type X1 and X2.
Vessel	:	Two survey vessels, V1(Shoshin maru) and V2(Shin-ei maru).
Area	:	Two survey areas, A1 and A2.
Depth	:	Two survey depths, deeper than and shallower than 250 meters.

We have designed the experimental plan with the same combination of each factors so as to detect the effects of all these factors after the experiment (Table 3). The plan intended to make six tows per day. But in reality, as sometimes the number of tows was less than 6, one day's

experiment extended over two days. Still, the combination of vessel and fishing gear with the specified data and order was continuously kept as is seen in Table 3.

3. Survey results and its analysis

The survey was carried out rather smoothly and could cover all the designated tows on schedule. In 30 days in the survey area, a total of 163 paired tows were made, among which 19 pairs were proved to be ineffective for inclusion in the data because of a ripped net from either of the two vessels. Of six tows other than these, towing durations were curtailed of 30 minutes because of an extraordinary big catch detected on netrecorder, and two those of two tows were prolonged by the winch trouble. But these 8 pairs were judged as effective tows. The last two days of the survey were spent for the underwater photography and the gear test. In this analysis, the catch data of a total 144 effective tows were adopted and the actual values of the catch amount were used without statistical processing.

The detailed results are under analysis with the cooperation of specialists.

1) Analysis based on the average catch by survey area

To gain a wide view of the selective catch, the average catch (kg/tow) of the five major species (or species group) were sought for each survey area for each net (Table 4). From this, the following tendency was observed.

a) Catch of pollock by X1 and X2 nets was more than by C1 and C2 nets in both areas. The catch of pollock was more in A1 than A2.

b) Catch of sablefish was very small with X1 net, and slightly smaller with X2 net than with C1 and C2 nets.

c) Catch of Pacific cod was very small with X2 net in both areas. It was more in A1 than A2.

d) Catch of flatfishes other than Pacific halibut was smaller with X2 net

than C1 and C2 nets in both areas, but it was not so small with X1 net as X2 net.

e) Catch of rockfishes was smaller with X1 than C1 and C2 nets in A1. It was very small in A2, which made analysis impossible.

2) Examination by regression analysis

Based on 1985's analysis, it is regarded the data of a pair of parallel operations as a value of sampling from the same populations. Here, it was assumed that the catchability of modified X1 and X2 nets has a special value of ratio to the catchability of conventional nets.
Based on these hypotheses, regression coefficient of the catch by modified nets for each species to the catch by conventional nets was calculated (Table 5). In this case, we integrated the data of both vessels into one and the data by C1 and C2 into C net.
Furthermore, in order to make it easier to define how different the catch of species in parallel operation depends on the type of nets, the results are shown graphically (Figs. 4-7). In these figures, broken lines passing the origin were sought by the method of least squares in order to make a clear judgment.

According to this analysis, the following results were obtained.

a) The ratio of catchability of X1 to conventional net for Pacific cod is about 80% in both areas. Catchability of X1 for pollock and sablefish ranged 88-116% and 30-71% respectively. This means catchability for pollock and sablefish varies considerably by the area, where the school density of the target species is quite different. Thus, X1 net was effective in avoiding incidental catch of sablefish, specially in the area of low density, but not highly effective for Pacific cod.

b) The ratio of catchability of X2 to conventional net for Pacific cod was about 40% in both areas. Thus, X2 net was effective in avoiding incidental catch of Pacific cod. However, catchability of this net for pollock and sablefish ranged 47-124% and 37-75% respectively, which shows the same tendency as X1. It is assumed that these variations will be caused by the population density. X2 net was

effective in avoiding incidental catches of sablefish, though some degrees of fluctuation were recognized.

Relationships of the catch of major species between X1 and X2, and between V1 and V2 are also shown in fig. 8 and 9 respectively. According to these results, a) The ratio of catchability for pollock was almost the same value between X1 and X2 nets. b) The catchability of X2 net to X1 net for sablefish, Pacific cod and flatfishes were 57%, 75% and 60% respectively. Thus X2 net appears to be more effective in reducing incidental catches of these species than X1 net. c) The ratio of catchability for major species were almost the same value between V1 and V2.

3) Analysis of length frequency of major species

A total of 26,537 specimens of pollock, 12,408 of sablefish and 16,573 of Pacific cod was measured for the analysis of size selectivity by each net. Length frequencies of these species by net and area are shown in Figs. 10-12. Although the number of measurement by each net was little more or less than 100 specimens for each species and/or it was very few in case of small catch, the actual number measured was used in this analysis. The following tendencies were found. a) There are no recognizable differences in the length frequency of pollock between the conventional nets (C) and the modified nets (X1,X2). b) The modes of the length frequencies of sablefish in A1 area by X1 and X2 nets are a little smaller than that by C nets. c) The length frequency of Pacific cod in A1 area shows a little difference by net. The frequencies (%) of the smaller fish by X1 and X2 nets are higher than that by C nets.

4) Results of measurements of shining chains

To detect the effective length of hanging chains from the bottom, shining length of hanging chains was measured, which indicate the contact with sea-bottom during the tow. The results are shown in Fig. 13. In this

figure, the condition of B was tested and observed once a day during the survey in A1 area and that of C did in A2 area. The condition of D was tested all the tows during the last two days of the survey in A2 area. Following these results, the actual condition of the wing tips of the modified nets in the field is supposed to be in the condition shown in A of Fig. 13, that is, the effective length of hanging chains of the wing tips is shorter than that of the middle part. Moreover, in proportion to increase buoyancy of the floats, the length of shining chains were decreased (B-D of Fig. 13). These evidences will suggest the modified trawl gears in the field were not operated so effective as the designers intended. As a result, it will be required to spread the distance between the fishing line and the ground rope of the modified net by increasing the number of floats in the future survey.

5) Analysis by underwater photography:

A total of 40 times of the underwater photography was conducted in both areas shallower than 200 meters successfukky. In this photographing, the underwater camera was attached at various positions of the fishing line or the ground rope of the conventional and modified nets to detect the condition of net in the field and the behavior of major species against the net. These films are under editing and a 30 minutes video tape will be produced to analyze the condition of net in the field and the behavior of the target species against the net.

Table 1. Itinerary of the cruise in 1986. Date in JST.

July 8	Commencement of charterage at Hachinohe port	1 day at port
July 9	Leave Hachinohe port	10 days for cruise
July 18	Arrive at Dutch Harbour Leave "	
July 19	Arrive at survey area Start survey	30 days for survey
August 17	Leave survey area	1 day for cruise
August 18	Arrive at Dutch Harbour Leave "	9 days for cruise
August 26	Arrive at Shiogama port	3 days at port
August 29	Termination of charterage	
		Total : 53 days

Table 2. Major specification of conventional small net.

Part	Length or number
Number of net pendants	2
Dandylines length (m)	157
Length of head rope (m)	52.9
Length of ground rope (m)	63.4
Diam. rubber bobbin (mm)	150
Diam. ball (mm)	350
Height at net mouth (m)	5 - 6
Dist. betw. wing tips (actual measurement) (m)	18 - 28
Overall length of net (m)	61.3
Mesh size (mm)	180,150,120,90
Length of cod-end (m)	20
Mesh size in cod-end (mm)	100

Table 3. Experimental design for the survey in 1986.

Day	Area	1 V1-V2	2 V1-V2	3 V1-V2	4 V1-V2	5 V1-V2	6 V1-V2
1	A1	C1-X1	C1-X1	C1-X1	C1-X1	C1-X1	C1-X1
2		C1-X2	C1-X2	C1-X2	C1-X2	C1-X2	C1-X2
3		C2-X1	C2-X1	C2-X1	C2-X1	C2-X1	C2-X1
4		C2-X2	C2-X2	C2-X2	C2-X2	C2-X2	C2-X2
(net exchange)							
5		X1-C1	X1-C1	X1-C1	X1-C1	X1-C1	X1-C1
6		X2-C1	X2-C1	X2-C1	X2-C1	X2-C1	X2-C1
7		X1-C2	X1-C2	X1-C2	X1-C2	X1-C2	X1-C2
8		X2-C2	X2-C2	X2-C2	X2-C2	X2-C2	X2-C2
(net exchange)							
9		C1-C2	C1-C2	C1-C2	C1-C2	C1-C2	C1-C2
10		X1-X2	X1-X2	X1-X2	X1-X2	X1-X2	X1-X2
(net exchange)							
11		C2-C1	C2-C1	C2-C1	C2-C1	C2-C1	C2-C1
12		X2-X1	X2-X1	X2-X1	X2-X1	X2-X1	X2-X1
13	A2	X2-X1	X2-X1	X2-X1	X2-X1	X2-X1	X2-X1
14		C2-C1	C2-C1	C2-C1	C2-C1	C2-C1	C2-C1
(net exchange)							
15		X1-X2	X1-X2	X1-X2	X1-X2	X1-X2	X1-X2
16		C1-C2	C1-C2	C1-C2	C1-C2	C1-C2	C1-C2
(net exchange)							
17		X1-C1	X1-C1	X1-C1	X1-C1	X1-C1	X1-C1
18		X2-C1	X2-C1	X2-C1	X2-C1	X2-C1	X2-C1
19		X1-C2	X1-C2	X1-C2	X1-C2	X1-C2	X1-C2
20		X2-C2	X2-C2	X2-C2	X2-C2	X2-C2	X2-C2
(net exchange)							
21		C1-X1	C1-X1	C1-X1	C1-X1	C1-X1	C1-X1
22		C1-X2	C1-X2	C1-X2	C1-X2	C1-X2	C1-X2
23		C2-X1	C2-X1	C2-X1	C2-X1	C2-X1	C2-X1
24		C2-X2	C2-X2	C2-X2	C2-X2	C2-X2	C2-X2

A1,A2:Areas V1,V2:Research vessels
C1,C2:Control nets X1,X2:Experimental nets

Table 4. Average catches (kg/tow) of major species classified by area and net with 144 tows in the survey of 1986.

Species	Pollock			Sablefish			Pacific cod			Flatfishes *1			Rockfishes		
Area / Net	A1	A2	A1+A2 Average	A1	A2	A1+A2 Average	A1	A2	A1+A2 Average	A1	A2	A1+A2 Average	A1	A2	A1+A2 Average
X1	4269	2850	3560	56	152	104	779	177	478	822	483	653	47	7	27
X2	4190	2945	3568	132	211	172	357	128	243	373	402	388	80	13	47
C1	4009	2394	3202	*2 365	274	320	960	241	601	1153	652	903	74	5	40
C2	3778	1773	2776	*2 59	348	204	1365	261	813	560	760	660	133	13	73
C1+C2 Average	3894	2083	2989	212	311	262	1162	251	707	857	706	782	104	9	57
Notes	Slightly increased in X1 and X2			Heavily reduced in X1. Slightly reduced in X2			Heavily reduced in X2. Slightly reduced in X1			Heavily reduced in X2. Slightly reduced in X1			Heavily reduced in X1. Slightly reduced in X2		

*1. Included all the species except for pacific halibut.

*2. The differences are caused by the catch differences in the first 10 tows.

Table 5. Regression coefficient of the catch by species using two modified nets (X1,X2) compared with the catch with the conventional nets (C1+C2) for 96 tows in the survey of 1986. Here, this value is regarded as the catchability of the modified nets to the conventional. The difference between vessels is disregarded.

Species / Net	Area	Pollock	Sablefish	Pacific cod	Flatfishes (excl. P.halibut)
X1	A1	0.88	0.30	0.87	0.49
	A2	1.16	0.71	0.81	0.74
X2	A1	0.47	0.37	0.38	0.63
	A2	1.24	0.75	0.40	0.65

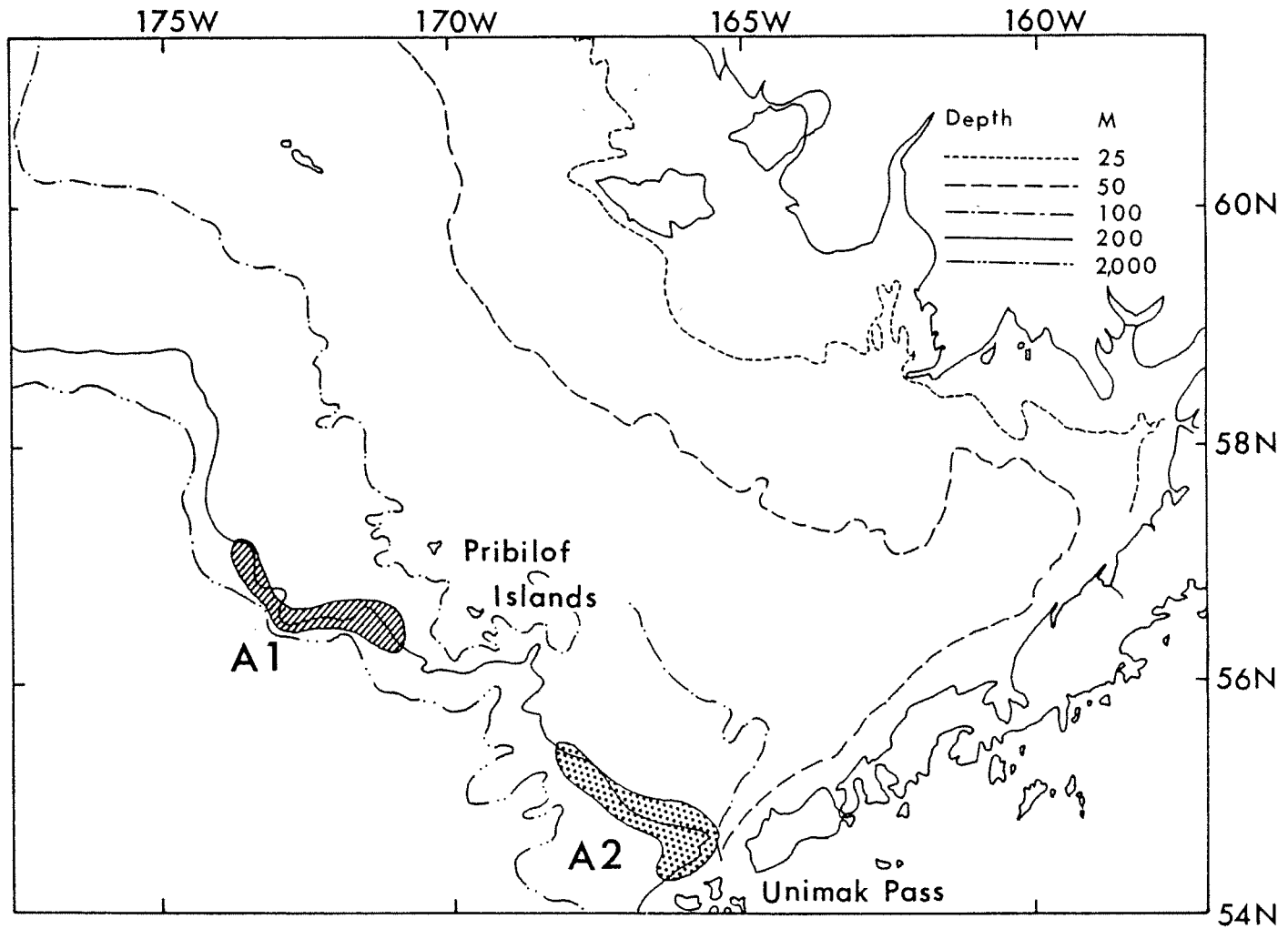

Fig.1. Survey areas in 1986. A1: southwest area off Pribilof Islands.
A2: northern area of Unimak Pass.

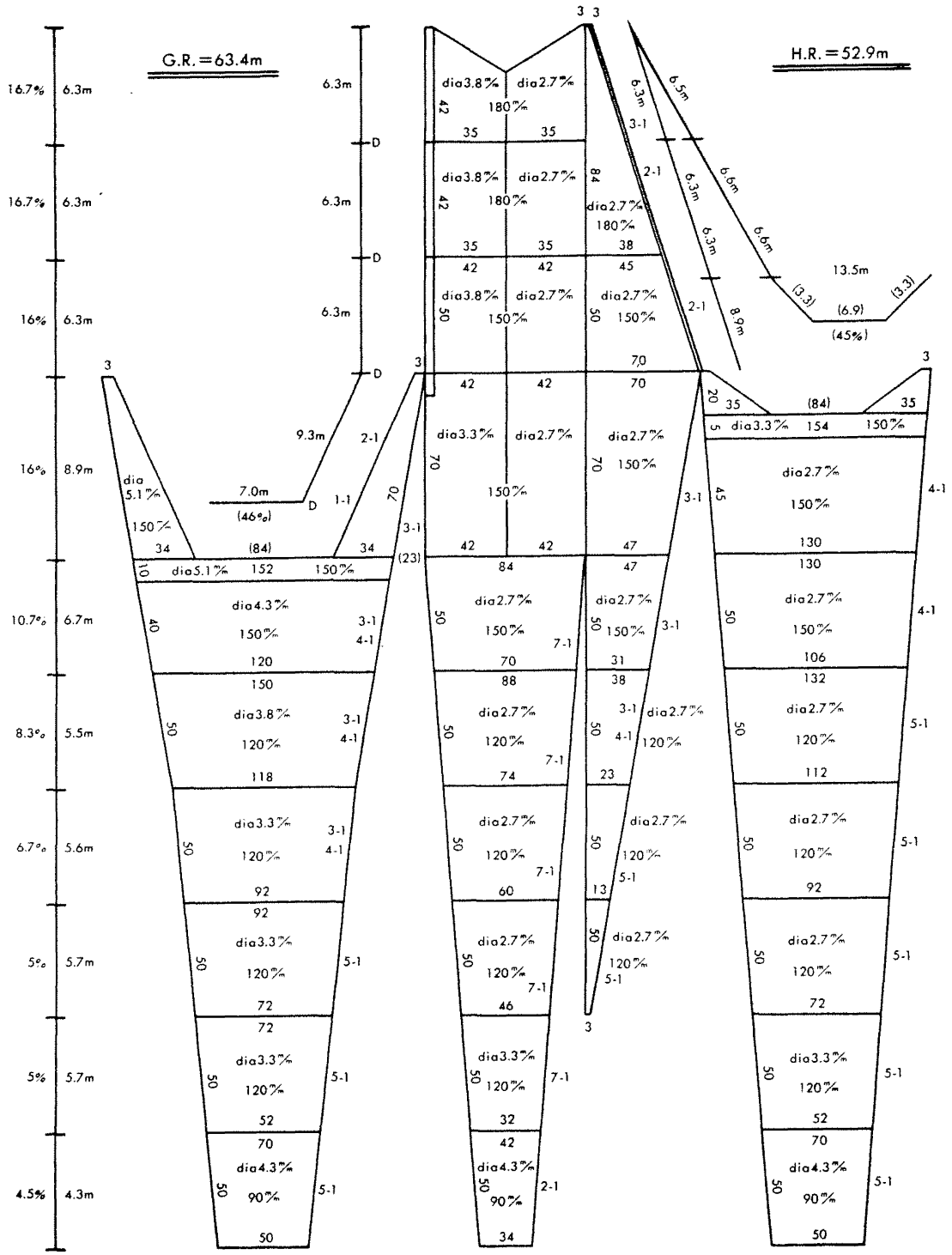

Fig.2. General design and major dimensions of the conventional trawl net (C1 and C2) used in the experiment.

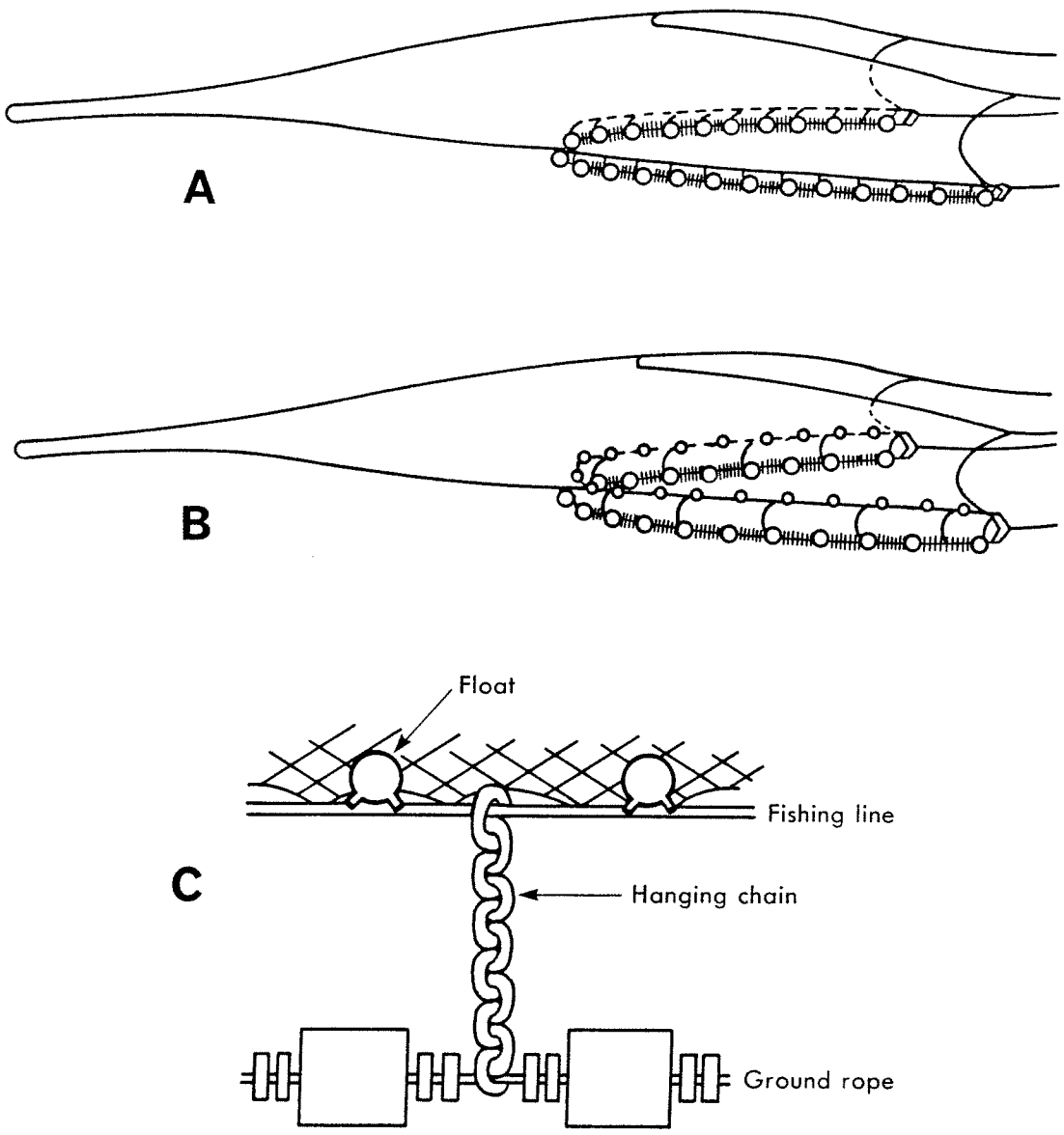

Fig.3. Basic structure of the trawl net with long hanging chains. The other part of the net is completely identical to that of the conventional trawl net (A), but with this net (B), the ground rope which drags along the sea bottom and the fishing line at the outer margin of the net body are separated by ten hanging chains of 1.5m long (X1 net) and 2.0m long (X2 net).

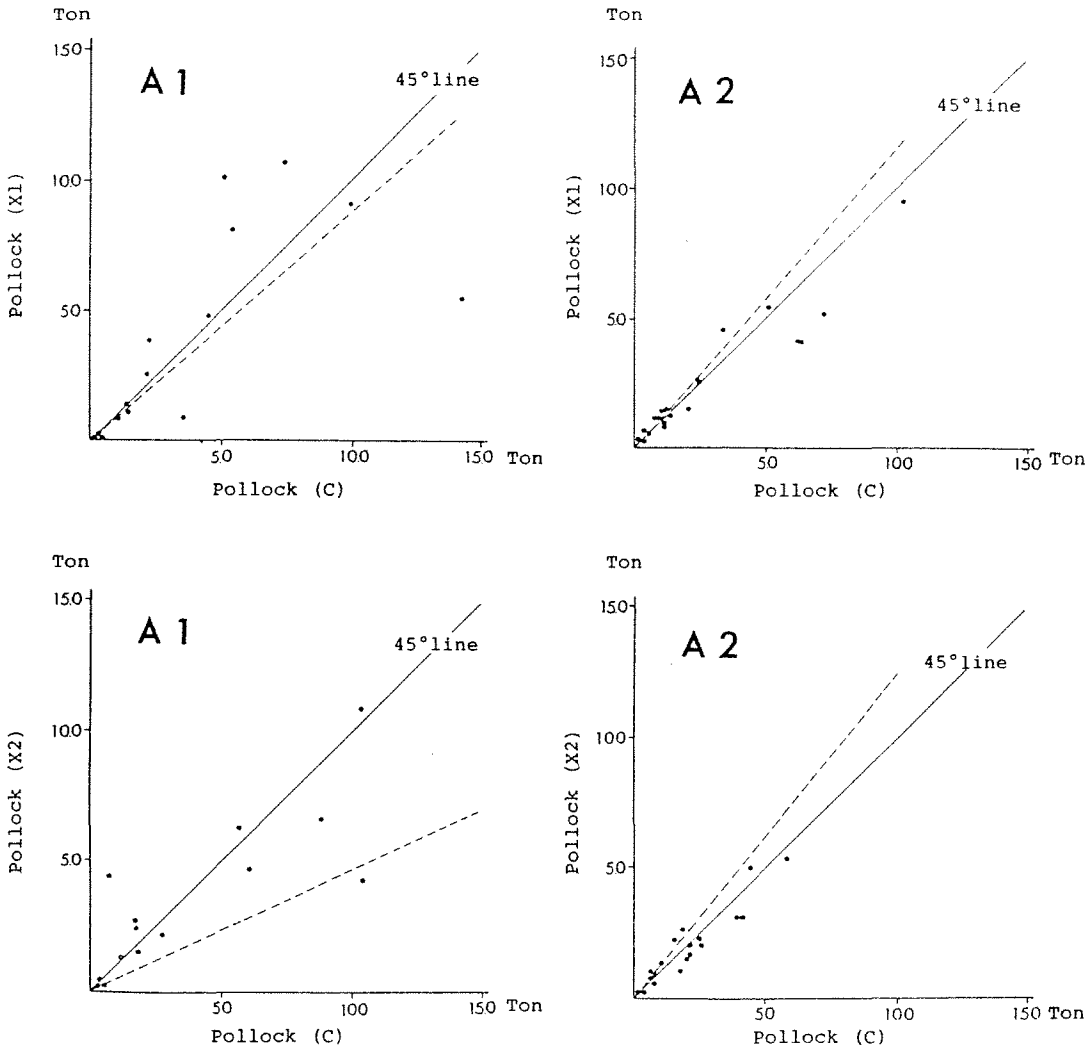

Fig.4. Relationships of the catch of pollock between modified nets (X1,X2) and conventional nets (C) by area (A1,A2). Some catch data exceeded over the sacle are not shown in this figure. Broken line means a regression line.

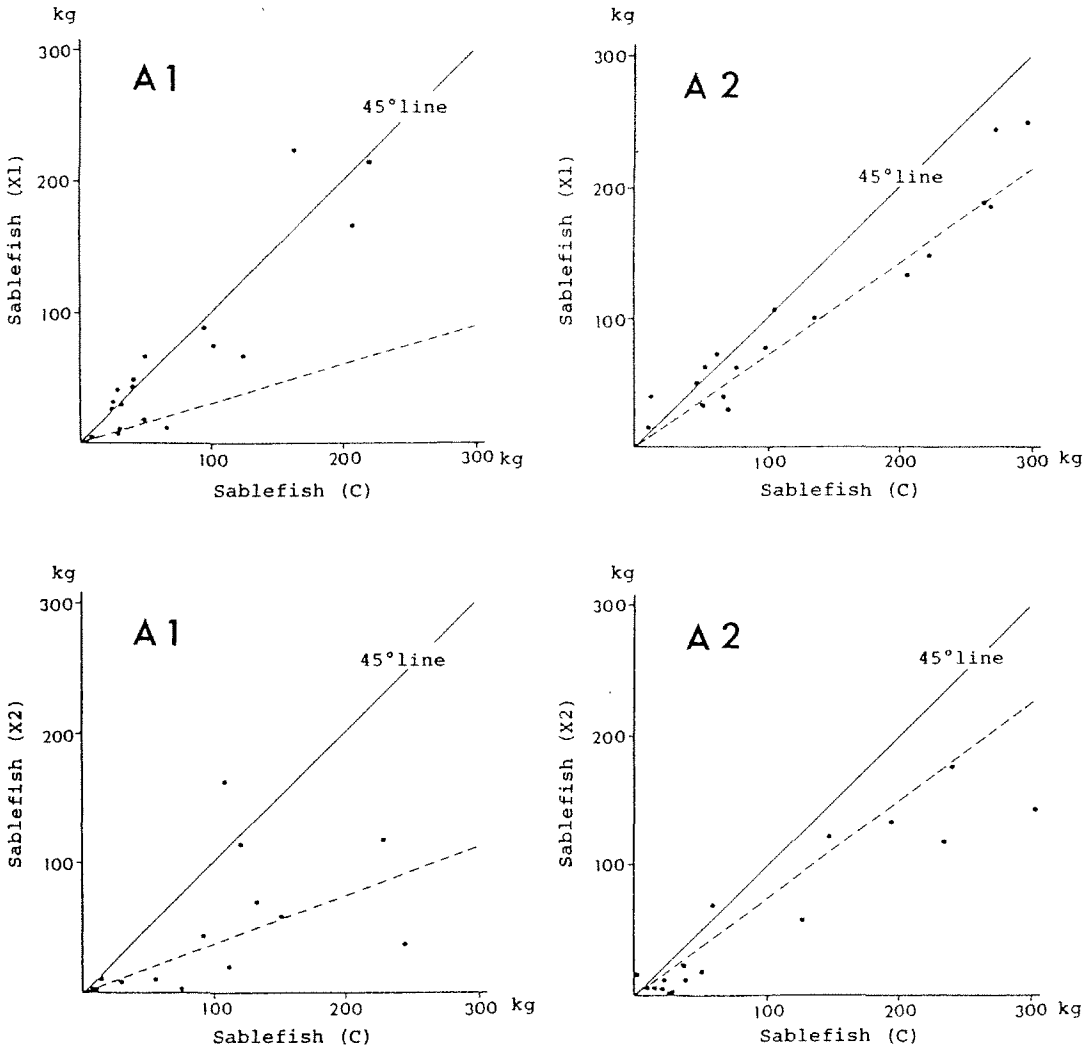

Fig.5. Relationships of the catch of sablefish between modified nets (X1,X2) and conventional nets (C) by area (A1,A2). Some catch data exceeded over the scale are not shown in this figure. Broken line means a regression line.

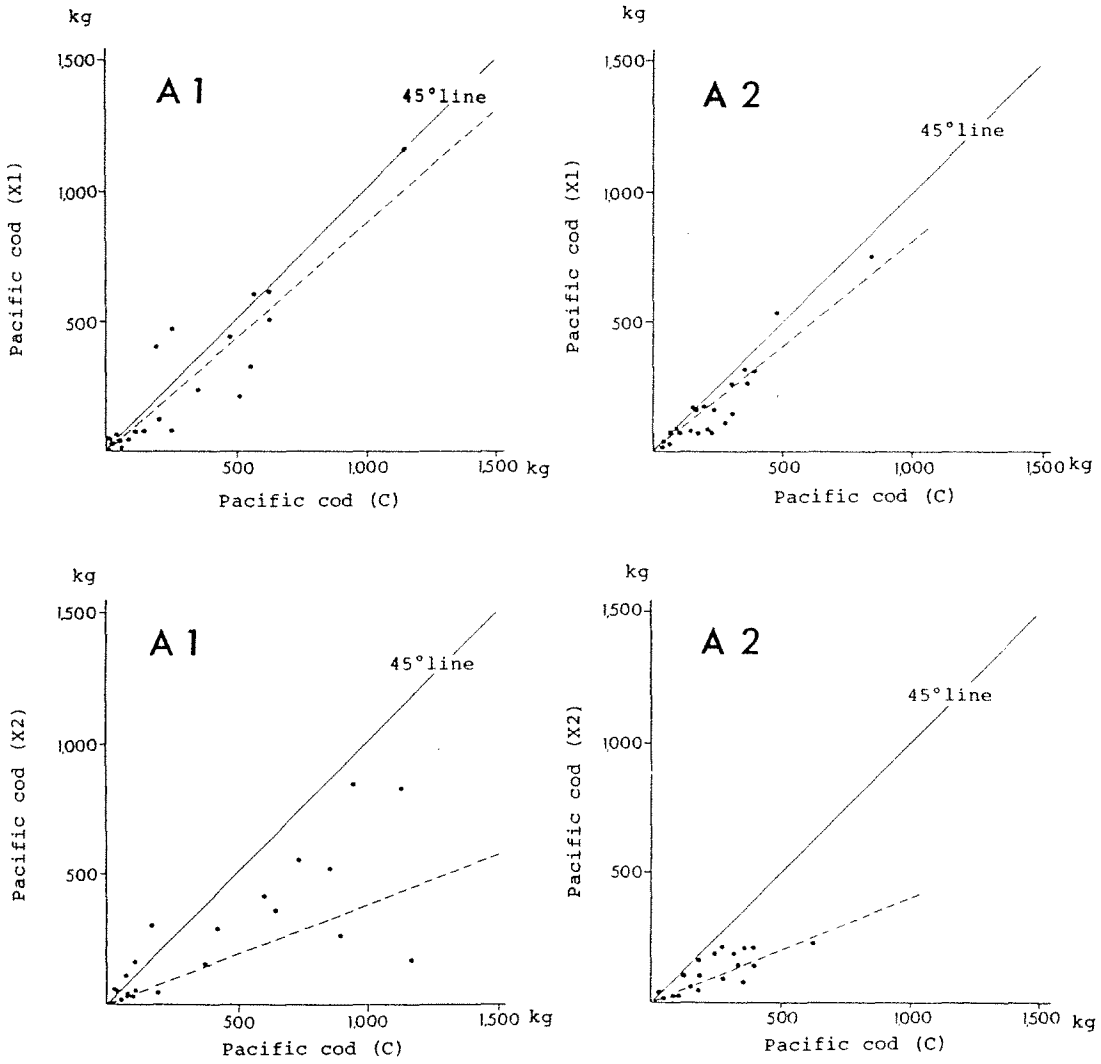

Fig.6. Relationships of the catch of Pacific cod between modified nets (X1,X2) and conventional nets (C) by area (A1,A2). Some catch data exceeded over the scale are not shown in this figure. Broken line means a regression line.

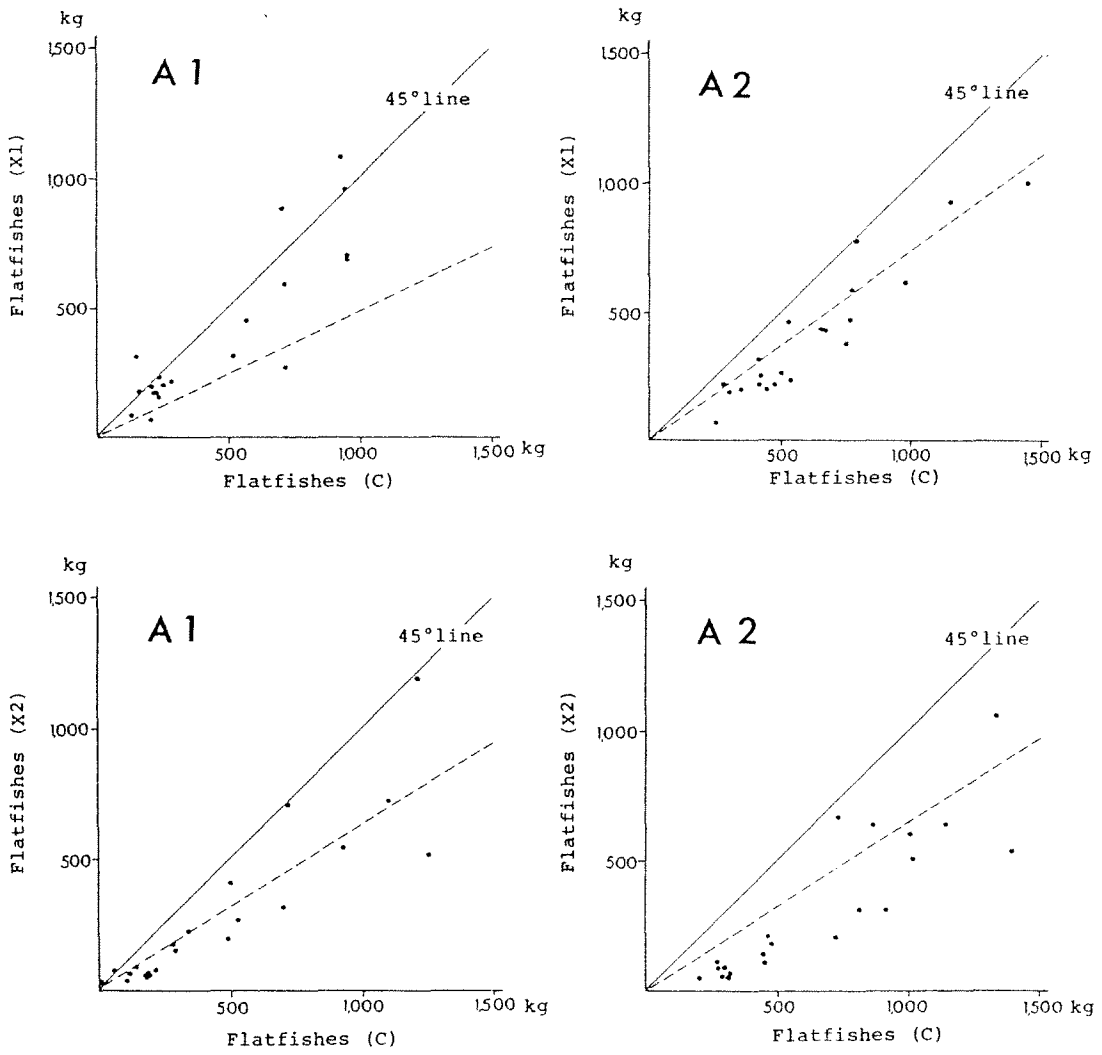

Fig.7. Relationships of the catch of flatfishes between modified nets (X1,X2) and conventional nets (C) by area (A1,A2). Some catch data exceeded over the scale are not shown in this figure. Broken line means a regression line.

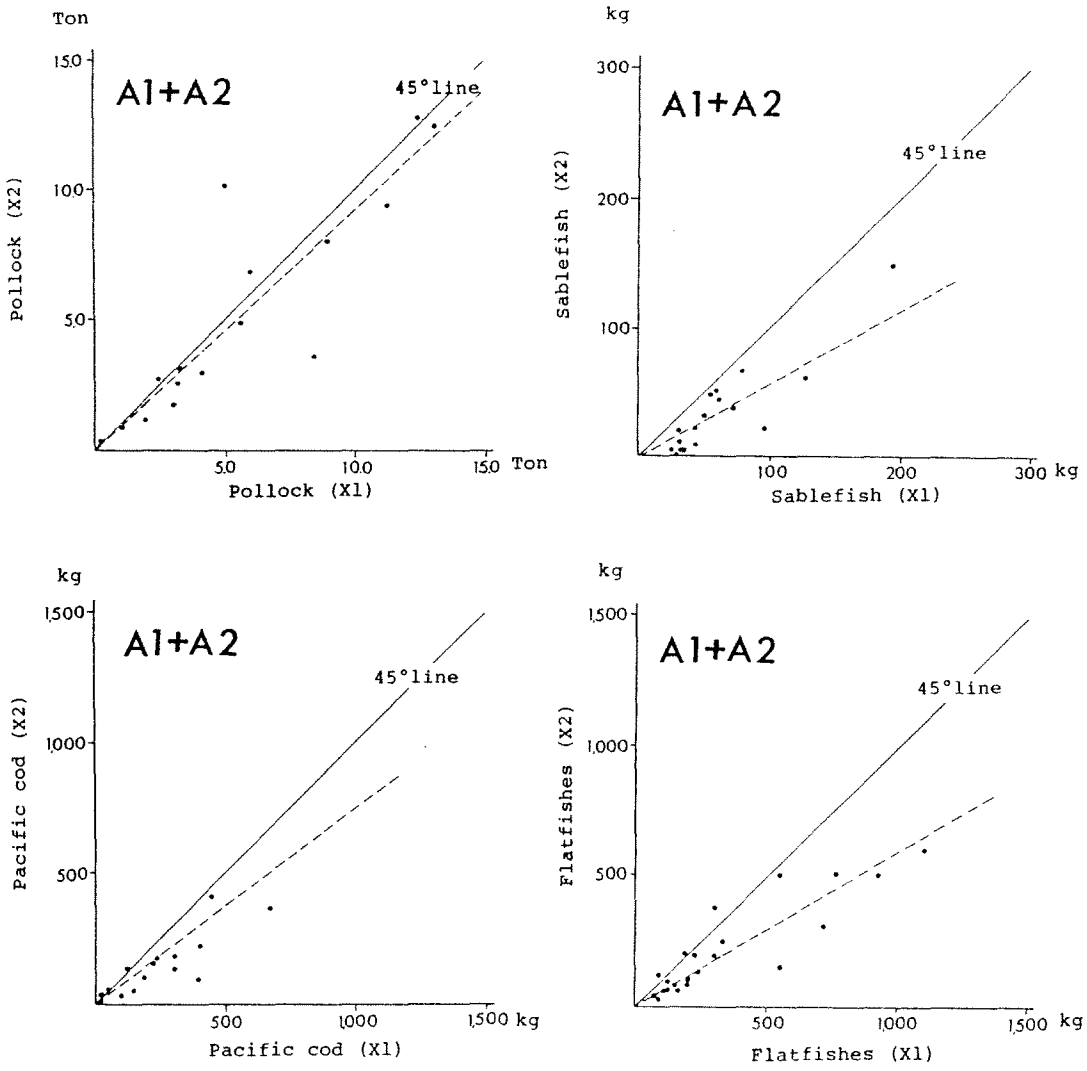

Fig.8. Relationships of the catch of major species between X1 net and X2 net in both areas. Some catch data exceeded over the scale are not shown in this figure. Broken line means a regression line.

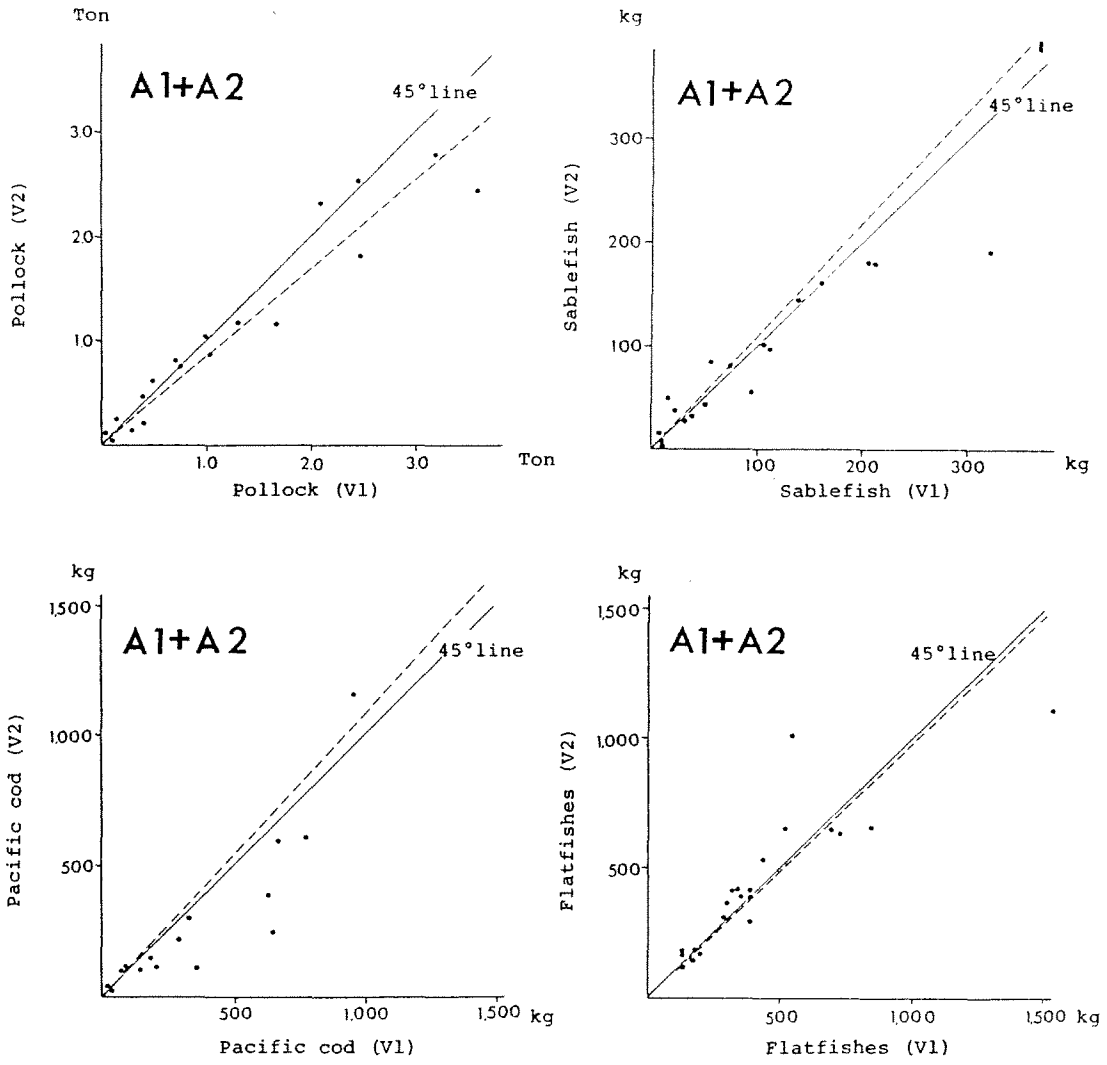

Fig.9. Relationships of the catch of major species between V1 (Shoshin Maru) and V2 (Shin-ei Maru) in both areas based on the data of pair tows by conventional nets. Some catch data exceeded over the scale are not shown in this figure. Broken line means a regression line.

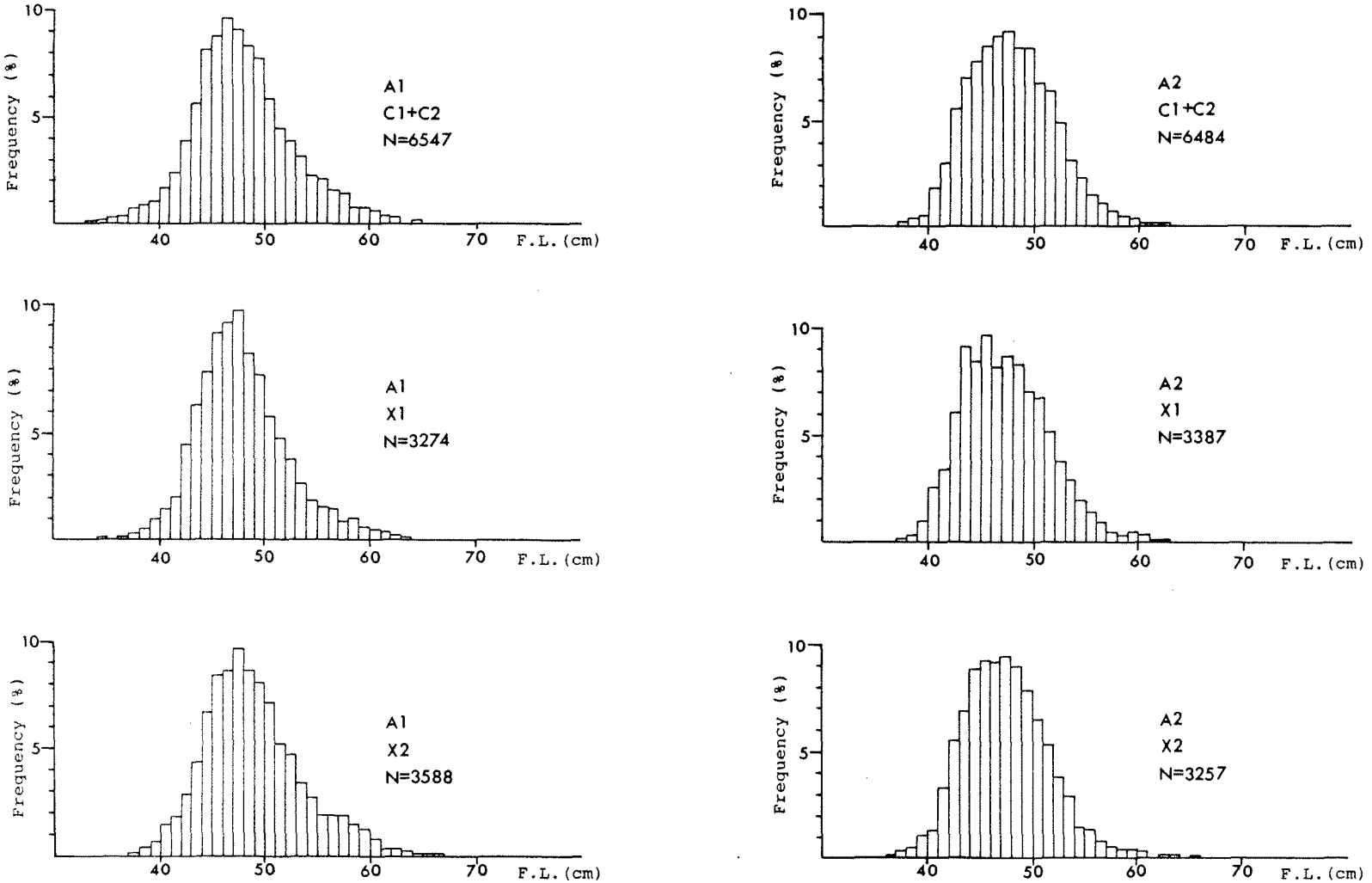

Fig.10. Length frequency of pollock by net and area from subsample of catch.

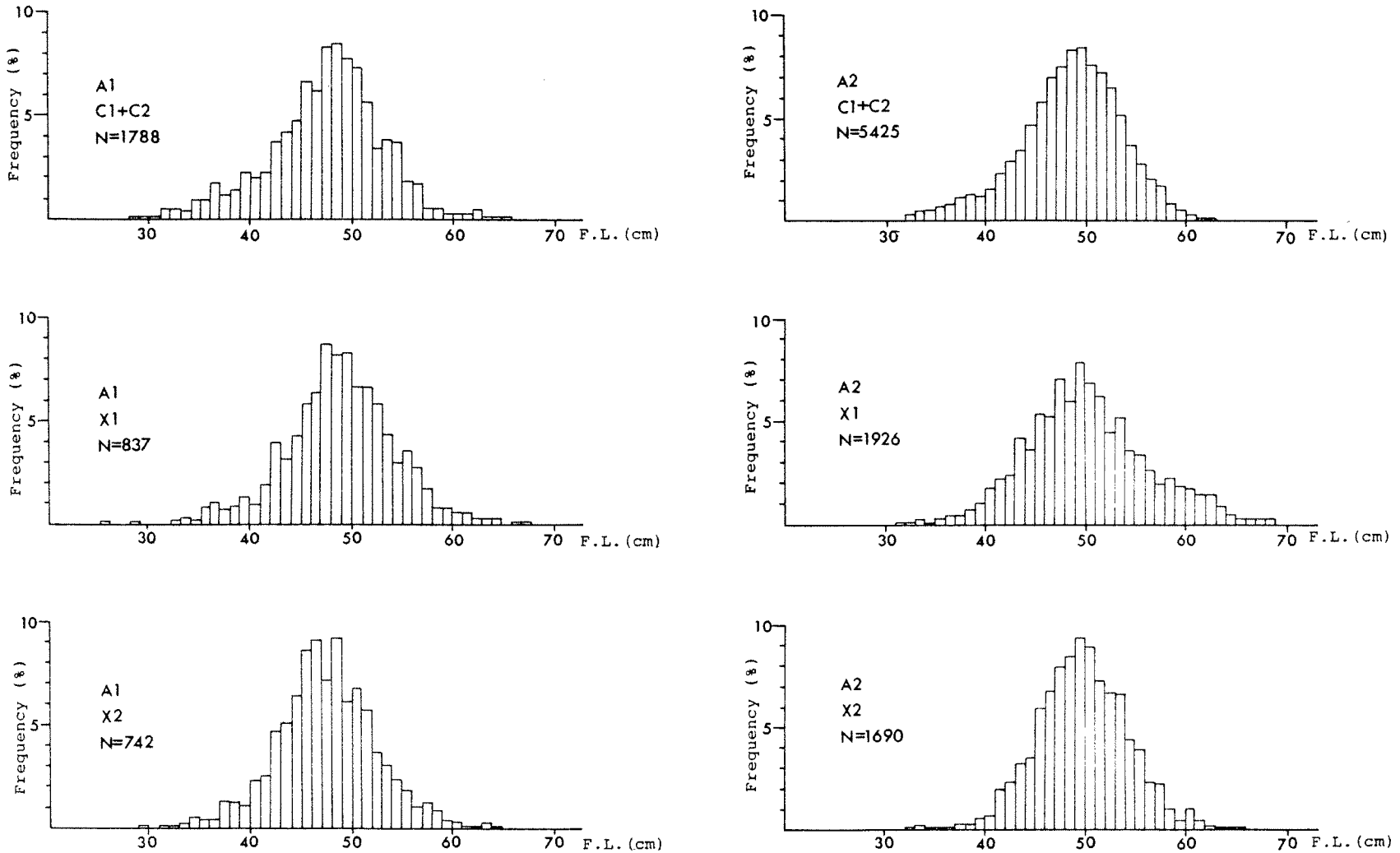

Fig.11. Length frequency of sablefish by net and area from subsample of catch.

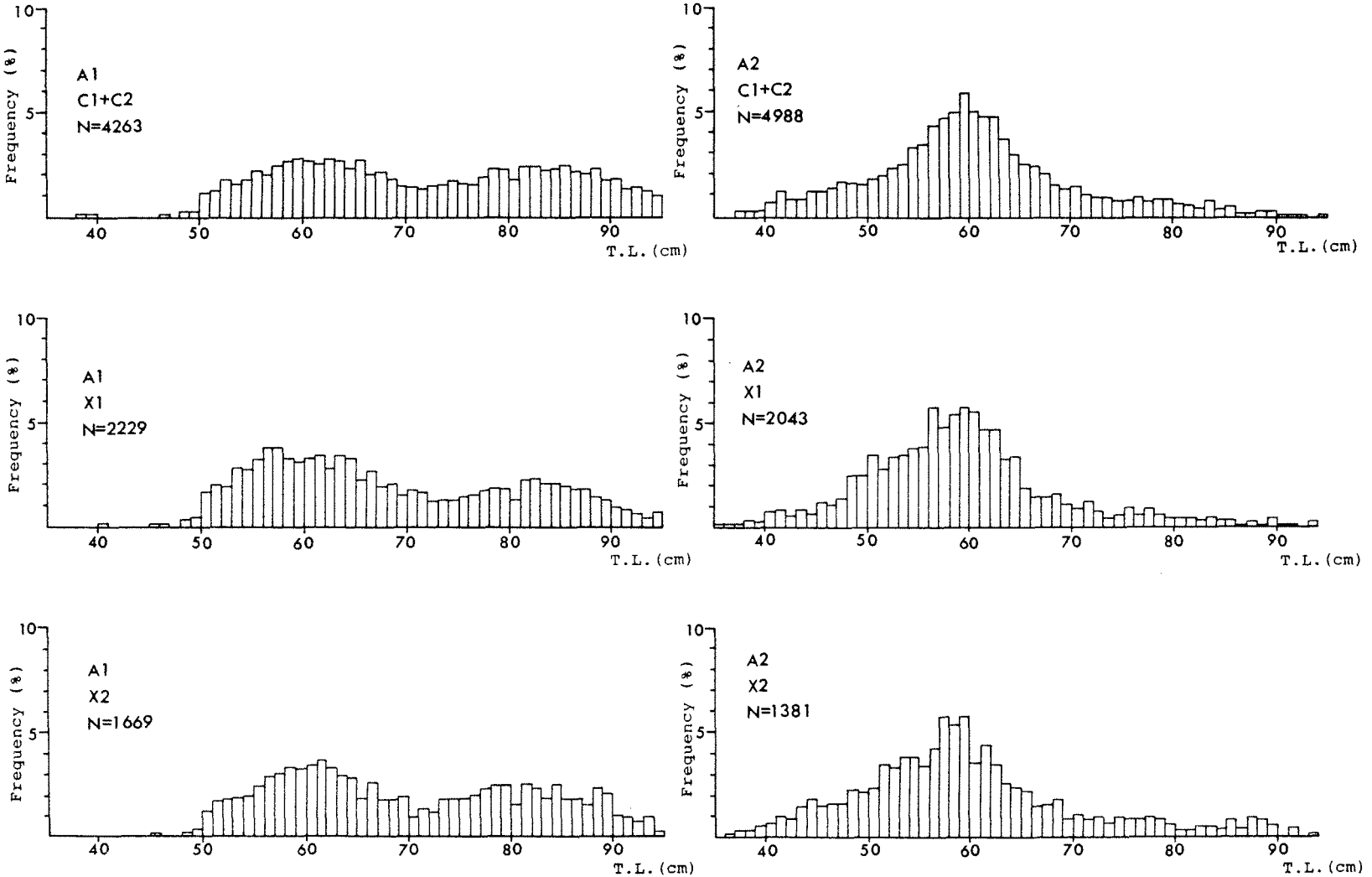

Fig.12. Length frequency of Pacific cod by net and area from subsample of catch.

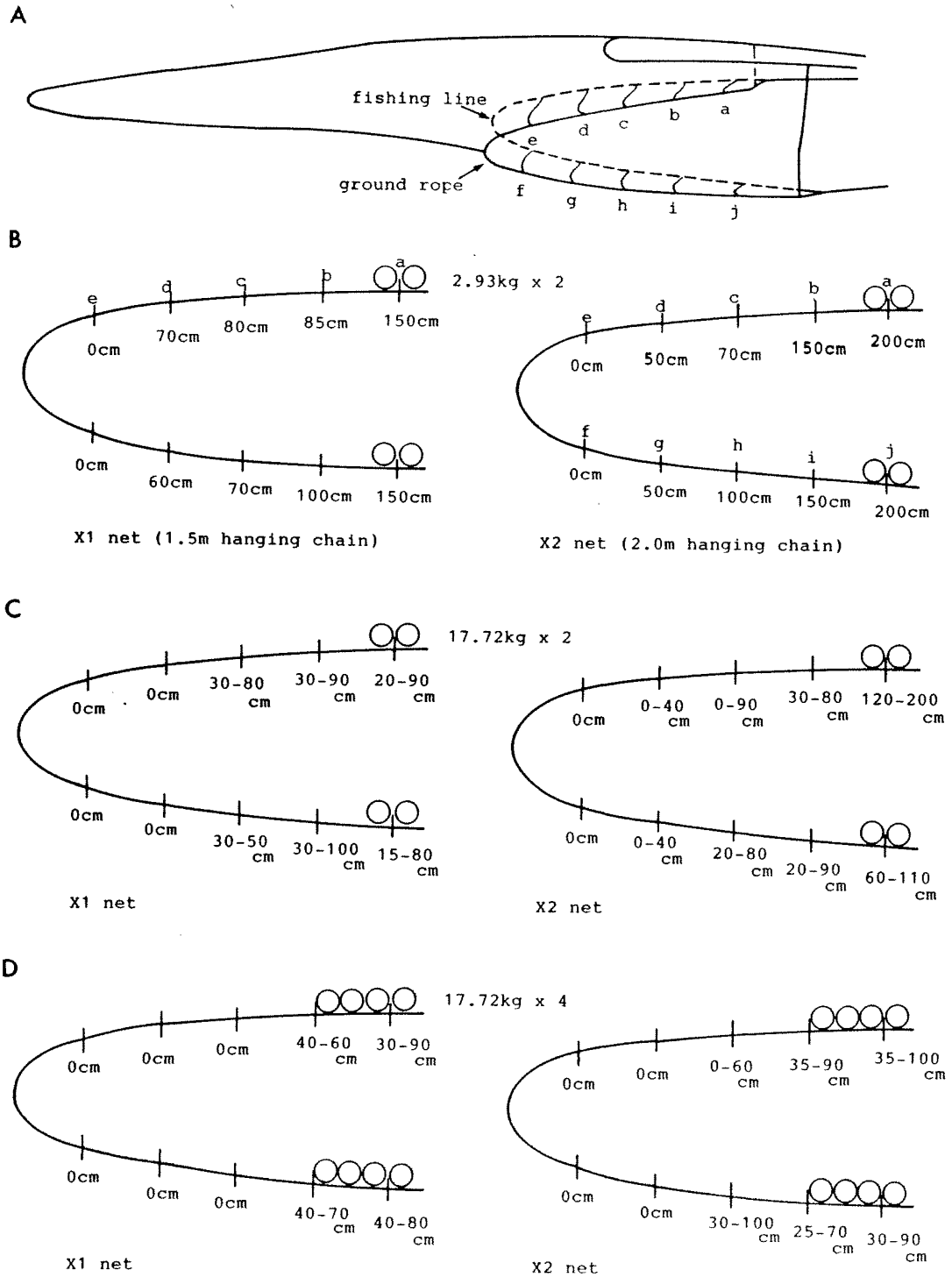

Fig. 13. Shining length of the hanging chains (a-j). A. Supposed actual condition of net with hanging chains in the field. B. Test with 5.9 kg floats at each tip of wing net. C. Test with 35.4 kg floats at the same part. D. Test with 70.8 kg floats at the same part. Numerals denote the length of shining part of each hanging chain, (mean length in B, and range in C and D).