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Title

A Report on the Trawl Fishery at Cape Lazo and Nanoose Bay during the Winter Months of 1949-50.

Author

K.S. Ketchen

Assistant Biologist

Pacific Biological Station

FOREWORD

For the past three years the Pacific Biological Station has submitted reports to the Department of Fisheries on observations and recommendations for the administration of two trawl fisheries opened on an experimental basis in the strait of Georgia. This manuscript report is based on the report submitted for the winter season of 1949-50.

K.S. Ketchen

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by

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Introduction

In the summer of 1947 almost all of the productive trawling grounds in the strait of Georgia were closed to trawlers in order to safe-guard the interests of the line fishery for lingcod. Such closures, although presumably of benefit to the lingcod fishermen, resulted in a severe shortage in the supply of other species of fresh fish to the Vancouver market during the following winter.

In response to a request from the industry to alleviate this situation, the Fisheries Research Board recommended to the Department of Fisheries that two grounds in the strait, namely, cape Lazo and Nanoose bay, be opened on an experimental basis to determine whether or not effective utilization could be made of the sole, gray cod, and dogfish stocks without undue destruction of lingcod. Permission was granted to fish both these areas between February 20 and March 20, 1948. By the end of this period approximately 130,000 pounds of soles and gray cod and 3,215 pounds of dogfish liver had been landed at Vancouver. The landing of lingcod was by comparison insignificant, being only 1,350 pounds. Observations on the fishing grounds by officers of the department and field workers of the Pacific Biological Station revealed some destruction of undersized lingcod but this also was insignificant in relation to the total catch.

Because of the unavoidably late opening of the fishery, the lemon soles landed from the cape Lazo area were far advanced in spawning and consequently not in good condition for filleting. In view of this a

request was made by the industry to the Fisheries department for an earlier opening of the Cape Lazo ground during the following winter. Permission was granted to fish from December 1, 1948 to January 15, 1949. The date for the Nanoose bay fishery was advanced to the same period.

Although the early reopening of the cape Lazo area proved very beneficial from the standpoint of the quality of fish produced, there was an almost total failure of the gray cod fishery at Nanoose bay. In that area the catch was only 1,900 pounds as compared with 42,450 pounds the year before.

The total landings of gray cod and soles from the two areas showed a substantial drop (130,000 pounds to 60,000 pounds) partially because of the failure at Nanoose bay and partially because of the 30,000 pound drop in the catch of soles at cape Lazo. The landing of dogfish liver, however, was 2,500 pounds greater than that in the previous year. As the open period occurred entirely within the general closed season for lingcod, there was no commercial landing of that species. Field experiments from the "Investigator No. I" and observations of the catches on the grounds showed that very few lingcod were being caught by the trawlers.

Following the 1948-49 season it was recommended that the cape Lazo fishery be opened for the same period in the following season, namely December 1, 1949 to January 15, 1950. However, it was also recommended that the dates for the Nanoose bay fishery be advanced to the same ones set in the original experiment, February 20 to March 20. Permission to fish these areas during the periods mentioned was subsequently granted by Order in Council P.C. 5870.

The fishery during the winter of 1949-50

I. The Cape Lazo fishery

The catches throughout almost the entire open period (December 1 - January 15) were very poor in comparison with those in the 1948-49 season (figure 1). To some extent this may have been due to the adversely cold weather which greatly hampered the efficient operation of the boats. However, there are indications that oceanographic conditions in the winter of 1949-50 were much different from those in the previous year, which may have had a more profound effect on production. Evidence to support this belief is presented in Appendix 1.

Throughout all but the last day of the fishery in the 1949-50 season the total catch per day never exceeded 2,000 pounds. On January 15 over 5,000 pounds of soles were caught by two boats. Following the official closure on that date representations were made to the Fisheries Department for an extension of the fishery, in view of the poor catches and the belief that the major spawning run had been missed. An order in council was issued shortly thereafter which granted an extension of the fishery to the last day of January. Fishing recommenced on January 20.

The day to day totals for the various species caught between December 1 and January 31 are given in table I. It is worthy of note that 70% of the lemon sole, 50% of the dogfish, and 30% of the gray cod were taken during the ten day extension period. The figures which are given were based on estimated daily boat landings prepared by the skippers of the vessels in special log books distributed by the Pacific Biological Station. In some instances it has been necessary to adjust these estimates to conform with the actual weighed-in values obtained by the contact man in Vancouver.

FIGURE 1. A comparison of the total catch and availability of lemon soles at Cape Lazo during the winter seasons of 1948-49 and 1949-50.

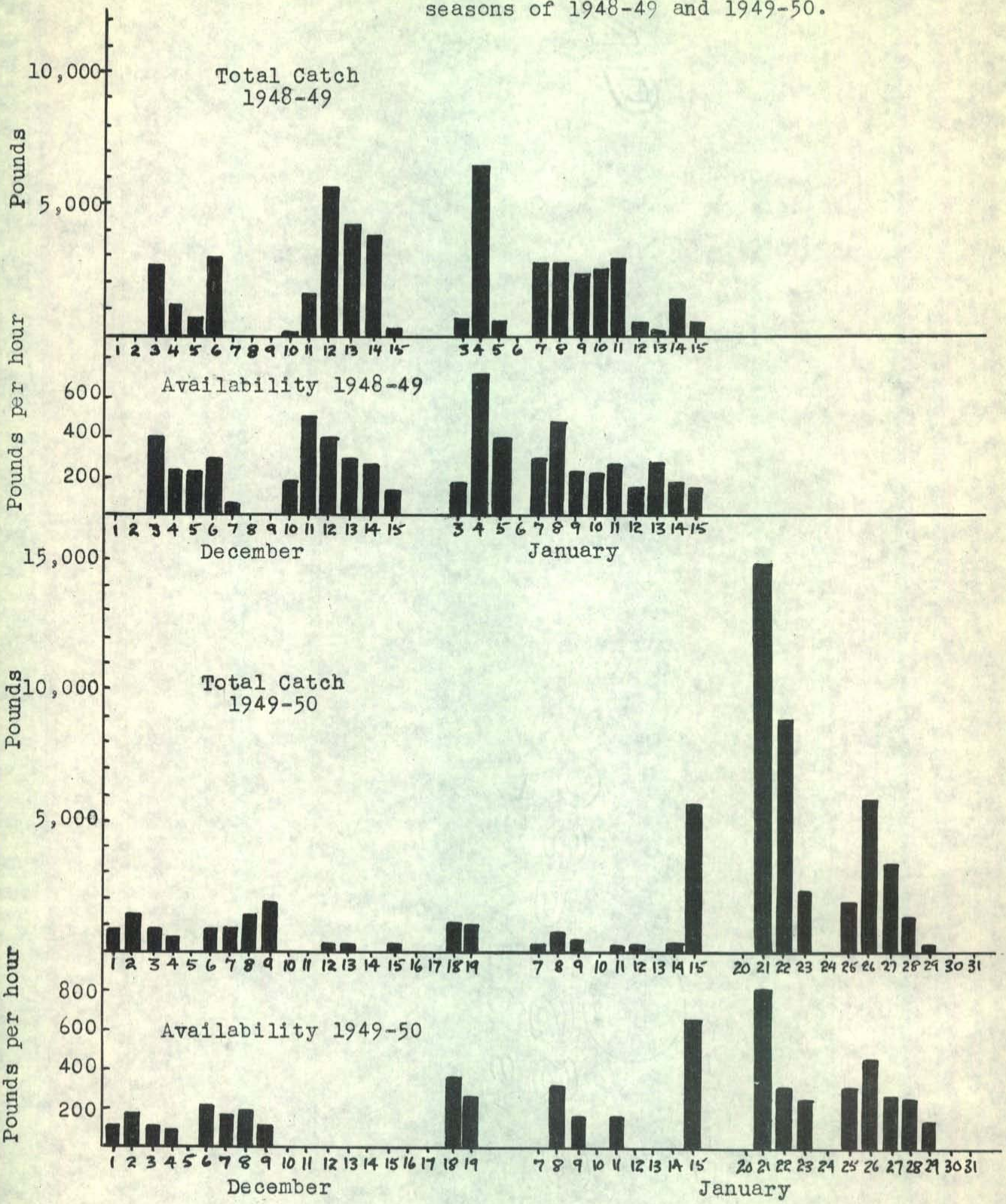


TABLE I

The daily catch of fish by trawlers operating in the cape Lazo area between December 1 and January 31, 1950.

Date	Number of Boats	Hours Fished	Pounds of Fish				
			Lemon Soles	Rock Soles	Gray Cod	Dogfish	Rockfish
Dec.							
1	2	12.5	745	600	250	60	1,000
2	2	21.0	1,580	900	380	110	100
3	3	19.0	915	1,000	305	5	500
4	2	13.2	410	1,000	210	125	500
5	2	2.5	-	-	140	1,515	-
6	2	10.0	840	800	200	595	-
7	4	12.2	750	500	300	440	-
8	4	17.0	1,310	700	195	655	-
9	4	23.5	1,205	-	240	630	-
10	1	1.0	-	-	125	-	20
12	1	9.0	200	200	200	-	100
15	1	3.0	50	-	-	-	45
18	1	6.0	1,000	-	200	-	-
19	1	8.0	1,000	-	240	-	-
Jan.							
7	1	4.0	75	-	-	210	-
8	1	6.0	600	-	500	70	-
9	1	4.0	260	-	-	50	-
11	1	6.0	225	-	-	595	-
14	2	7.0	70	-	700	365	-
15	2	13.0	4,200	-	560	-	-
.....							
20	1	4.5	300	-	-	630	-
21	5	36.5	14,800	-	120	-	-
22	9	63.0	8,350	-	580	440	-
23	6	23.5	2,400	-	760	140	-
25	7	11.5	1,600	-	90	-	-
26	7	34.0	5,850	-	255	3,440	-
27	7	36.5	3,295	100	450	320	-
28	3	16.5	1,650	-	80	20	-
29	2	6.0	300	-	200	-	-
30	3	10.0	185	-	50	200	-
Total	88	439.7	54,165	5,800	7,330	10,615	2,265

A detailed account of lemon sole availability as determined from catch-effort data is given in Appendix 2. A comparison of availability is made with estimates of population size in Appendix 3, and the results of migration studies are given in Appendix 4.

The landing of lemon sole (54,165 lbs.) was 8,000 pounds over the catch for the 1948-49 season, but if comparable periods are considered (i.e. with the exclusion of the extension period) the landing was 30,000 pounds less than that for the 1948-49 season. The catches in both years were, however, considerably beneath the 1947-48 total of 76,000 pounds. The gray cod catch of 7,265 pounds was below the 10,505 pound catch of 1948-49 and 10,260 pound catch of 1947-48. In contrast, the amount of dogfish liver landed (10,515 lbs.) showed a marked increase over the 1,880 pounds in 1948-49 and the 1,505 pounds in 1947-48.

As the open period occurred entirely within the closed season for lingcod there was none of that species landed. Through observation of the catches during the extension period, it was concluded that between one and two dozen undersized fish were caught in every drag, while commercial-sized fish occurred at a frequency of less than one fish per drag.

As a result of the paucity of fish on the regularly trawled parts of the cape Lazo grounds (35-48 f.) during the early part of the fishery, several of the boats moved up into the shallower water (8-20 f.) along the periphery of the grounds. The bottom in this region is composed of hard sand, kelp, and rock, and is inhabited by such fish as the rock sole and one or two species of rockfish (Sebastodes caurinus and maliger). The appearance of these species in the catches during the early part of the season is accounted for by the shift in effort to shallower water.

In addition to the totals given in the table there should also be included 820 pounds of perch (Damalichthys vacca), 280 pounds of skate

wings and 140 pounds of octopus. Also not included in the table were the catches and effort expended in a small area lying just outside the experimental area which is open all year round. During the Cape Lazo open period a few boats entered this area and caught 6,850 pounds of rock sole, 300 pounds of lemon sole, 550 pounds of gray cod, and 2,440 pounds of dogfish liver.

The condition of the fish landed

As mentioned previously the industry was dissatisfied with the late opening date of the 1948 fishery because the lemon soles were in an advanced stage of spawning and consequently very thin. Reports at that time from Mr. Wilson (the Vancouver contact man for the Biological Station) stated that most of the fishing companies were recovering only 28% of the total weight in fish fillets. Thus it may be supposed that the 76,500 pounds of soles landed in that year produced only about 21,400 pounds of fillets. During the 1949-50 season it was reported that one of the companies was recovering 36% in fillets. If this figure is representative of all companies and all catches it would appear that the 54,200 pound landing produced about 19,500 pounds of fillets, or only about 2,000 pounds less than that recovered from the very much larger catch early in 1948. This might serve to illustrate the undesirable effect of delaying the opening of a fishery which depends on a run of fish which are about to spawn. If the fishery is opened at a later date there may be more fish on the grounds and consequently more fish captured, but, as a result of deterioration from spawning, there is not a proportionate increase in usable fish flesh.

In the 1949-50 fishery only 28% of the fish caught were females. This is in contrast to 41% in 1948 and 38% in 1948-49. The females

were a little larger than in previous years but the males showed no appreciable change. A study of age composition shows that the dominating age group in males was V, while that for females was V and IV. This may be compared with VI (males) and VII (females) in 1948, and V (males) and V (females) in 1948-49. A more comprehensive analysis of length, age, and sex composition changes is given in appendices 5 and 6.

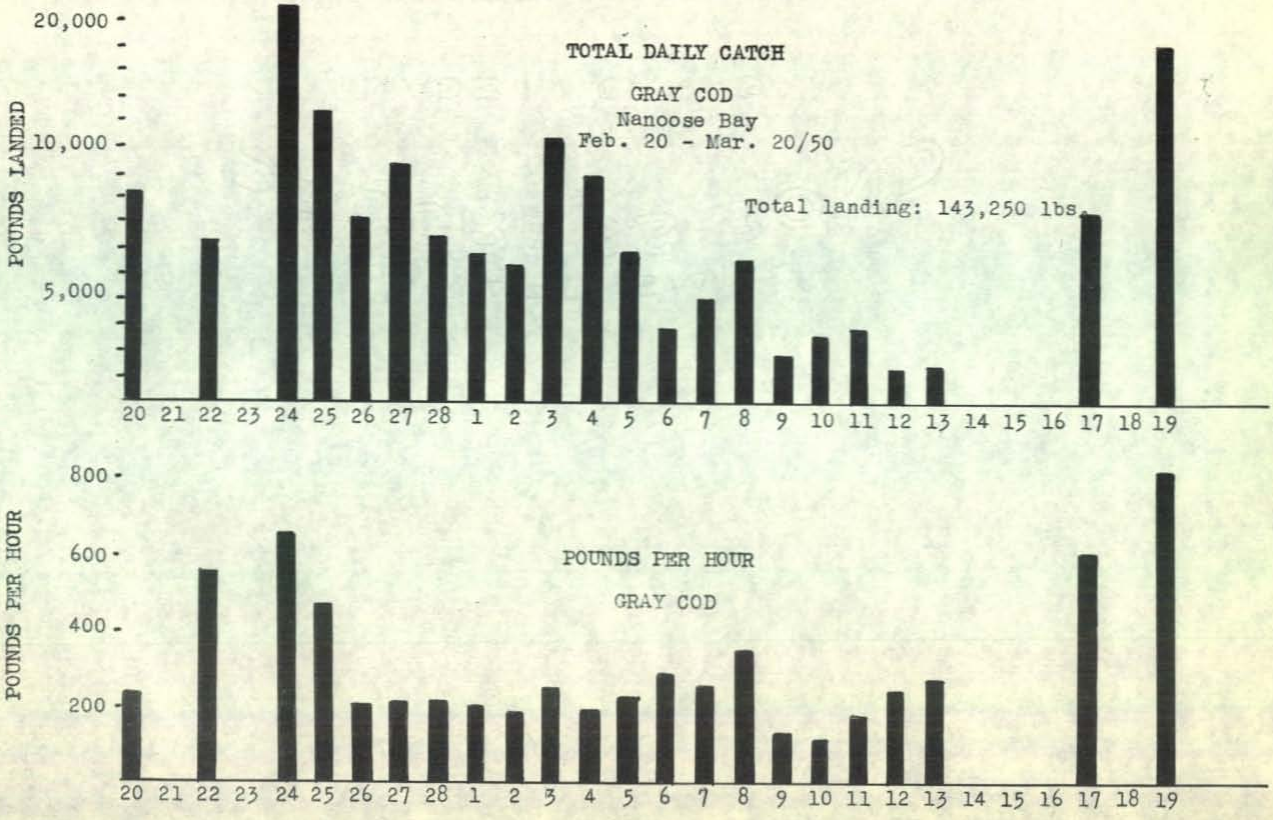
II. The Nanoose bay fishery

The Nanoose bay fishery of 1950 was opened for the period between February 20 and March 20 instead of December 1 to January 15 as in the previous year. This change was instituted in order that the fishermen might be given the opportunity to exploit the gray cod stock which ordinarily does not become available until the late winter months. The December-January opening of the 1948-49 fishery resulted in an almost complete failure of the gray cod fishery at which time only 1,900 pounds were landed at Vancouver.

The day to day landings from the 1950 fishery as obtained from the special log record forms are given in table II and an illustration of the gray cod catch and availability appears in figure 2. Despite the small size of the Nanoose bay grounds and the heavy concentration of boats, the catches of gray cod remained remarkably good throughout almost the entire period. By the end of the alloted time almost 146,000 pounds had been landed at Vancouver. These fish, described as being of good size and condition, found a ready market and a satisfactory price.

As shown in figure 2 the total yield dropped off slowly throughout the period, but the boat catch-per-hour remained fairly constant

FIGURE 2. Graph of total daily catch and catch per hour of gray cod at Nanoose Bay in 1950.



at 200 pounds after the first few days. The significance of the high catch-per-hour at the beginning and towards the end of the fishery is discussed in Appendix 7.

TABLE II

The daily catch of fish by trawlers operating in the Nanoose bay area between February 20 and March 20, 1950.

Date	Number of Boats	Hours Fished	Pounds of Fish				
			Gray Cod	Lemon Sole	Lingcod	Dogfish	Rockfish
Feb.							
20	6	35.0	8,000	800	-	48	1,020
22	3	14.0	6,200	250	-	-	1,000
24	4	25.0	15,500	285	-	8	300
25	3	26.0	11,700	210	-	8	220
26	6	32.5	7,150	310	-	8	525
27	6	44.0	9,250	240	-	1,000	485
28	5	28.0	6,350	225	-	-	360
Mar.							
1	4	26.5	5,700	175	125	-	350
2	5	28.0	5,420	200	115	-	100
3	5	42.0	10,330	260	155	-	635
4	6	45.0	8,930	205	200	-	325
5	3	26.0	5,900	40	6	-	100
6	2	11.0	2,950	-	-	-	550
7	3	16.0	4,000	30	90	-	500
8	2	16.0	5,500	60	15	-	320
9	2	14.0	1,750	50	3	-	70
10	4	18.5	2,400	155	25	-	90
11	3	17.5	2,800	105	160	-	220
12	3	9.5	1,270	245	20	-	120
13	3	5.0	1,300	10	10	-	-
17	2	12.5	7,500	-	-	-	-
19	3	17.0	16,000	40	30	-	-
Total	83	509	145,900	3,895	955	1,072	7,290

The 509 hours of fishing and the resultant 146,000 pounds of gray cod may be compared with the catch made two years previously during the same period, at which time 223 hours of fishing produced 42,450 pounds. In other words the average hourly catch in 1948 was 190 pounds

while that in 1950 was 285 pounds.

The general closed season for lingcod ends on February 28, which accounts for the sudden appearance of that species in the catches starting March 1. The catch of lingcod in relation to the total catch was quite insignificant.

The rockfish catch was almost entirely of the species Sebastodes flavidus, the yellow-tailed rockfish, or black bass as it is called by the fishermen. The sole catch, although composed mostly of lemon sole also includes quantities of rock sole, brill, and flounder.

The size and age of gray cod

A sample from the commercial catch contained 81 fish which ranged in size from 48 to 76 centimetres. Approximately 68% of these were three-year-olds with an average size of 56.7 centimetres. About 28% were four-year-olds with an average size of 63.8 centimetres. The remaining 3% were two and five-year-olds.

According to Miss Peterson, who has conducted the analyses, the very rapid growth rate is considerably higher than that found in fast growing (inshore) populations of cod on the Atlantic coast.

A more complete presentation of the age and length analysis is given in Appendix 8.

III. Recommendation

In setting up periods for fishing in restricted areas such as cape Lazo and Nanoose bay, the following questions have to be considered: (1) Is the period early enough to assure the capture of fish while they are still in a good condition for market? (2) Is the period late enough so that the main run of fish, if late, will not be missed? (3) Is the period of sufficient length to be conducive to a moderate intensity of

fishing and to a more or less prolonged flow of fish to the market?

Attempts have been made in the past to establish periods which, in the light of prevailing knowledge, seem to be the most suitable, both from the biological and economic standpoint. Complete satisfaction of the above conditions, however, can come only when sufficient information is collected to enable the accurate prediction of the movements of fish and the consequent course of the fishery. In the meantime the annual recommendations must be open to modification in keeping with the advance in knowledge of the many complicated biological and oceanographic factors. It is hoped that such modifications will lead to the more effective utilization of the fish stocks of the strait of Georgia.

The following recommendations are made for the cape Lazo and Nanoose bay fisheries for the winter of 1950-51:

Cape Lazo. It is recommended that this area be opened from December 1, 1950 to January 31, 1951 (inclusive). This should not only accomodate any late arrival of the fish on the grounds (as was the case in the past season) but should also spread the effort out over a longer period and thereby assure a more prolonged supply of fish to the market. It is not felt that the two week extension will materially affect the quality of the fish landed.

Nanoose Bay. It is recommended that this area be opened from February 20 to March 20, 1951 (inclusive). The dates are the same as in the past season and seem to conform with the biological and economic requirements.

It is further recommended that the Department give notification of the reopening well in advance. Although there were no objections relative to the official opening in the past season, there were a few complaints that the notification of extension of the cape Lazo fishery did not reach all of the fleet.

APPENDIX 1

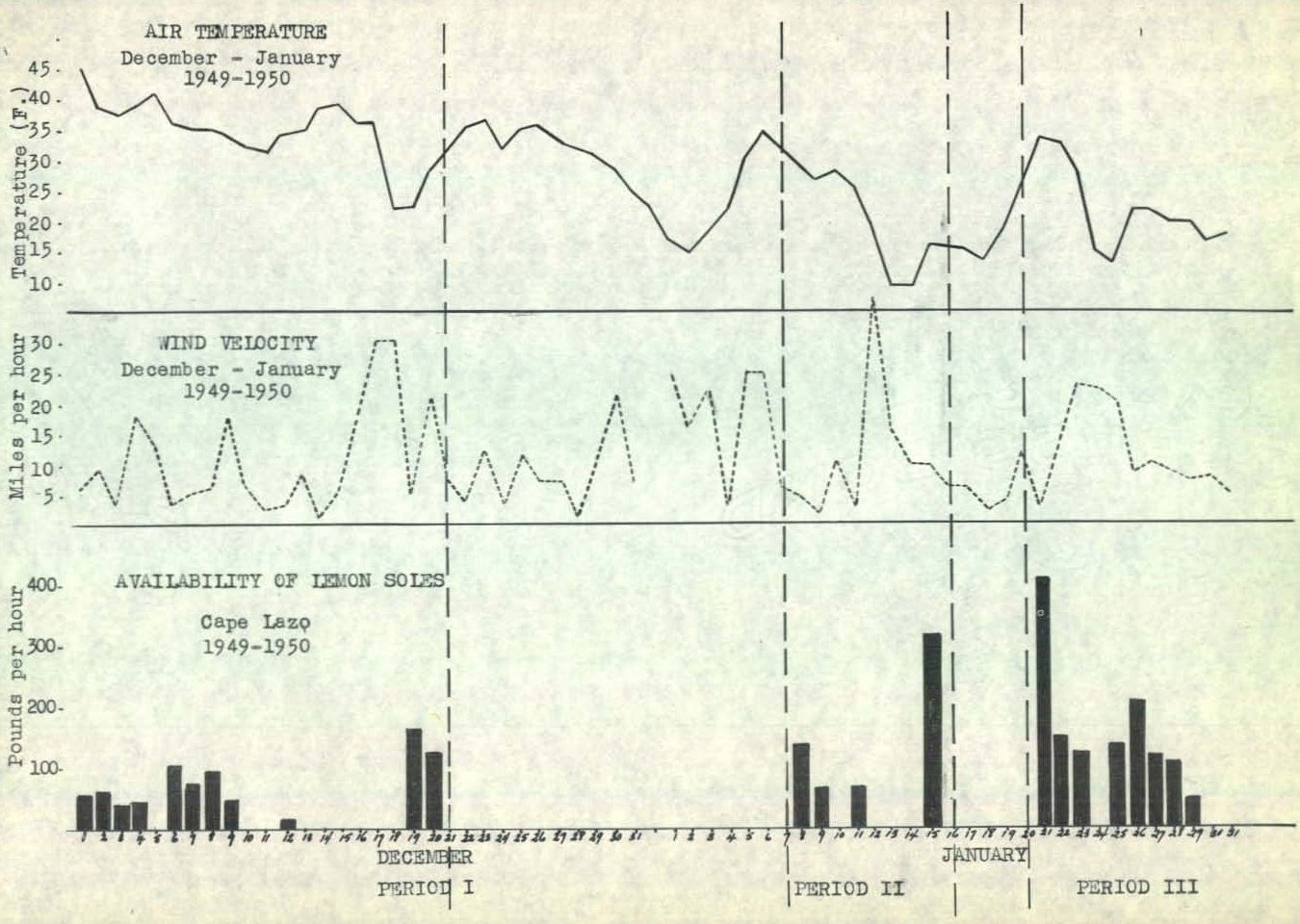
The possible relationship of lemon sole catch to changes in oceanographic conditions at cape Lazo.

Attention has already been drawn to the difference between the cape Lazo fisheries of 1948-49 and 1949-50 (see figure 1). There is a possibility that the failure of the main body of lemon soles to appear on the grounds in the 1949-50 season until the middle of January was related to some oceanographic condition which did not exist in the previous season.

Analysis of records from the cape Lazo weather station has been attempted in the hope that differences in meteorological conditions might give some clue to the differences in oceanographic conditions. In the three months preceding the fishery (September - November) the mean air temperature in 1948 was 45.9°F. as compared with 50.4°F. in 1949. Since there were frequent periods of high wind in these months it might be presumed that water temperatures were somewhat higher in 1949 than in 1948. If it is correct to presume further that spawning condition of the lemon sole is dependent on temperature--then there is a possiblility that higher water temperatures in 1949 delayed maturation of fish which in turn delayed their arrival on the grounds.

It will be noted in figure 3 that the availability of lemon sole increased sharply after the storm on December 17 and 18, and that a very marked increase occurred after the storm on January 12. There is an indication, similar to that found in the study of the gray cod at Nanoose bay (Appendix 7) that good catches follow storms. The high availability on January 20 does not necessarily contradict this suggestion since it is possible that there was an accumulation of fish

FIGURE 3. Graph comparing daily availability of lemon sole at Cape Lazo with air temperature and wind velocity records.



during the five day period of no fishing prior to that date.

Whether or not the mechanical action (per se) of a storm or the resulting change in temperature or salinity structure provided the stimulus for the movement of fish down into deeper water and hence onto the trawling grounds, is not as yet clear. Unfortunately, because of the absence of the research vessel, it was not possible to make an adequate coverage of temperature changes during the fishing season. However, a few records have been made available by the Pacific Oceanographic Group which has one of its "Georgia Strait" stations on the cape Lazo ground. A bathythermograph record taken on December 6 (at the time of relatively poor fishing) showed a temperature structure which was almost completely isothermal (47.5°F.) from the surface to the bottom (40 fathoms). Another record was taken on January 16, the day after the first reports of exceptionally good catches. This showed the presence of a relatively cold upper zone (isothermal, 40°F.) from the surface to a depth of 15 fathoms. Between 15 and 20 fathoms the temperature rose sharply to 45°F. From 20 to 45 fathoms (bottom) there was a gradual increase to 47°F.

Pre-season sampling revealed that very few female lemon soles were inhabiting depths greater than 20 fathoms. Apparently this condition existed throughout period I of the fishery since most of the catch on the more frequently trawled grounds was composed of male fish. In periods II and III there was a marked increase in the percentage of females (see Appendix 5). It is conceivable that this influx was a result of the movement of the shoal dwelling females into deeper water in advance of the downward progressing mass of cold surface water.

APPENDIX 2

The availability of lemon sole at cape Lazo

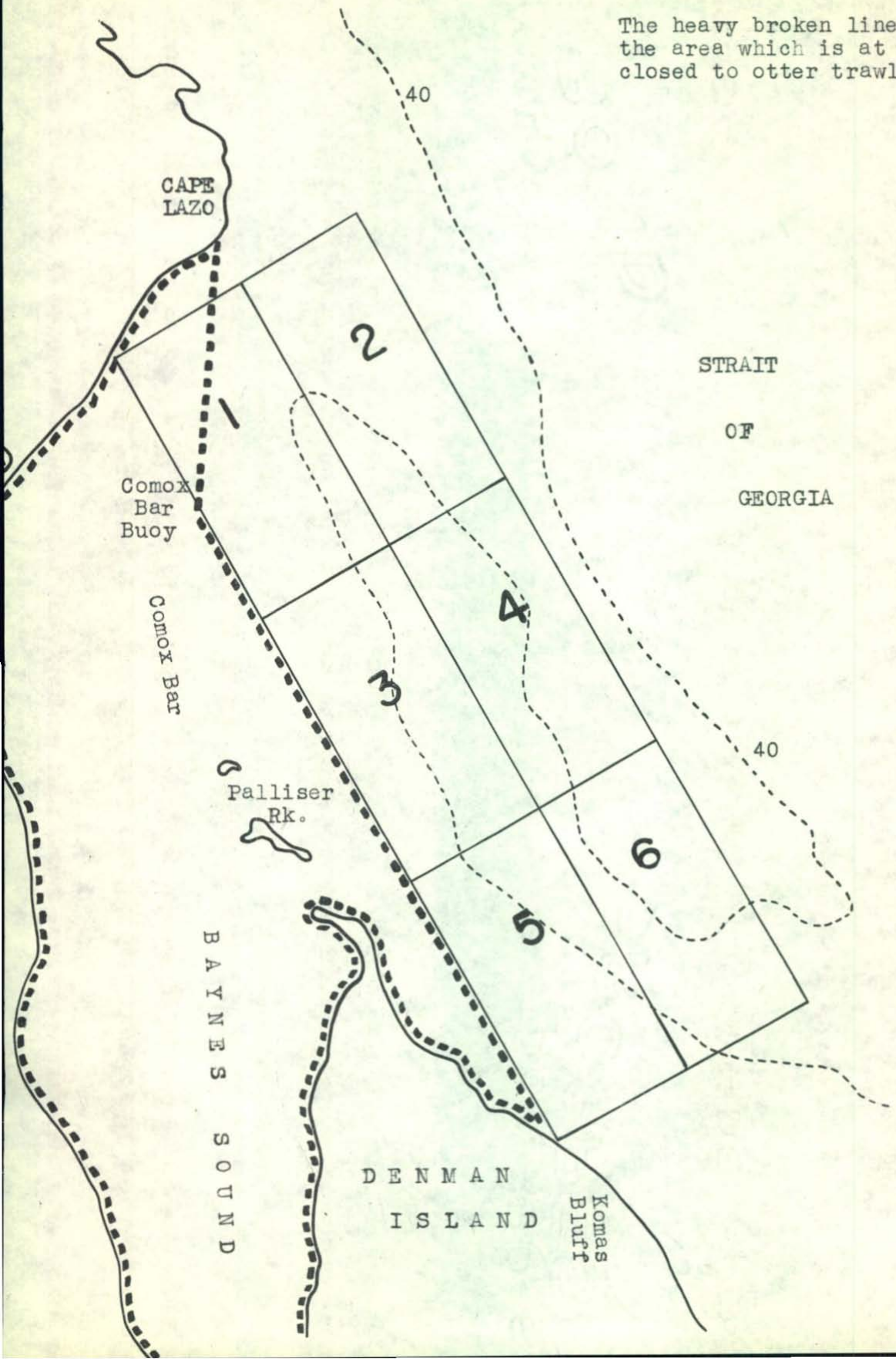
In studying the changes in abundance of lemon sole on the cape Lazo grounds use has been made of the special log record forms distributed to the fishermen prior to the fishing season. These supplied data on the daily catch of each species together with the number of hours fishing, from which was extracted information on the catch-per-unit-of-effort.

Before the catch-effort data can be used to give an expression of availability they must be handled in such a way as to eliminate the distortion effects of a number of factors. The first of these might be conveniently called the species factor. To use the cape Lazo fishery as an example, it is common knowledge among the fishermen that there are two distinct fisheries in the Lazo area--one in the northern part for soles and the other in the southern part for dogfish. Since the boats often fish in both areas in one day it has been virtually impossible in the past to separate from the landing reports the amount of time spent in fishing for soles and the amount of time spent in fishing for dogfish. Thus the information from the total catch figures for the 1947-48 and 1948-49 seasons that the catches per hour of soles were 220 pounds and 160 pounds, respectively, is apt to be misleading since there was no information on just how much time was spent on the lower ground in search of dogfish.

To overcome this deficiency a map (fig. 4) was incorporated with the 1949-50 log sheets which would enable the fishermen to give some indication of the approximate area covered each day. From these records it was possible to separate the fishery for soles in areas 1, 2,

FIGURE 4. A map showing the divisions of the Cape Lazo fishing grounds.

The heavy broken line bounds the area which is at present closed to otter trawlers.



3, and 4 (henceforth to be referred to as area A) from the fishery for dogfish in areas 5 and 6 (henceforth to be referred to as area B). Total figures indicate that while 49,000 pounds of soles and 150 pounds of dogfish liver were taken in area A, 5,100 pounds of soles and 11,690 pounds of dogfish were taken in area B. The calculations of availability of lemon soles are based on the catch and effort expended in area A only. In this way the major part of the distortion caused by the species factor is eliminated. The seasonal average catch per hour in area A during the 1949-50 season was approximately 140 pounds, while that for the entire Lazo area was less than 120 pounds. This latter figure may be compared in table III with similar gross averages for the two preceding seasons.

TABLE III

A comparison of seasonal average catch-per-hour of fishing for lemon soles and dogfish in the three fishing season at cape Lazo.

Season	Hours Fishing	Pounds Soles	Pounds of Soles Per Hour	Pounds of Dogfish	Pounds of Dogfish per Hour
1947-48	347	76,500	220	1,505	4
1948-49	295	47,630	160	1,880	6
1949-50	440	54,165	120	11,845	27
1949-50 (corrected)					
Area A	354	49,050	140	150	-
Area B	86	5,100	60	11,690	135

Included in this table are seasonal catch figures for dogfish and adjusted figures for the 1949-50 season involving separate consideration of the two fishing grounds. By segregating the catches in areas

A and B a very marked difference is produced in the calculation of catch-per-hour of dogfish. When the entire area is considered the catch per hour was only 27 pounds, but in area B it amounted to 135 pounds.

The data in the fourth column of table III suggest a decline in overall catch per hour of lemon sole over the three year period. However, since the fishery in 1947-48 occurred very much later than those in 1948-49 and 1949-50 it cannot very well be compared. Furthermore, it is known that effort expended on dogfish in the 1948-49 fishery was only slight, which would suggest that the catch per hour of soles would not have been affected markedly in that year by a segregation of the effort expended on the two species. Hence, it may be more reasonable to compare the 1948-49 figure of 160 pounds with the 1949-50 figure for area A which was 140 pounds. Considering the limitations of the data it is doubtful that the decline in 1949-50 was significant.

In order that proper interpretation might be given to the results of tag recoveries it has been necessary to assess the availability for a number of periods during the fishery. Advantage has been taken of three natural periods: (I) December 1-18, 1949, (II) January 8-15, 1950, and (III) January 21-30, 1950. Period I was separated from period II by the Yule-tide season and period II was separated from period III by the six day lapse between the official ending of the fishery and the beginning of the extension period.

The calculation of availability during each of the three periods has entailed the consideration of the <u>period factor</u> which must be accounted for when certain of the boats engaged in fishing do not operate during the entire season, and the <u>boat factor</u> which must be accounted for when there are efficiency differences between boats.

In the interest of brevity a detailed explanation of this weighting procedure has been omitted. The weighted average catch per hour of fishing during each period as determined for area A at cape Lazo is given in table IV.

TABLE IV

The weighted average catch of lemon soles per hour of fishing in area A at cape Lazo during the three periods of the fishery.

	Period I	Period II	Period III
Weighted average catch per hour of fishing (pounds)	65	270	190

The unweighted daily average catch per hour of fishing in area A was shown previously in figure 1. It was noted that a high level of availability actually did not exist throughout the whole of period II, but rather was confined to the closing days of that period. The use of averages for rather lengthy periods has unfortunately obscured the trends within periods. This has been unavoidable, not only because of the sporadic nature of the fishery, but also because later comparisons with population estimates (Appendix 3) have entailed the use of data which could not be refined to shorter periods than those used.

APPENDIX 3

The results of lemon sole marking and tagging experiments at cape Lazo

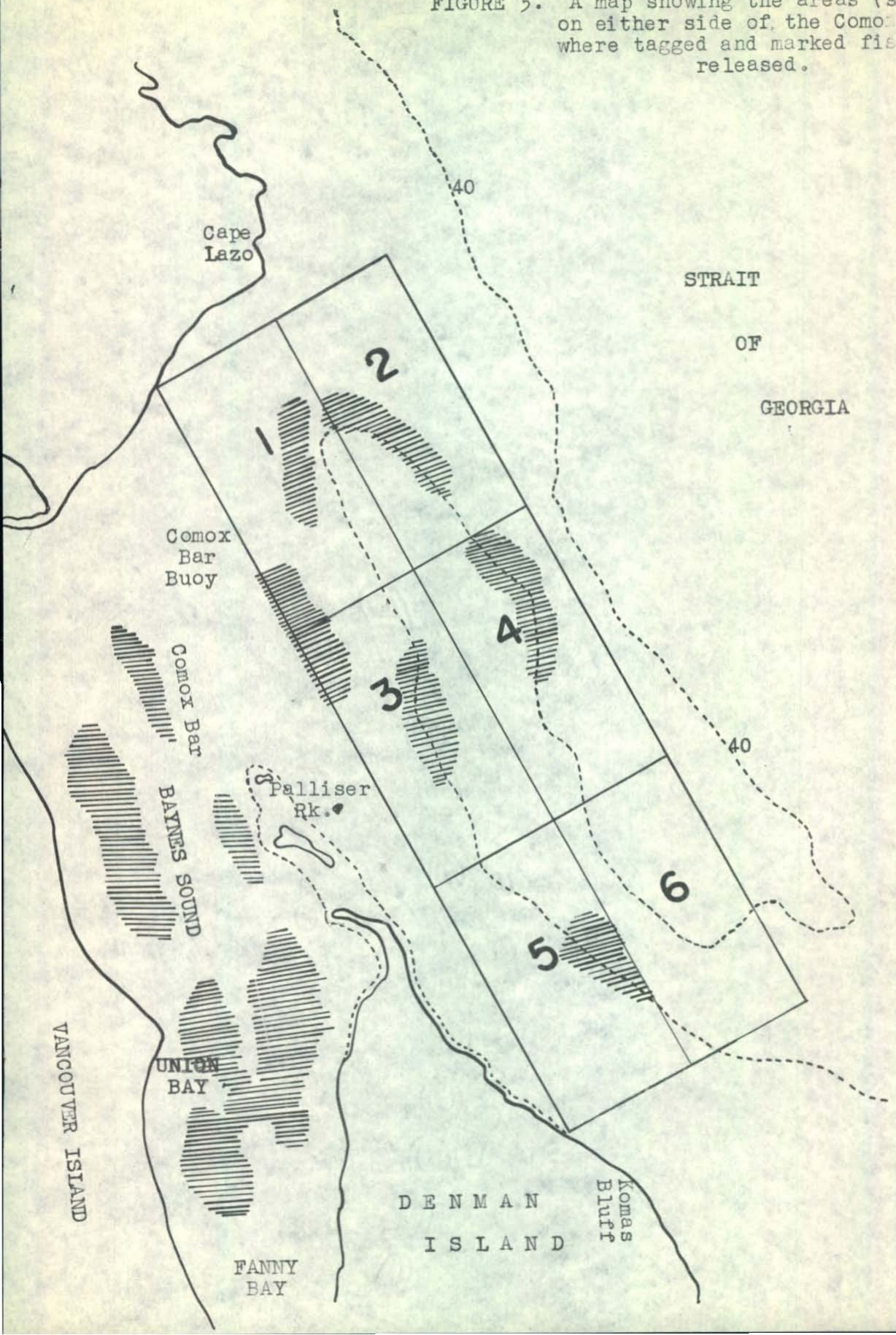
During the month preceding the fishery at cape Lazo an extensive marking and tagging programme was carried out on the cape Lazo grounds and in the adjacent closed area of Baynes sound. The purpose of this experiment was to obtain estimates of population size and fishing intensity and to gain an understanding of the relationship of the population of lemon sole at cape Lazo to that in the much disputed closed area of Baynes sound. Accordingly, there were released on the cape Lazo grounds approximately 830 tagged fish and 2,200 fish marked by the removal of one of the pectoral fins. In Baynes sound over 1,500 tagged fish were liberated along with 7,200 marked fish. Most of the tagging and marking in the inside waters was carried out mainly between Union bay and the Comox bar (see fig. 5) in order to ensure adequate recovery if there was extensive outward migration across the bar to the Lazo grounds.

Tagged fish which were captured by the fishermen were turned over to the contact man upon arrival at Vancouver. However, the fishermen were not expected to make recoveries of marks. This was done by the contact man and his assistant at Vancouver. Frequent samples of 1,000 fish were taken from the commercial catch throughout the course of the fishery and examined for the percentage of marked fish.

1. Estimation of abundance from marks

In marking the lemon soles at cape Lazo no consideration was given to the size of fish. Thus it had to be presumed that not all marked fish would be large enough for market and that a certain percentage would escape through the nets or be culled by the fishermen.

FIGURE 5. A map showing the areas (shaded) on either side of the Comox bar where tagged and marked fish were released.



In order to calculate the percentage of effective marks, that is, the probable percentage which would be retained by the fishermen, the percentage length frequency polygon for all marked fish was superimposed on that for the commercial catch in each period. The region of overlap then gives a percentage by area of the effective marks. An example is given in figure 6. From this calculation it was estimated that during the first period 80% of the male and 73% of the female marks were effective. The effective marks in the later periods were almost the same, being 81% and 72% respectively.

Using the weighted catch for each period together with length-weight data it was possible to estimate the number of fish landed during each period. Since the ratio of marked to unmarked fish was obtained by sampling it was then possible to obtain an estimate of the probable number of marks landed in each period. Then, by the use of simple proportion a rough estimate was obtained of the probable number of commercial-sized fish on the grounds.

In the commercial landing for period I, 3,474 fish were examined and 36 marks were recovered. Of 1,652 fish examined in period II, 8 were marked fish, and of 6,943 fish examined in period III, 31 were marked. The ensuing calculations of population size in the three periods are summarized in table V.

TABLE V

A summary of the calculation of population size from the recovery of marked fish.

Period	Number of Marks Estimated Recovery	Number of Marks At Large	Number of Fish Landed	Probable Number of Commercial Sized Fish at Large
I	137	1,667	12,200	148,000
II	34	1,530	8,710	392,000
III	222	1,496	47,520	320,000

The population estimate from marks confirms the results of the study of availability in Appendix 1, that the population was of greatest size in period II. However, a more detailed consideration of this relationship has been reserved for a later section.

It might be argued that calculations based on the recovery of marked fish are not as accurate as those based on the recovery of tagged fish. In the first place marks are not as readily discernible as tags and secondly, it is necessary to apply an adjustment of questionable accuracy for the estimated number of effective marks. However, the method has one important advantage in that the recovery for the various size groups will be more closely proportional to the actual strengths of the size groups. It is reasonable to presume that if the fisherman is unaware of the presence of marked fish in his catch, the number of marks amongst fish of say 30 centimetres which he retains for market should be in the same ratio as marked to unmarked fish of 30 centimetres which happen to be returned to the water. On the other hand, where tags are involved, undersized tagged fish when captured would be retained by the fisherman, but had there been no tags on those fish they would probably have been returned to the water. This process of disproportionate selection would tend to distort any calculations of population size and fishing intensity.

2. The estimation of abundance from tags

As in the previous section the weighted total catch for each period has been employed to estimate the numbers of fish landed. It was then possible to obtain the ratio of tagged to untagged fish in the commercial catch. With the aid of an adjusted estimate of the probable maximum number of tags at large a calculation was made of

the population size in each period. A summary of these calculations is given in table VI.

TABLE VI

A summary of the calculation of population size from the recovery of tagged fish.

Period	Number of Tags Recovered	Number of Tags At Large	Number of Fish Landed	Probable Number of Commercial Sized Fish at Large
I	56	814	12,200	177,000
II	22	758	8,700	300,000
III	92	736	47,520	380,000

It will be noted that whereas the estimated population from marks was greatest in period II, the greatest size as estimated from tags came in period III.

A graphic comparison of the population sizes determined by marking and tagging is shown in figure 7 along with the availability figures from Appendix 1. A point which is immediately apparent is the close agreement between the trend in population estimated by marks and that of availability. Aside from a reasonably close agreement in the first period the population estimates by the two methods are widely divergent both in trend and absolute numbers. There is an agreement between periods I and III insofar as relative numbers are concerned, for estimates by both methods show an increase of X2.1 from period I to period III.

These results suggest that the tagged fish reacted differently from those which were marked, either independently of, or as a direct result of the difference in the effect on the fish of marking and tagging.

FIGURE 7. Showing the relationship of population estimates by marks and by tags to availability

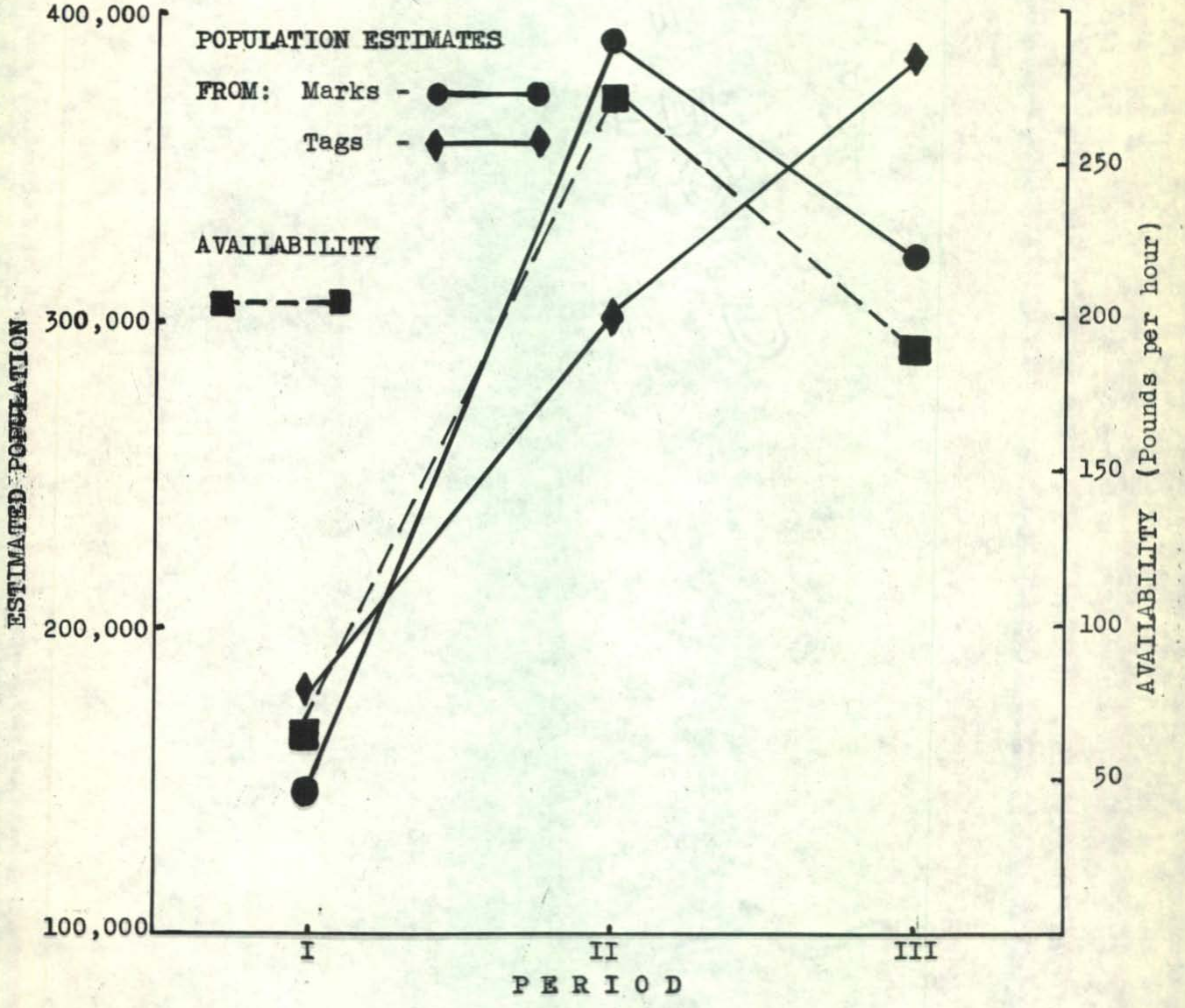
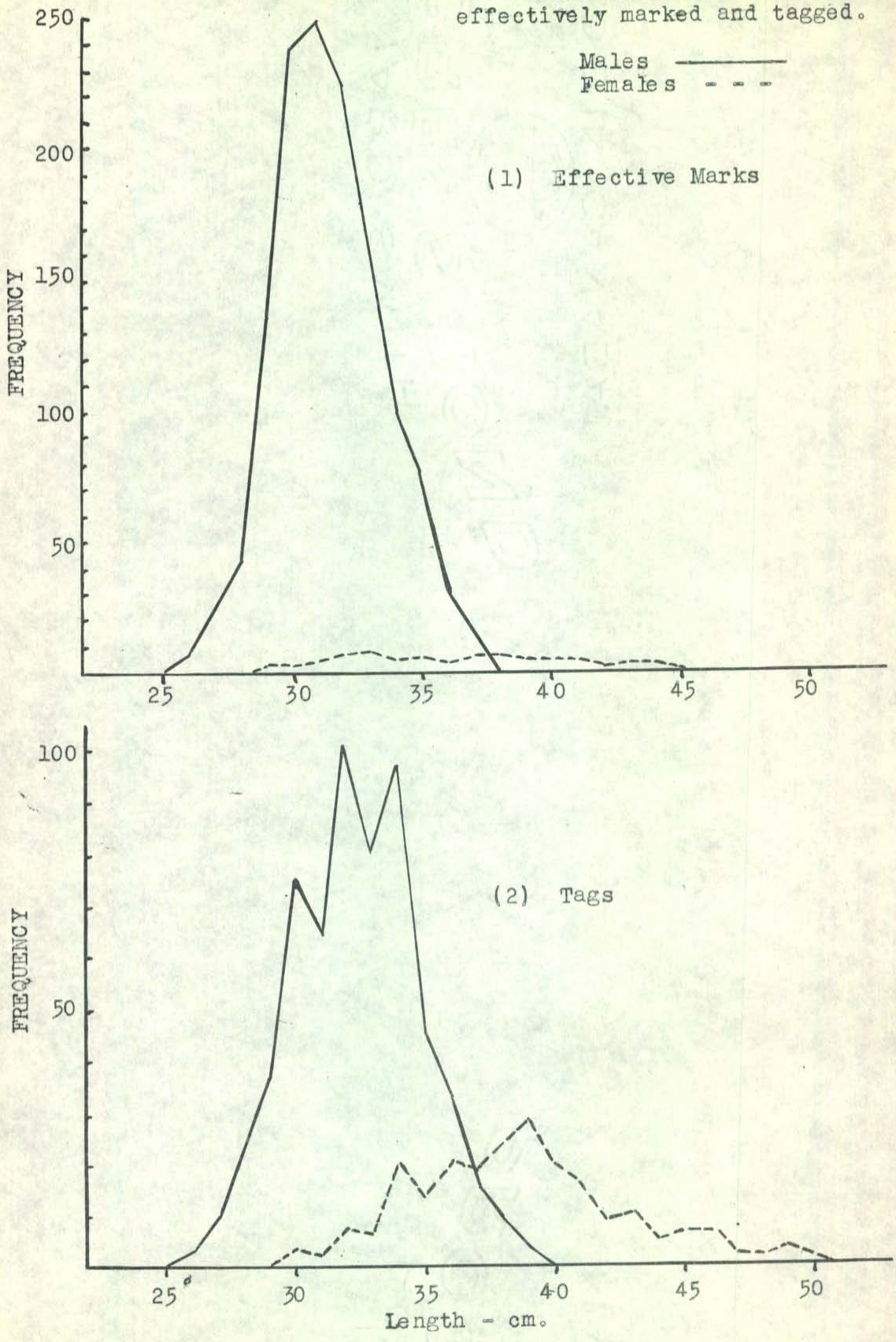


Figure 8 shows length frequency polygons of marked and tagged fish. The marked males were slightly smaller than the tagged males. The marked females were much smaller than the tagged females and were not nearly as well represented (5% in the mark sample as compared with 29% in the tag sample). These size and sex ratio differences may account for the differences in recoveries. Yet, if the factor of size played some part in the chance of recovery, then it would have made itself evident in the size distribution of recovered tagged fish. Length frequency polygons of tagged and recovered fish when tested by means of Chi-square, showed no significant differences.

A clue to the difference between the estimates may lie in the fact that the percentage of females in the recovered tagged fish was 22% as compared with 29% at the time of tagging, which suggests that the females are moving away faster than the males. If this is true then it might serve to partially explain the apparent increase in population (as determined by tags) in period III. If the sample of marked fish contained a higher percentage of males than the sample of tagged fish and if males remain available to the fishery for a longer period of time than females, then it is reasonable to suppose that population estimates from marks would follow the trend in availability more closely than those from tags.

When the percentage of females among tagged fish was determined for each of the three periods it was found that 39% of the recovered tagged fish in period I were females (as compared with 29% at the time of tagging), only 7% in period II, and 16% in period III. In Appendix 5 it will be shown that during period II and III there was a sharp increase in the percentage of female fish on the grounds. This fact together with the apparent decline in the percentage of tagged female

FIGURE 8. Length frequency polygons of the lemon soles which were effectively marked and tagged.



fish lends support to the belief that female fish do not remain on the grounds as long as the males. Thus it may be expected that the tagging experiment, since it involved more females than did the marking experiment, would tend to give less accurate estimates of population.

3. Estimation of rate of exploitation

Estimates of the rate of exploitation at cape Lazo have been obtained from the percentage recovery of marks and tags. These figures must be considered only as approximations since such factors as natural and tagging mortality and rate of migration off the grounds cannot be given any quantitative evaluation. The rate of exploitation as determined from marks was 393/1,667 or 23.6%, while that determined from tags was 170/814 or 20.7%. However, a much closer agreement with the estimate from marks is obtained if only the tagged male fish are considered, the result being 132/578 or 22.8%. This is another indication of the differential mobility of males and females on the spawning ground. If the females move off the grounds more rapidly than the males, the estimated exploitation rate will be greater when females are excluded from the calculations.

The rate of exploitation calculated by Manzer (manuscript) for the winter fishery of 1948-49 was found to be about 24%.

APPENDIX 4

Migration of lemon soles as shown by tagging

Of the 194 tags recovered on the cape Lazo grounds during the winter fishery of 1949-50, 19 had been released prior to the 1948-49 season and 170 had been released during the two week period prior to the 1949-50 season. The remaining 5 tags had been released prior to the 1949-50 season, not at cape Lazo, but in the adjacent waters of Baynes sound.

The relationship of the fish in Baynes sound to those inhabiting the cape Lazo ground is the subject of considerable interest. Many fishermen contend that the Baynes sound population is distinct from that in the outside waters and that any prolonged closure of that area to trawlers would result in a great wastage of fish. Heavy tagging was carried out in Baynes sound, particularly in the northern part between Union bay and the Comox bar (see fig. 5) in order to determine whether or not there was extensive movement across the bar to the cape Lazo ground. During the first week of the fishery one of the boats fishing along the shallow water on the outside of the bar picked up a tag released two weeks earlier on the inside of the bar. No other inside tags were recovered on the Lazo grounds until the extension period late in January, during which period four tags were recovered. One had been released just inside the bar, two had been released at Union bay and one at Fanny bay. Of the inside fish taken outside, three were mature males and two were large females.

A month after the closure of the cape Lazo fishery, nine lemon sole tags were recovered on that ground by the "Investigator No. I". Five of these were small male fish tagged prior to the fishing season.

Three had been released at cape Lazo and two had been released at Union bay.

Sampling in Union bay produced four tags all of which had been released in that area prior to the fishing season. Five tags (all large females) were recovered at Fanny bay. Two were from inside the Comox bar, two were from Union bay, one was from Deep bay, and one was from cape Lazo. A cape Lazo tag and a Deep bay tag were recovered in Deep bay.

Four tags were picked up by commercial vessels between March and June, 1950, in the area above cape Lazo (north-west of area 2). Three were from the Lazo ground and one was from Union bay. One of 500 tags released on the cape Lazo ground a month after the close of the fishery was picked up three months later by a commercial boat operating 85 miles to the south in Pylades channel.

To summarize these recoveries it may be said that there is some mixing in both directions between Baynes sound and cape Lazo, that some cape Lazo fish move across the bar to Fanny bay and spawn and that some Fanny bay fish find their way to cape Lazo and spawn in that area. It would appear that the Baynes sound population makes only a small contribution to the fishery at cape Lazo. This is based on the fact that only 5 tags of the 1,500 liberated within the sound were captured outside during the open season.

There is strong evidence to confirm the conclusions of Taylor (unpub. manuscript) that spawning takes place mostly in Fanny bay. Tagging and special sampling from the "Investigator" indicate a pronounced southerly movement in Baynes sound with the advent of the spawning season.

Migration of spent fish from Baynes sound and cape Lazo in a

northerly direction towards Oyster river is suggested by the recoveries made so far. There have been indications from former tagging experiments that there is some migration from cape Lazo southward towards the Qualicum beach region. The lone tag from Pylades channel falls in this southerly migration pattern but covers a much greater distance than any previous record.

APPENDIX 5

Length and sex composition of lemon soles at cape Lazo

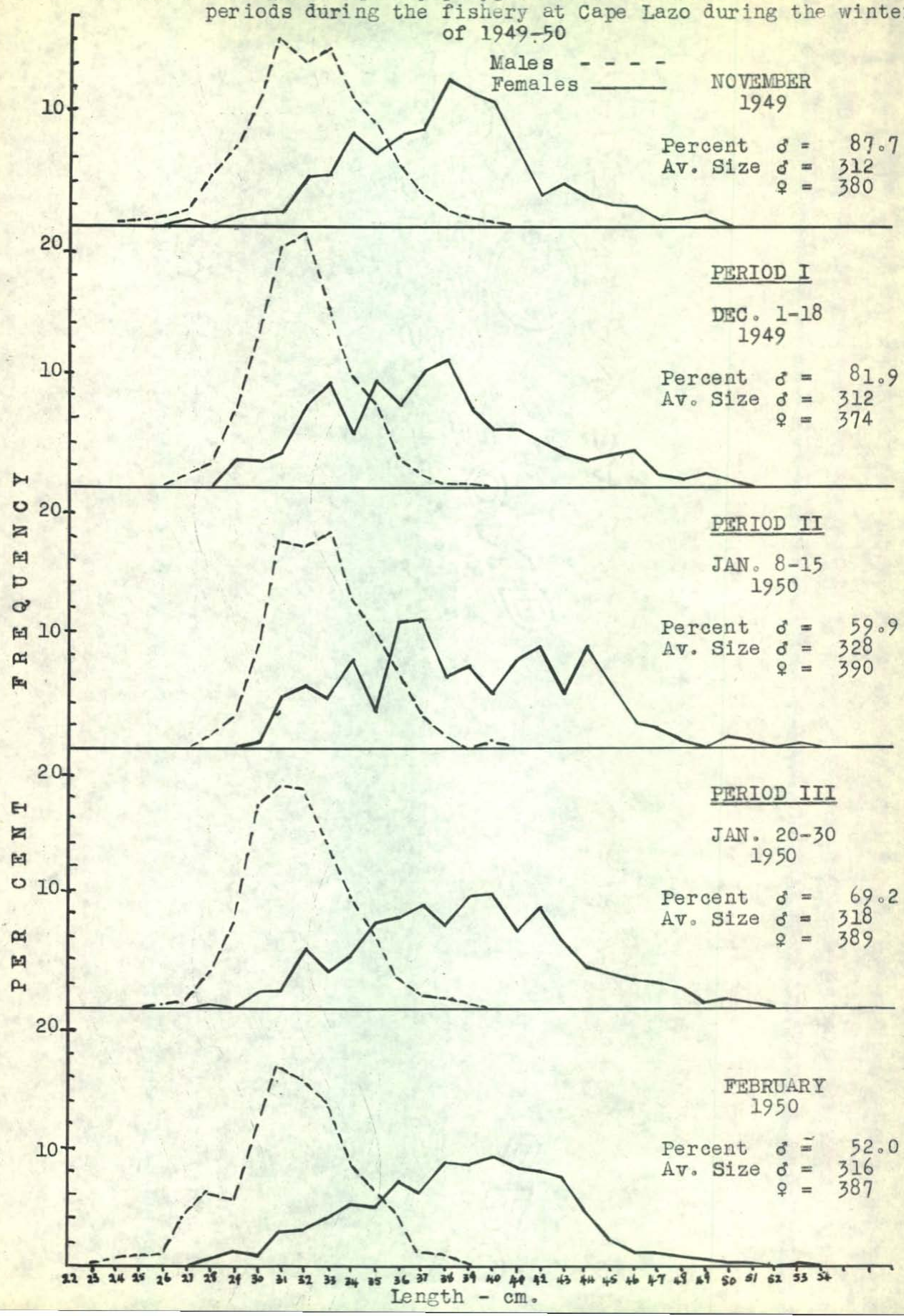
The length frequency composition of lemon soles taken from the cape Lazo ground during the winter of 1949-50 is shown in figure 9. The November sample was taken from the chartered vessel "Phyllis Carlyle" and is a composite of marked and tagged fish and samples of otoliths. The December and January samples were from the commercial catch landed at Vancouver and the February sample was obtained by the "Investigator No. I" after the fishery had closed.

The males caught during November were on the average about half a centimetre smaller than those taken in the commercial catch in December (period I), but this might be expected since the November sample would contain a higher prercentage of unmarketable fish. Aside from an increase in average size of almost a centimetre in male fish during the first half of January (period II) the average size remained fairly constant from December through to February.

Female lemon soles taken in the first period of the fishing were smaller than those sampled prior to the opening. However, after the New Year there was a marked increase in average size of almost 1.5 centimetres. A study of the sex ratio would suggest that this change was the result of an influx of a body of large female fish. In November and December the females comprised under 20% of the catch. In the period II and III samples, however, there was an increase to 40% and 30% respectively. Samples taken in February showed an almost equal representation of males and females.

The percentage of females taken in the entire fishery from December to January was only 28. This may be compared with 41% and

FIGURE 9. Length frequency polygons of lemon soles taken at various periods during the fishery at Cape Lazo during the winter of 1949-50



38% in the fisheries of 1947-48 and 1948-49, respectively (table VII). The failure of the cape Lazo fishery to materialize until the middle of January, coupled with the low percentage of females in the catches up until that time suggests that the females were unusually late in their arrival on the grounds in the 1949-50 season. The possibility that this might be related to oceanographic conditions has been discussed in Appendix 1.

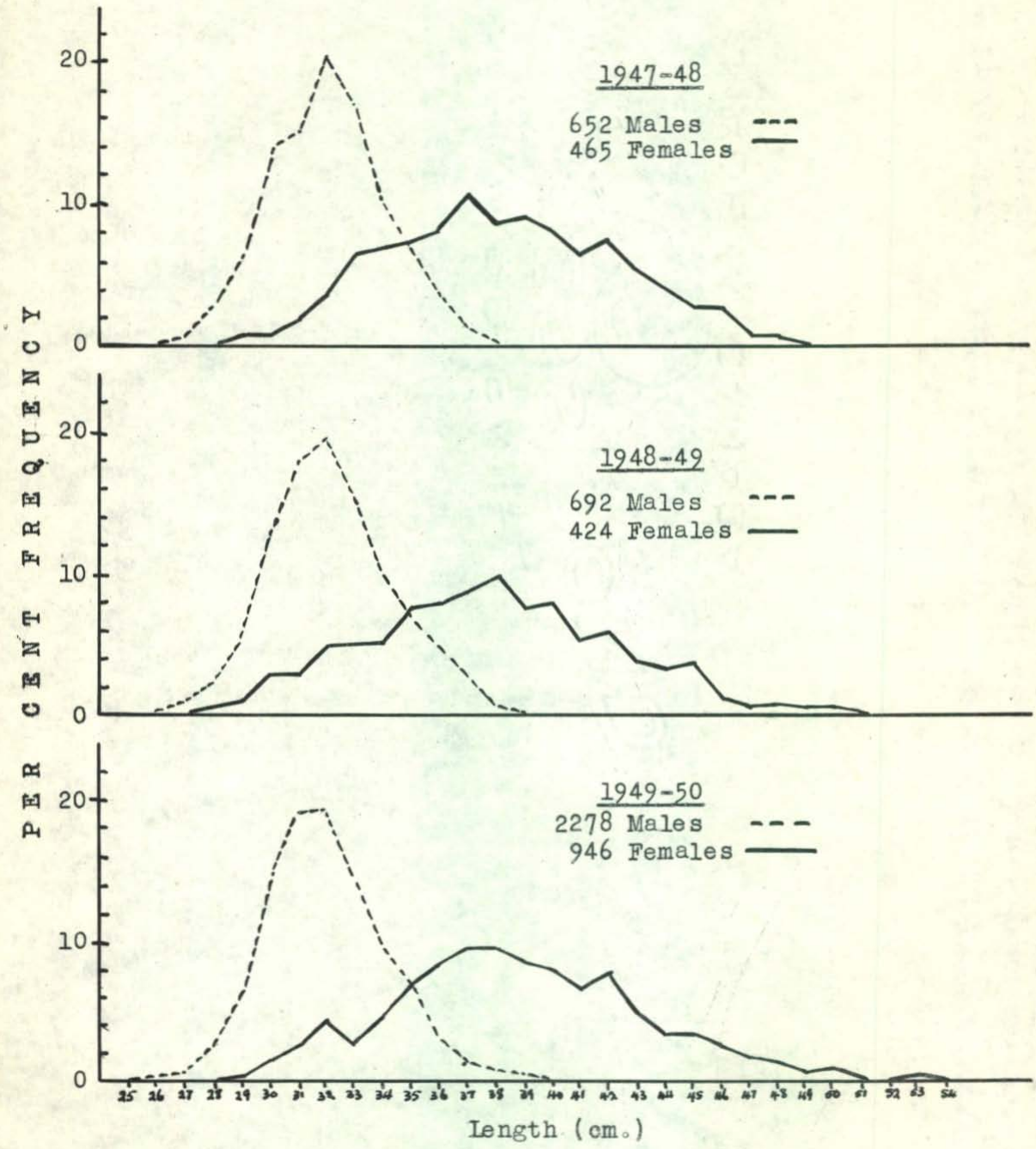
TABLE VII

A summary of all available data on the trend in sex ratio and average size of lemon sole in the cape Lazo area since 1946.

Year	Percent Females	Average Size	
		Male	Female
1946	53	316	378
1947	56	317	370
1948	41	320	382
1948-49	38	322	379
1949-50	28	320	387

A comparison of the average size of male and female lemon soles taken in the cape Lazo area before and after the restriction of the fishery in 1947, shows little indication of any significant increase or decrease. In figure 10, a comparison is made of the size distributions in the three years of restricted fishing. The modes in male fish have remained fairly close to 31 and 32 centimetres, while those for female fish have remained close to 37 or 38 centimetres. In neither sex is there any indication of the progression of a dominant size group.

FIGURE 10. Length frequency polygons of lemon soles taken from the commercial catch during the three winters that the fishery has been opened on a restricted basis.



APPENDIX 6

Age analysis of the lemon sole fishery at cape Lazo in 1949-50

Sampling from the research vessel has shown that the distribution and movements of lemon soles on the cape Lazo ground are very complex. Not only is there segregation according to sex and age but also according to spawning condition. This, coupled with the arrival and departure of obviously different schools of fish, presents a very difficult problem in the assessment of the age composition of the commercial catch.

An example of the high degree of segregation on the cape Lazo ground was revealed in the study of samples collected from a series of depths, 36 fathoms, 39 fathoms, and 42 fathoms, just before the fishery opened. The age distributions for male fish found in each sample are given in the table below. The female fish were poorly represented in all samples and therefore have been excluded.

	Age Frequency (%)								
Depth	III	IV	V	VI	VII	VIII	IX	X	Total
36 f.	1.1	18.0	25.1	23.7	16.8	6.6	6.9	1.4	421
39 f.	1.0	9.6	18.5	30.1	27.4	8.6	3.9	0.5	404
42 f.	2.3	16.1	12.7	21.3	24.1	16.5	5.2	0.9	211

With increase in depth the modes shifted (with some overlapping) from V through VI to VII years. The average lengths in these samples were 308 mm., 320 mm., and 317 mm., respectively, with modes moving from 305 mm. to 315 mm., to 330 mm. Thus it is apparent that the age and size composition of the catch of a boat depends to a very great extent upon the amount of time which is spent in fishing at the various depths.

The picture is complicated further by the arrival on the grounds of schools of fish which, for reason of difference in growth condition

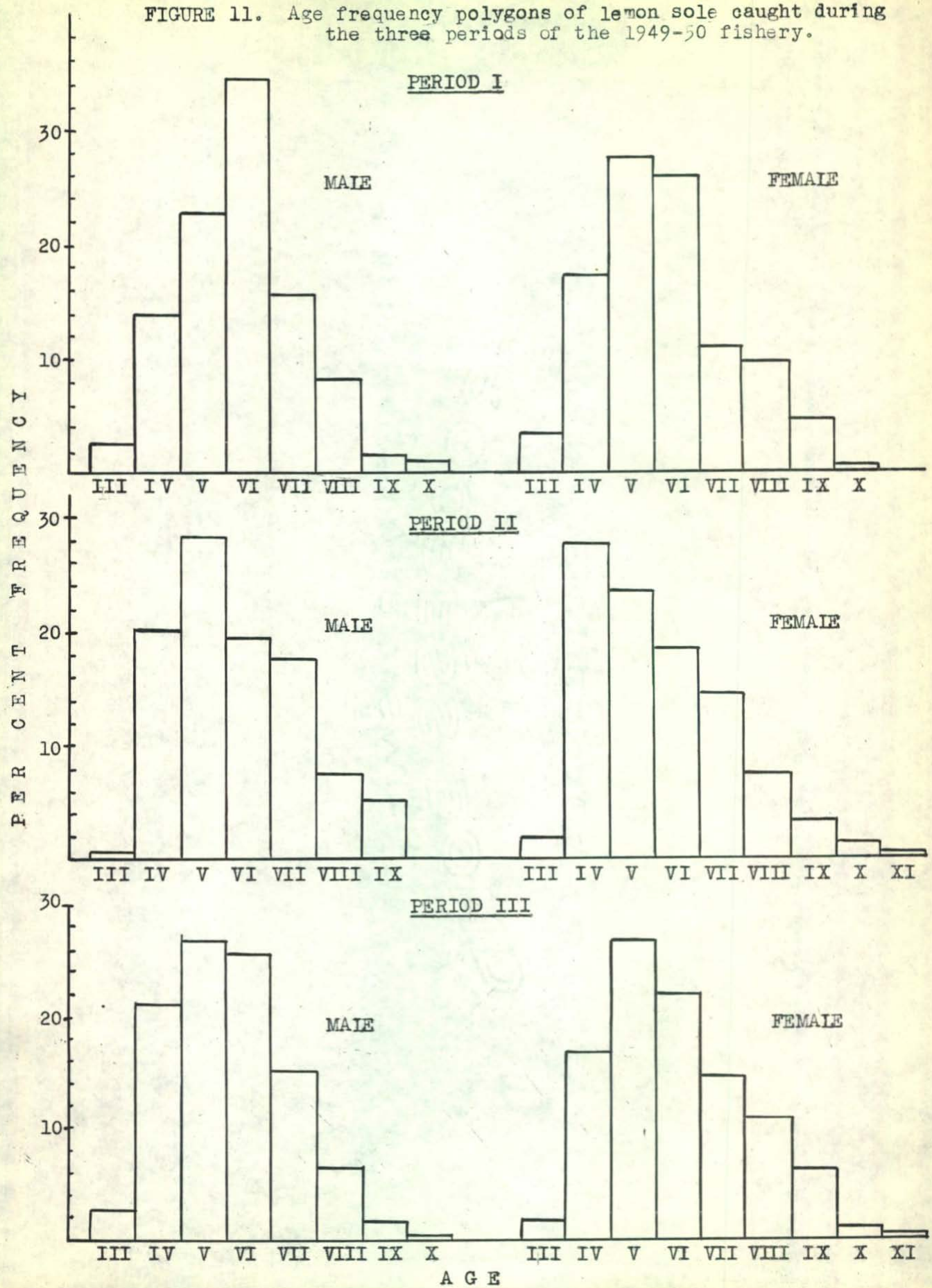
on the summer feeding grounds, are distinctly different in their age and size compositions. First indications of this complication appeared in the comparison of the age composition of the catches made in the winters of 1947-48 and 1948-49. In samples from the 1947-48 catch the best represented age group among male fish was six-year-olds while among females it was five-year-olds. In the following year a sample taken early in January showed the strongest age group both in males and females to be five-year-olds. Yet, the fish were actually larger than those taken in the 1947-48 season.

Intensive sampling in the 1949-50 season has revealed very pronounced intra-seasonal changes. In figure 11 are shown the age frequencies for the three periods of the fishery. In period I (December) six-year-olds predominated among male fish while five- and six-year-olds predominated among females. The age-length paradox observed in the previous season appears in the samples for period II. The dominating age-group in males dropped to five-year-olds while that in females dropped to four-year-olds. However, if reference is made to figure 9, it will be observed that in period II there was a marked <u>increase</u> in average size over that in period I.

In period III, the mode in male fish remained approximately the same as that in period II at five-year-olds but there were more six-year-olds. Among the females the mode shifted back to much the same as that in period I. However, these fish were still much larger than those taken in period I.

In view of the marked intra-seasonal changes it is very difficult to assign an <u>average</u> age composition for the 1949-50 season, which in turn makes it very difficult to give an accurate picture of inter-seasonal trends.

FIGURE 11. Age frequency polygons of lemon sole caught during the three periods of the 1949-50 fishery.



APPENDIX 7

The availability of gray cod at Nanoose bay

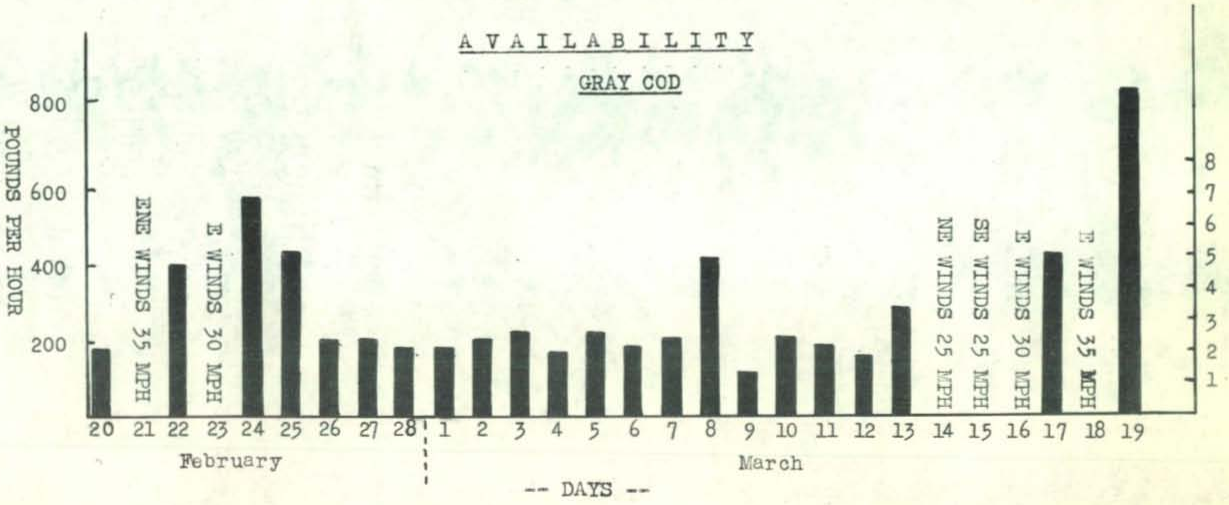
The availability of gray cod in the Nanoose bay area has been calculated for daily periods. The catch-effort data from table II have been appropriately weighted to account for the period and boat factors and a graph of the daily availability appears in figure 12.

Periods of high availability occurred shortly after the opening and shortly before the closure of the fishery. During the sixteen days between these periods the availability fluctuated closely around 200 pounds per hour.

It is very apparent that high availability occurred immediately after periods of stormy weather which forced the boats to suspend operations. Three possible explanations of these fluctuations present themselves: (1) if the gray cod tend to move to inaccessible areas when the grounds become disturbed by the trawls then it might be expected that they would return when bad weather forced a suspension of the fishery, or (2) if the gray cod are constantly arriving on the grounds then a suspension of the fishery would result in an accumulation and consequently an increase in availability, or (3) strong easterly winds might have had a more direct effect on gray cod movement either by setting up currents which direct them into the bay or by affecting the distribution and abundance of feed (herring) in the bay.

In view of the small size of the Nanoose bay ground it is difficult to believe that a period of four days of intensive fishing had to elapse before the disturbance became sufficient to cause the gray cod to migrate onto the reefs. However, it is very difficult to say whether one supposition is any more plausible than the others.

FIGURE 12. The availability of gray cod at Nanoose Bay during the winter season of 1949-50.



Reports that boats were making their good hauls only in the early morning suggested that availability might be intimately tied with light conditions or the tidal cycle. However, no correlation is evident.

APPENDIX 8

The length and age of gray cod

It is ordinarily very difficult to collect adequate samples of gray cod for otolith sampling principally because it entails the cornering of a large poundage of unprocessed fish. The use of filletted specimens as in the case of flatfish is impossible since gray cod are usually headed just prior to filletting. Sampling is further complicated by the lack of a means to determine the sex of the fish since they are landed in a dressed condition.

One sample of 81 unsexed gray cod was collected from the 1950 Nanoose bay commercial catch. The results of otolith readings conducted by Miss R.I. Peterson are shown in figure 13 together with the length frequency polygons for the whole sample and for each age group in the sample.

If this sample is representative of the commercial catch it would appear that the fishery is dependent to a large extent on very young fish. Approximately 68% were three-year-olds, 28% were four-year-olds, and the remaining 4% were two- and five-year-olds.

The fact that the three-year-olds averaged 56.7 cms. in length is indicative of a very rapid growth rate in the first few years of life. This is a somewhat faster rate than that observed for the inshore population of Atlantic cod--but perhaps may be expected in view of the higher water temperatures on this coast.

FIGURE 13. Age and length frequency graphs of gray cod caught at Nanoose Bay in March, 1950