Cruise of the *F/V NUCLEUS*, January 5-17, 1987 to Hecate Strait to Study Reproductive Biology of Pacific Cod and English Sole

R. P. Foucher, J. Fargo and J. B. Lucas

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

May 1987

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1941

Fisheries and Oceans | Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of
Fisheries and Aquatic Sciences No. 1941

May 1987

CRUISE OF THE F/V NUCLEUS, JANUARY 5-17, 1987 TO HECATE STRAIT TO STUDY REPRODUCTIVE BIOLOGY OF PACIFIC COD AND ENGLISH SOLE

by

R. P. Foucher, J. Fargo and J. B. Lucas

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

Cat. No. Fs 97-4/1941E ISSN 0706-6473

Correct citation for this publication:

Foucher, R. P., J. Fargo, and J. B. Lucas. 1987. Cruise of the F/V NUCLEUS, January 5-17, 1987 to Hecate Strait to study reproductive biology of Pacific cod and English sole. Can. MS Rep. Fish. Aquat. Sci. 1941: 25 p.

ABSTRACT

Foucher, R. P., J. Fargo and J. B. Lucas. 1987. Cruise of the F/V NUCLEUS, January 5-17, 1987 to Hecate Strait to study reproductive biology of Pacific cod and English sole. Can. MS Rep. Fish. Aquat. Sci. 1941: 25 p.

Ovaries were obtained from Pacific cod and English sole from two areas in Hecate Strait for histological examination of the ovarian cycle. Length at 50% maturity was estimated at 55 cm for Pacific cod. Pacific cod were also sampled for fecundity from both areas. Ageing structures were taken from all English sole (otoliths) and from Pacific cod (fin rays) from the northern fecundity sample. The overall length frequency of Pacific cod suggests a weak 1984 year-class and a relatively strong 1985 year-class. Water temperatures during the cruise were warm--8.0 to 8.6°C at 50 m.

RESUME

Foucher, R. P., J. Fargo and J. B. Lucas. 1987. Cruise of the F/V NUCLEUS, January 5-17, 1987 to Hecate Strait to study reproductive biology of Pacific cod and English sole. Can. MS Rep. Fish. Aquat. Sci. 1941: 25 p.

On a prélevé des ovaires chez des morues du Pacifique et des soles anglaises capturées à deux endroits du détroit d'Hécate en vue d'un examen histologique du cycle ovarien. On a déterminé que la morue du Pacifique mesurait 55 cm à un taux de maturité de 50%. Cette espèce a aussi fait l'objet d'un échantillonnage à ces deux endroits afin de déterminer sa fécondité. Dans l'échantillon recueilli dans le secteur septentrional, on a prélevé les otolithes chez les soles anglaises et les rayons de nageoire chez les morues du Pacifique afin de déterminer l'âge. La fréquence des longueurs globale de la moure du Pacifique porte à croire à l'existence d'une faible classe de 1984 et à une classe de 1985 relativement importante. Les températures de l'eau au cours de l'expédition étaient chaudes, soit de 8.0 à 8.6°C à 50 m de profondeur.

INTRODUCTION

This report summarizes results of the second cruise in a series to investigate the reproductive biology of Pacific cod and English sole in Hecate Strait. In the first cruise, ovaries of both species were collected for histological examination of the annual ovarian cycle (Tyler et al. in prep.). Every month of the year will be sampled during the course of this study.

In this cruise ovaries were collected from both species for histological study. Ovaries were also collected from Pacific cod for estimation of fecundity. Fecundity has been previously estimated for Pacific cod in Hecate Strait in 1961 (Thomson 1962). A further 581 female Pacific cod were sampled for maturity to gain further information on size at maturity. No English sole were found that contained developing eggs.

MATERIALS AND METHODS

The vessel used was the F/V NUCLEUS, a 20-m (65-ft) steel-hulled stern trawler equipped with 2 net drums. Fishing gear consisted of a Skagen trawl net with a 4.5-in mesh codend, 91.4-m (50-fath) sweep lines and steel doors. No liner was used in the codend.

The areas fished were White Rocks and Two Peaks/Butterworth (Fig. 1). The White Rocks area was also fished in the first cruise (Tyler et al. in prep.) which was cut short because of a winch failure. The Horseshoe Ground was also to have been a target area during that cruise, however, on this cruise it was avoided because of traditionally very low landings during the first quarter. Reef Island, another southern ground with more first quarter landings, was avoided because of its distance from protected mainland waters and the prevailing weather conditions. Two Peaks/Butterworth was selected because of evidence (Brian West, pers. comm.) that there might be English sole in spawning condition in that area and also because of its distance from White Rocks. Two areas, significantly far apart, were desired so that a test for homogeneity in the data with regard to latitude could be made. Positions for trawl hauls were selected at the discretion of the vessel skipper, who has extensive trawling experience in Hecate Strait.

Because of the predominantly rough weather, sampling was carried out in a protected anchorage after fishing was completed each day. Also, due to space limitation and the volume of catch, fish were not kept separate when more than one haul was made on the same day.

For histological samples, ovaries of Pacific cod (both ovaries) and English sole (right ovary only) were removed and placed in 1-l jars with buffered formal saline made up (for 20 l of solution) as follows:

2 l formalin
18 l water
80 g NaH_2PO_4
130 g Na_2HPO_4
180 g NaCl

Both otoliths were removed from each English sole and stored in glycerine/thymol for later age determination.

For fecundity samples (Pacific cod only) both ovaries were placed in 1-l jars with 70% ethanol. Fin rays (rays 4-8 from the second dorsal fin) were taken from fish sampled from Two Peaks/Butterworth for later age determination. A length-stratified sampling procedure was used to ensure that samples were spread throughout the anticipated length ranges (Table 1). All fish were measured for fork length to the nearest cm.

An additional 581 female Pacific cod were sampled for length, sex and maturity (i.e. immature or mature) to provide additional data on size at maturity of females. Percent maturity by size was plotted for Pacific cod from both areas.

Temperature profiles were taken using expendable bathythermographs for each haul except haul 5 which was on the same day and in the same location as haul 4.

RESULTS

A total of seven hauls were made between January 7 and January 14. Haul locations are shown in Figure 1. Haul duration varied from 45 to 162 minutes with a mean of 85 minutes. A total of 1492 Pacific cod and 147 English sole were measured. Length-frequency data for Pacific cod included 351 immature females, 474 mature females, 410 males and 257 fish measured without reference to sex or maturity. For English sole, the data included 38 immature females and 109 mature females. Lengths for male English sole were not recorded. Tables 2 and 3 summarize the sampling completed for Pacific cod and English sole respectively. In hauls 1 and 7 all Pacific cod were measured. For other hauls and for English sole in all hauls, fish were selected in an attempt to follow the designated sampling strategy. Table 4 gives the numbers collected per size interval for the fecundity and histological samples compared to the numbers specified by the sampling schedule.

Pacific cod length frequencies are summarized for White Rocks, Two Peaks/Butterworth and both areas combined in Figures 2-4, respectively. Figures 2 and 3 each show immature, mature and all females. The length composition is quite similar between grounds. Figure 4 shows males, females and all fish (males, females and unsexed) for all hauls combined. The

dominant length modes are generally those corresponding to the 1983 and 1985 year-classes with an apparently poor representation of the 1984 year-class. No individuals of the 1986 year-class were captured possibly because a codend liner was not used.

Percent maturity at length for both White Rocks (Fig. 5) and Two Peaks/Butterworth (Fig. 6) is approximately 55 cm. Although the length at 50% maturity is similar, length at first maturity is greater for Two Peaks/Butterworth (54 cm) compared to White Rocks (44 cm) (Table 5). This suggests that either maturation begins at a smaller size at White Rocks, a more southerly ground, or that there is some movement of those fish which are maturing for the first time.

A graph of percent maturity at length was not produced for English sole due to the paucity of data. The smallest mature females were 32 and 35 cm for White Rocks and Two Peaks/Butterworth Grounds, respectively (Table 6).

Vertical temperature profiles (Table 7) show warm temperature regimes for the time of year.

ACKNOWLEDGMENTS

We wish to thank Captain Cliff Keeping of the F/V NUCLEUS and his crew Paul Harding, Brian West, and John Wick for their able seamanship and their assistance in facilitating our work.

REFERENCES

Thomson, J. A. 1962. On the fecundity of Pacific cod (Gadus macrocephalus Tilesius) from Hecate Strait, British Columbia. J. Fish. Res. Board Can. 19(3): 497-500.

Tyler, A. V., J. Fargo, R. P. Foucher, and J. B. Lucas. In press. Studies on the reproductive biology of Pacific cod and English sole in Hecate Strait from the cruise of the FR/V W. E. Ricker, November 25-29, 1986. Can. MS Rep. Fish. Aquat. Sci.

Table 1. Sampling schedule for English sole and Pacific cod (both females only) for F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Species	Sample type	Maturity state	Size range(cm)	No. per interval	Interval size(cm)	Total no.[a]
Pacific cod	Fecundity	Mature	40 - 90	10	5	100
	Histology	Immature	10 - 50	5	10	20
	"	Mature	40 - 90	8	5	80
	Maturity ogive	Mat/Imm	any size	up to total[b]		of 1000
English sole	Fecundity	Mature	25 - 50	10	2	125
	Histology	Immature	10 - 35	5	5	25
	"	Mature	25 - 50	15	5	75

[a]Specified numbers to be sampled for fecundity and histology applies to each sampling area. Two areas to be sampled.

[b]Total including fish sampled for fecundity and histology.

Table 2. Pacific cod numbers sampled, by haul, by sex, maturity and sample type, F/V NUCLEUS, January 5-17, 1987.

	Length-sex					Histology[b]			
	Females								
Haul(s)[a]	Immature	Mature	Males	Length only	Total	Immature	Mature	Fecundity[b]	Fin rays[b]
1[c]	4	2	-	-	6	4	2	-	-
2,3[d]	74	40	112	-	226	12	36	-	-
4,5[d]	201	345	163	-	709	1	24	71	-
6	61	67	108	257	493	15	43	18	18
7[c]	11	20	27	-	58	-	-	18	18
Total	351	474	410	257	1492	32	105	107	36

[a]Hauls 1-5 from White Rocks, 6-7 from Two Peaks/Butterworth.

[b]Females only, included in length-sex, all males not recorded.

[c]Total sample, other hauls were selected samples.

[d]Fish mixed between hauls due to deck space/size of catch.

Table 3. English sole numbers of females sampled for histology and otoliths, by haul, by maturity, F/V NUCLEUS, January 5-17, 1987.

Haul	Immature	Mature	Total
1	21	35	56
2	-	5	5
3	-	6	6
4	-	2	2
5	-	-	0
6	17	61	78
7	-	-	0
Total	38	109	147

Table 4. Pacific cod and English sole numbers sampled per size interval (females only) compared to sampling schedule for F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Size interval (cm)	Pacific cod						English sole			
	Histology				Fecundity		Histology			
	White Rocks		Two Peaks				White Rocks		Two Peaks	
	Imm	Mat	Imm	Mat	White Rocks	Two Peaks	Imm	Mat	Imm	Mat
No. required per interval:	5[a]	8	5[a]	8	10	10	5	15	5	15
10-14	0[b]	-	0[b]	-	-	-	0	-	0	-
15-19		-		-	-	-	0	-	0	-
20-24	0[b]	-	0[b]	-	-	-	5	-	2	-
25-29		-		-	-	-	5	0	5	0
30-34	6[b]	-	5[b]	-	-	-	5	15	5	0
35-39		-		-	-	-	6	14	5	15
40-44	5[b]	1	5[b]	0	0	0	-	15	-	16
45-49		2		0	2	0	-	4	-	14
50-54	5[b]	4	5[b]	2	3	1	-	-	-	15
55-59		13		5	12	7	-	-	-	1
60-64	1[b]	9	-	8	11	9	-	-	-	-
65-69		8		8	10	6	-	-	-	---
70-74	-	8	-	9	11	5	-	-	-	-
75-79		8		7	10	7	-	-	-	-
80-84	-	8	-	4	9	1	-	-	-	-
85-89		1		-	3	0	-	-	-	-
Total	17	62	15	43	71	36	21	48	17	61

[a]Number required per 10-cm interval, 10-19 cm, 20-29 cm etc.

[b]Number sampled per 10-cm interval, i.e. number opposite 10-14 cm size interval indicates number sampled for 10-19 cm, etc.

Table 5. Length frequency by maturity and percent mature for female Pacific cod, by area, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Length (cm)	White Rocks				Two Peaks/ Butterworth			
	Imm	Mat	Tot	%M	Imm	Mat	Tot	%M
33	1	-	1	0	-	-	-	-
34	1	-	1	0	-	-	-	-
35	3	-	3	0	-	-	-	-
36	6	-	6	0	3	-	3	0
37	6	-	6	0	0	-	0	-
38	3	-	3	0	1	-	1	0
39	13	-	13	0	2	-	2	0
40	17	-	17	0	0	-	0	-
41	14	-	14	0	6	-	6	0
42	13	-	13	0	5	-	5	0
43	20	-	20	0	6	-	6	0
44	22	4	26	15	3	-	3	0
45	19	2	21	10	3	-	3	0
46	20	2	22	9	5	-	5	0
47	25	2	27	7	3	-	3	0
48	23	0	23	0	6	-	6	0
49	10	1	11	9	4	-	4	0
50	13	1	14	7	6	-	6	0
51	14	4	18	22	4	-	4	0
52	7	1	8	13	1	-	1	0
53	5	1	6	17	4	-	4	0
54	5	4	9	44	3	4	7	57
55	2	6	8	75	3	2	5	40
56	4	11	15	73	0	1	1	100
57	5	12	17	71	2	2	4	50
58	3	6	9	67	0	3	3	100
59	2	16	18	89	2	5	7	71
60	2	19	21	90	-	3	3	100
61	1	27	28	96	-	6	6	100
62	-	21	21	100	-	4	4	100
63	-	26	26	100	-	6	6	100
64	-	17	17	100	-	5	5	100
65	-	16	16	100	-	3	3	100
66	-	25	25	100	-	2	2	100
67	-	17	17	100	-	1	1	100
68	-	16	16	100	-	6	6	100
69	-	8	8	100	-	2	2	100
70	-	9	9	100	-	2	2	100
71	-	15	15	100	-	4	4	100
72	-	6	6	100	-	2	2	100
73	-	14	14	100	-	3	3	100
74	-	12	12	100	-	3	3	100

Table 5 (cont'd)

Length (cm)	White Rocks				Two Peaks/ Butterworth			
	Imm	Mat	Tot	%M	Imm	Mat	Tot	%M
75	-	13	13	100	-	7	7	100
76	-	7	7	100	-	3	3	100
77	-	11	11	100	-	1	1	100
78	-	5	5	100	-	2	2	100
79	-	5	5	100	-	1	1	100
80	-	4	4	100	-	1	1	100
81	-	5	5	100	-	1	1	100
82	-	6	6	100	-	2	2	100
83	-	1	1	100	-	-	-	-
84	-	5	5	100	-	-	-	-
85	-	2	2	100	-	-	-	-
86	-	1	1	100	-	-	-	-
87	-	0	0	-	-	-	-	-
88	-	0	0	-	-	-	-	-
89	-	0	0	-	-	-	-	-
90	-	1	1	100	-	-	-	-
Total	279	387	666		72	87	157	

Table 6. Length frequency of female English sole, by area, by maturity, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Length (cm)	White Rocks		Two Peaks/ Butterworth		White Rocks & Two Peaks/Butterworth		
	Imm	Mat	Imm	Mat	Imm	Mat	% M
20	1	-	-	-	1	-	0
21	0	-	-	-	0	-	-
22	3	-	-	-	3	-	0
23	0	-	1	-	1	-	0
24	1	-	1	-	2	-	0
25	0	-	0	-	0	-	-
26	1	-	0	-	1	-	0
27	0	-	1	-	1	-	0
28	1	-	3	-	4	-	0
29	3	-	1	-	4	-	0
30	2	-	1	-	3	-	0
31	0	-	2	-	2	-	0
32	3	5	2	-	5	5	50
33	0	3	0	-	0	3	100
34	0	7	0	-	0	7	100
35	1	5	4	4	5	9	64
36	2	3	0	2	2	5	71
37	3	1	0	1	3	2	40
38	-	3	0	1	0	4	100
39	-	2	1	7	1	9	90
40	-	6	0	3	-	9	100
41	-	4	0	4	-	8	100
42	-	0	0	3	-	3	100
43	-	5	0	2	-	7	100
44	-	0	0	4	-	4	100
45	-	2	0	5	-	7	100
46	-	0	0	5	-	5	100
47	-	1	0	2	-	3	100
48	-	0	0	2	-	2	100
49	-	1	0	0	-	1	100
50	-	-	0	3	-	3	100
51	-	-	1	6	-	7	100
52	-	-	-	1	-	1	100
53	-	-	-	0	-	0	-
54	-	-	-	4	-	4	100
55	-	-	-	0	-	0	-
56	-	-	-	1	-	1	100
Total	21	48	18	60	38	109	

Table 7. Vertical temperature profiles, by haul, for F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Haul no.[a]	Day	Time (PST)	N. lat. °	N. lat. '	W. long. °	W. long. '	Standard depths (m) 0	10	20	30	50	75	100	Bottom Temp °C	Bottom Depth (m)
1	7	1400	53	42.7	130	38.5	8.2	7.9	7.9	7.9	8.0	8.0		8.0	100
2	10	1040	53	40.8	130	45.7	8.7	8.6	8.5	8.5	8.5	8.5	8.5	8.5	119
3	10	1430	53	41.7	130	46.0	8.7	8.6	8.6	8.6	8.6	8.6	-	8.6	99
4	11	1050	53	46.0	130	50.9	8.7	8.7	8.7	8.6	8.6	8.6	8.6	8.6	101
6	13	1040	54	17.8	131	23.5	8.8	8.7	8.6	8.6	8.6	-	-	8.6	69
7	14	0915	54	5.7	131	3.4	8.8	8.4	8.4	8.4	8.4	8.4	-	8.3	91

[a]Temperature profile not taken during haul 5 because it was in the same area and on the same day as haul 4.

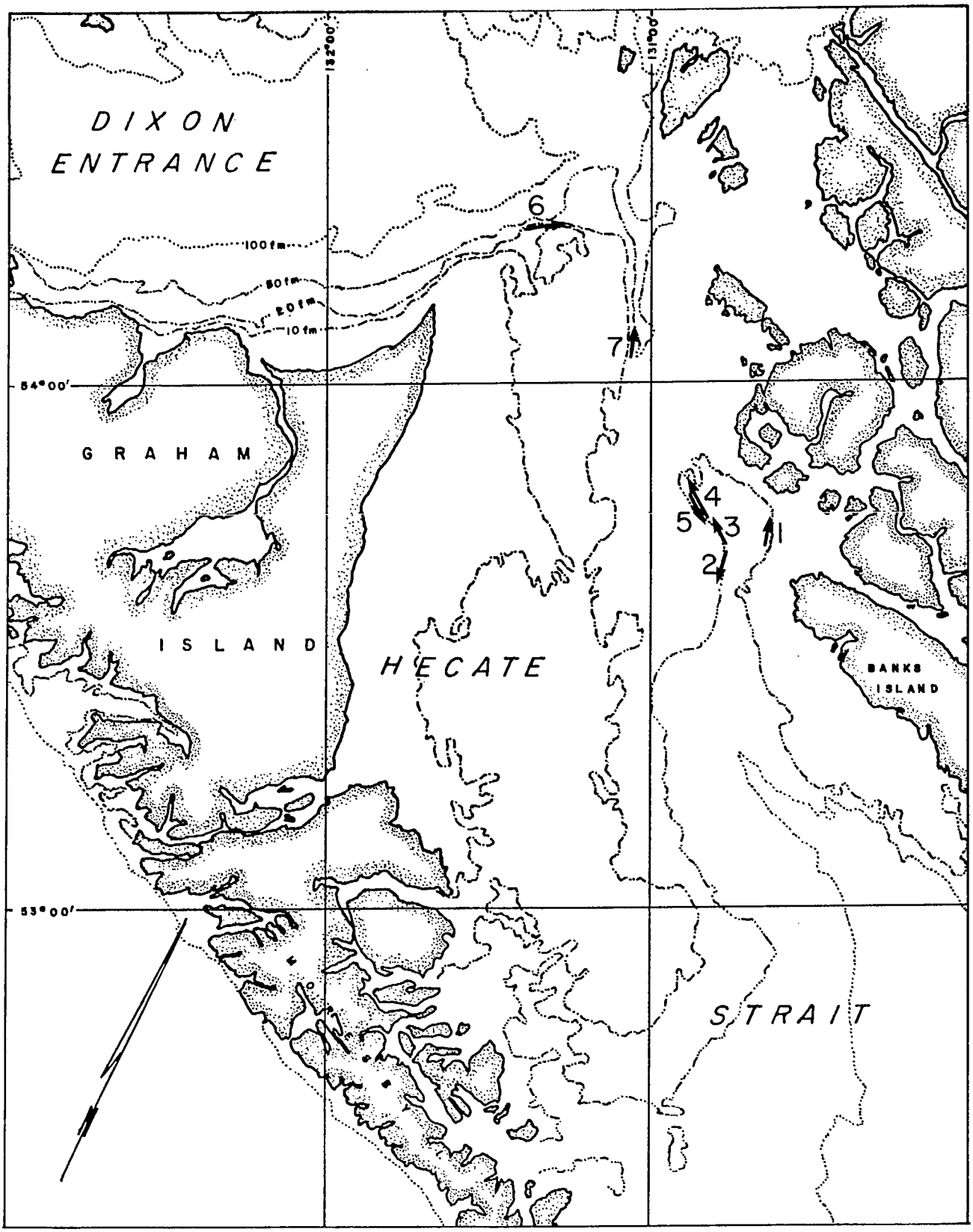

Fig. 1. Locations of trawl hauls completed during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

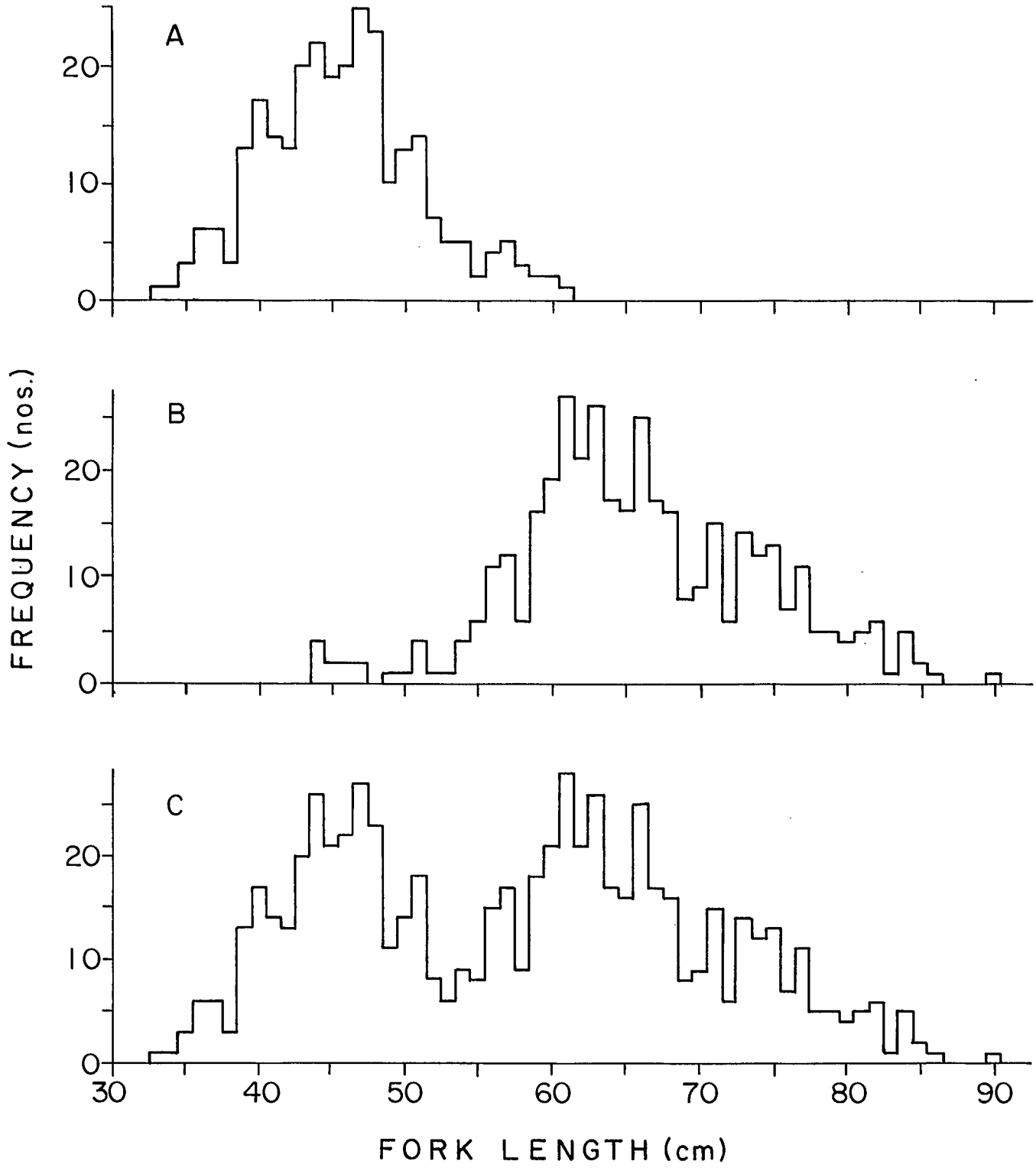

Fig. 2. Length frequency for female Pacific cod from White Rocks, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987. (A=Immature, B=Mature, C=All females).

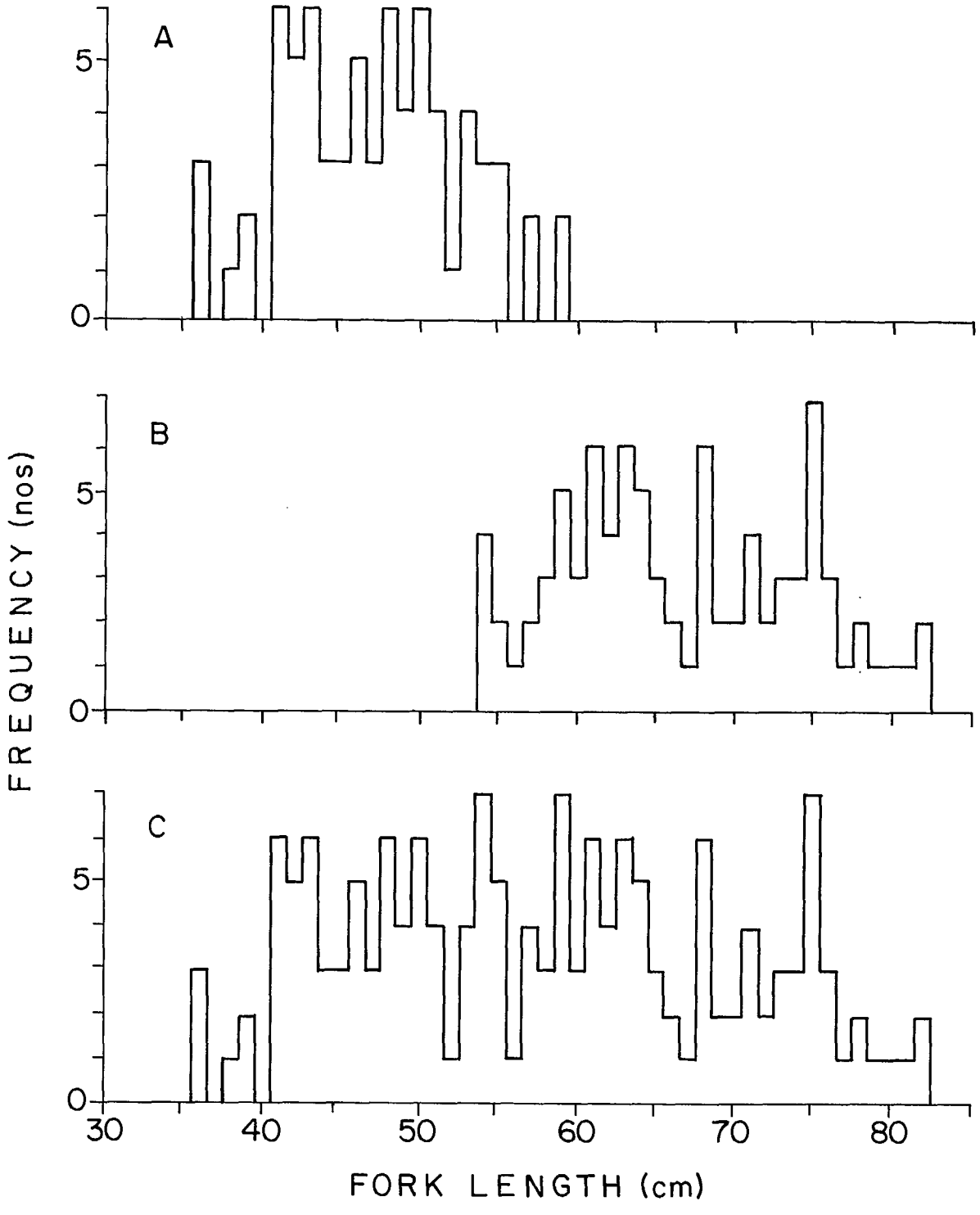

Fig. 3. Length frequency for female Pacific cod from Two Peaks/Butterworth, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987. (A=Immature, B=Mature, C=All females).

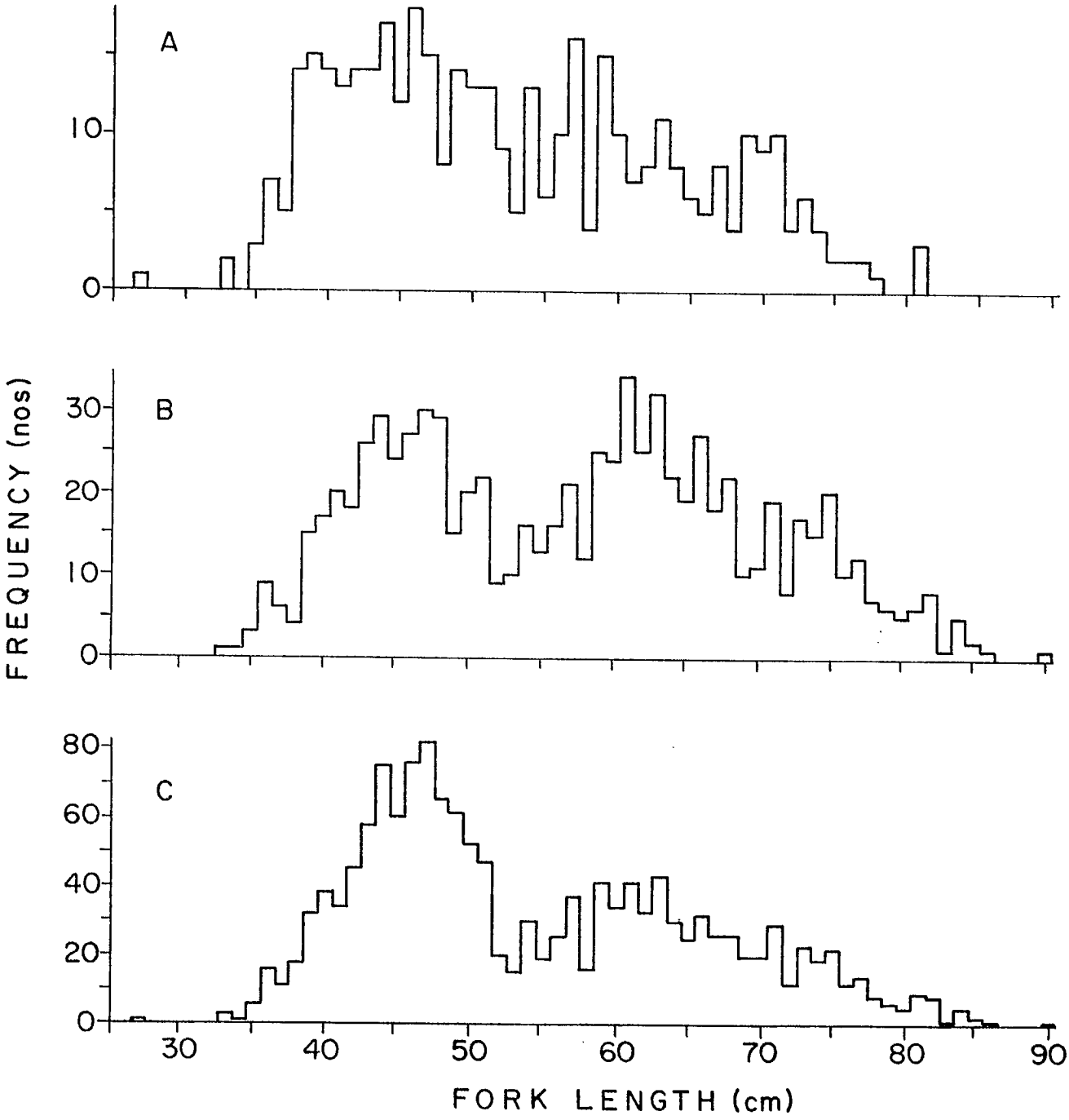

Fig. 4. Length frequency for Pacific cod for all areas and hauls combined, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987. (A=Males, B=Females, C=Males, females and unsexed).

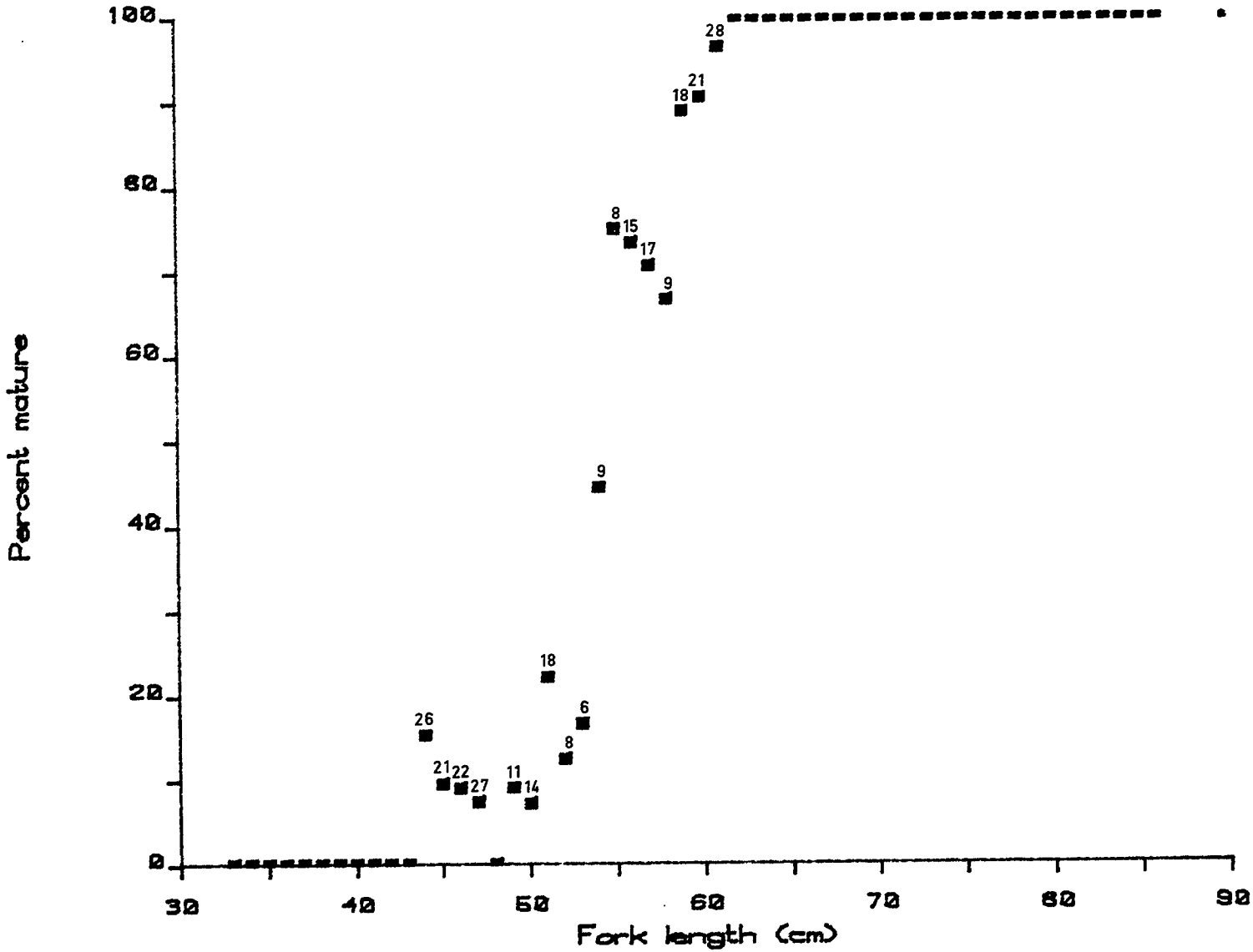

Fig. 5. Percent maturity by length for female Pacific cod from White Rocks, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987. (Numbers sampled indicated for intermediate lengths. Data in Table 5.)

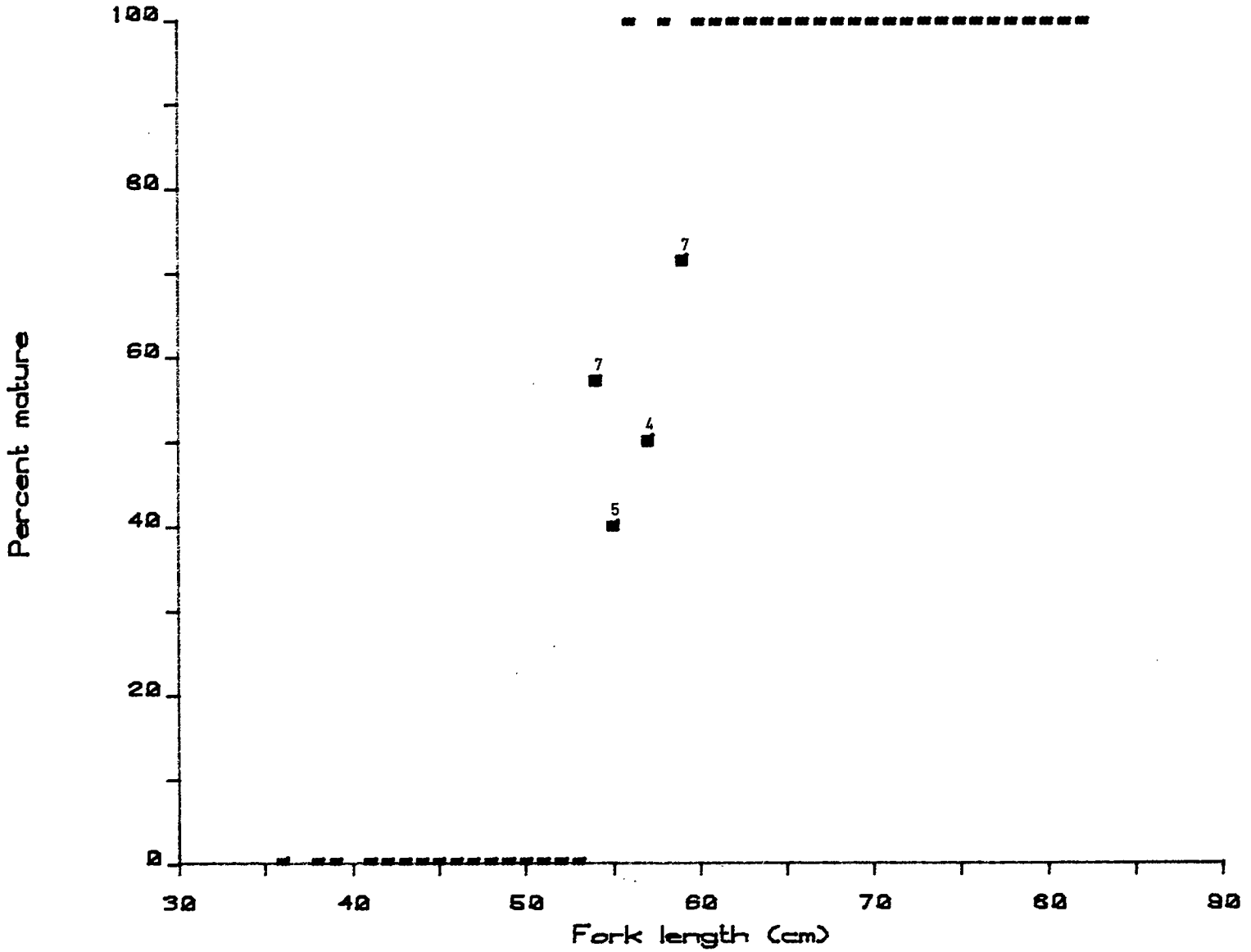

Fig. 6. Percent maturity by length for female Pacific cod from Two Peaks/Butterworth, sampled during F/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987. (Numbers sampled indicated for intermediate lengths. Data in Table 5.)

Appendix table 1. Fishing log for M/V NUCLEUS cruise to Hecate Strait, January 5-17, 1987.

Haul number	1	2	3	4	5	6	7
Date (January 1987)	7	10	10	11	11	13	14
Area (Major, Minor)	08,05[a]	08,05	08,05	08,05	08,05	04,02[b]	04,01[c]
Start time (PST)	1320	1035	1427	1015	1230	1027	0908
Duration (Min)	70	162	67	90	45	88	72
Start N. Lat. (Deg)	53	53	53	53	53	54	54
(Min)	41.7	40.8	41.7	44.8	47.2	17.8	5.7
W. Long. (Deg)	130	130	130	130	130	131	131
(Min)	38.9	45.7	46.0	49.4	53.1	23.5	3.4
Start LORAN-C X	12032	12010.9	12002.5	11965.1	11931.2	11573.2	11743.0
Y	41666	41653.0	41655.7	41661.3	41664.2	41719.4	41709.5
Finish N. Lat. (Deg)	53	53	53	53	53	54	54
(Min)	43.7	38.2	44.1	47.8	45.1	18.1	3.1
W. Long. (Deg)	130	130	130	130	130	131	131
(Min)	38.1	46.6	48.3	53.2	50.9	17.1	3.8
Finish LORAN-C X	12020	12027.8	11974.8	11926.2	11956.0	11592.3	11762.8
Y	41674	41642.9	41660.4	41666.0	41660.5	41728.6	41700.9
Haul distance[d] (km)	3.8	5.0	5.0	7.0	4.5	7.0	4.8
(N Mi)	2.1	2.7	2.7	3.8	2.4	3.8	2.6
Direction (Deg. true)	22	197	316	308	133	88	188
Start depth (m)	69	124	99	106	95	69	91
Finish depth (m)	108	110	106	95	95	69	91

[a]08,05 = White Rocks

[b]04,02 = Two Peaks

[c]04,01 = Butterworth

[d]Distance between start and finish points of haul.