Groundfish Stock Assessments for the West Coast of Canada in 1986 and Recommended Yield Options for 1987

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March 1987

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1930

Fisheries and Oceans / Pêches et Océans

Canada

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GROUNDFISH STOCK ASSESSMENTS FOR THE WEST COAST OF CANADA IN 1986 AND RECOMMENDED YIELD OPTIONS FOR 1987

by

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ABSTRACT

Tyler, A. V. and M. W. Saunders. (Eds.). 1987. Groundfish stock assessments for the west coast of Canada in 1986 and recommended yield options for 1987. Can. MS Rep. Fish. Aquat. Sci. 1930: 156 p.

Stock assessments and yield options are developed for the Pacific coast of Canada for the following species: lingcod, Pacific cod, Dover sole, rock sole, English sole, sablefish, Pacific hake, spiny dogfish, walleye pollock, Pacific ocean perch, yellowmouth rockfish, rougheye rockfish, silvergray rockfish, yellowtail rockfish, and canary rockfish. This is an interim report with assessments largely based on mathematical analyses presented in Tyler and McFarlane 1985, and interpreted with 1986 landing statistics. The yield options are recommendations to the fishery managers of the Field Services Division on catch limitations and other fishery management procedures. Biological considerations only, rather than economic factors, are addressed in this document. The yield options are quantitative and are based on a series of appropriate mathematical methods, e.g., virtual population analysis, dynamic pool analysis, and Fournier stock-reconstruction procedures. Alternative options address the possibility of the fishery managers considering high risk and low risk yields in relation to a stock's future potential to produce. Other options, particularly for rockfish and flatfish species, provide a selection of alternatives for managers to consider in regard to whether a stock should be re-built, maintained at <u>status quo</u>, or decreased through non-sustainable catches for present economic emergencies.

Key words: groundfish, stock assessment, fishery yields

RESUME

Tyler, A. V. and M. W. Saunders. (Eds.). 1987. Groundfish stock assessments for the west coast of Canada in 1986 and recommended yield options for 1987. Can. MS Rep. Fish. Aquat. Sci. 1930: 156 p.

Les auteurs présentent des évaluations et des solutions de gestion de stocks des espèces suivantes peuplant le Pacifique canadien: morue-lingue, morue du Pacifique, sole, sole du Pacifique, sole anglaise, morue charbonnière, merlu du Pacifique, aiguillat commun, goberge de l'Alaska, sébaste à longue mâchoire, sébaste à bouche jaune, sébaste à oeil épineux, sébaste argenté, sébaste à queue jaune et sébaste canari. Les évaluations présentées dans ce rapport provisoire sont basées en grande partie sur des analyses mathématiques tirées d'une étude de Tyler et McFarlane (1985) et interprétées en fonction des statistiques sur les débarquements réalisés en 1986. Les solutions de gestion sont des recommandations destinées aux gestionnaires des pêches de la Division des services sur le terrain pour ce qui est des limites de prises et d'autres méthodes de gestion des pêches. Le présent rapport porte sur les facteurs biologiques et non sur les facteurs économiques. Les solutions de gestion quantitatives sont basées sur une série de méthodes mathématiques appropriées dont l'analyse de population virtuelle, l'analyse dynamique de regroupements et les méthodes de reconstitution de stock de Fournier. Les diverses solutions de gestion fournissent aux gestionnaires des pêches le choix entre des rendements à risques faibles ou élevés par rapport au potentiel de production futur d'un stock. D'autres solutions, en particulier celles visant les sébastes et les poissons plats, présentent une série de choix que les gestionnaires devront étudier en ce qui concerne le rétablissement d'un stock, le maintien du _statu quo_ ou la diminution du stock de par des prises à un rendement non soutenu dans le cadre de circonstances économiques imprévues.

Mots-clés: poisson de fond, évaluation de stock, rendement de la pêche

1.0 INTRODUCTION

This report contains biological assessments of the important groundfish stocks, and recommendations for their management to the Offshore Division of the Field Services Branch. The report was prepared by the staff of the Groundfish Section of the Fisheries Research Branch, located at the Pacific Biological Station, Nanaimo, British Columbia, Canada V9R 5K6.

The year before last, groundfish research staff carried out an extensive new series of calculations and statistical tests as part of the assessment procedure (Tyler and McFarlane 1985). Such extensive new analyses are carried out only every third year. The purpose of the extensive analysis is to incorporate research findings that are of a more long-term nature. This year and last year are interim years, and so this report is not so lengthy. The assessments of last year have been updated by one more year. Statistical summary areas are shown in Figure 1.1 and Figure 1.2. Summaries of yield options are given in Tables 1.1 and 1.2. Table 1.3 is a summary of the condition of the stocks.

We present a number of levels of yield options in this document. All are not appropriate to apply to a particular species or stock. The seven yield options are: (i) zero yield; (ii) rebuilding; (iii) sustainable; (iv) conservative-sustainable; (v) risk-sustainable; (vi) non-sustainable and (vii) unrestricted yield.

(i) Zero yield

This option could be entertained under situations of known and severe stock depletion, or where particular areas may represent necessary refuges for the fish. Additional ecological considerations might include situations where the subject stock acts as a predator on a less desirable species, and the objective is to maximize predation.

(ii) Rebuilding yield

Under this option the probability of overfishing is minimized while that of rehabilitating depleted stocks is increased. With the exception of option (i), this approach will incur the lowest risk of deleterious effects on stock biomass and dynamics. It is also true that it represents a lower yield than could be taken out of the stock on a sustainable basis. The most common application of this option is for stock rebuilding although for rockfish stocks this should be the approach to developing fisheries, because of the detection, response and corrective time frames (10-20 y) for rockfish species.

(iii) Sustainable yield

This option provides some opportunity to maintain stocks at existing levels. In many ways this is the least certain of the options available since it entrains many assumptions about the behaviour of stocks in response to fishing and biological processes. This option should be taken to mean that the probabilities of either decline or increase in yield (biomass) are approximately equal. The term "sustainable" should be understood in its broad sense, i.e. that the stock will oscillate around the expected level as a result of oscillation in recruitment, rather than be maintained at a fixed level. The amplitude and frequency of these oscillations may vary considerably among and within stocks at different levels of biomass. In the simplest terms, this is our best estimate of the highest long-term yield at existing stock levels.

(iv) Conservative-sustainable yield

Like the Sustainable Option this is an estimate of the tonnage that can be caught during the year and leave enough of the biomass for the stock to replenish itself through reproduction and body growth. However, data are often not as complete as should be for calculation of a single, firm estimate of the true value of the sustainable yield. When there is a high degree of uncertainty about the estimate, a cautious approach to setting the catch limits should be taken. The cautious or conservative estimate is often set simply as 50% or 75% of the calculated sustainable yield, depending on the biologist's understanding of the firmness of the estimate.

(v) Risk-sustainable yield

This catch limit is slightly different from a Sustainable yield. The estimate is at the other end of the range from the Conservative-sustainable yield, and is above the Sustainable yield estimate. The level is often set simply as 25% or 50% higher than the Sustainable yield value. Sometimes a central value for the Sustainable yield is not given, only the Conservative and Risk levels. Risk levels should only be selected to provide relief from a specific case of economic hardship, and conscious recognition should be made that decreases to sustainable levels in the near future might be the result of selecting this option.

(vi) Non-sustainable yield

While the Sustainable option is derived from the biological properties of the species and stock composition, the non-sustainable level is largely an economic and management concept. The benefits of increased yield over the short term must be weighed against the lowered future yields resulting from overfishing. Employment of this option implies either experimental or non-biological management, since stock declines are highly probable with such a policy in effect over a significant part of the average life of a population cohort. This option might be considered when: socio/economic conditions require short-term yields in excess of sustainable harvest; experiments concerning well defined and disparate exploitation rates are necessary; or, management policy requires sequential, pulsed fishing on several stocks.

This option requires that management will have to shift to a conservative policy to offset deleterious effects prior to major and irreversible stock changes. Thus, this option either guarantees a pulsed exploitation pattern if the stock is to be maintained at the most productive level, or accepts short-term gains over long-term productivity.

The hazard associated with this option will vary with the biological characters of the target stocks. In particular, the residence time of a cohort in the vulnerable stock will be a key determinant in the time for detection and response. Where residency is long, higher than sustainable yields may be maintained over several years in spite of strongly deleterious, yet undetected effects on subsequent cohorts. Conversely, a short residency may permit more rapid detection of adverse effects although incremental increases in quotas should be small if uncertainty about effects is high.

(vii) Unrestricted yield

Few conditions would call for consideration of this option. Depletion of stocks and elimination of fisheries when harvests are uncontrolled are well documented throughout the world. However, this option might be considered: for experimental purposes; for stock eradication (in the case of competing species); or for economic returns where the loss of a particular stock does not outweigh the chaotic effects that lowered yield would create in the industry; for a stock that cannot be managed because only the fringe of it comes into the Canadian fisheries management zone.

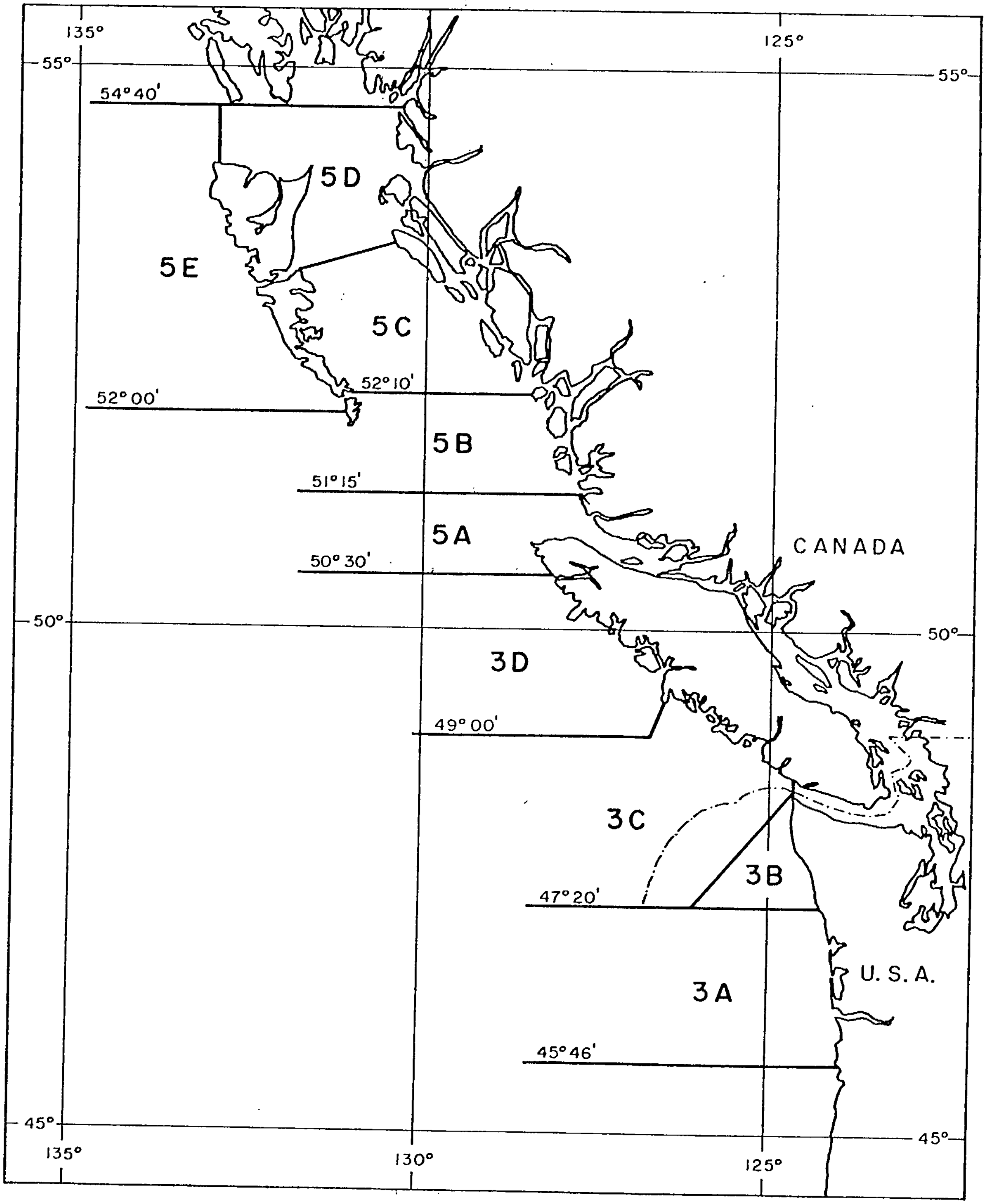

Fig. 1.1. International (Pacific Marine Fisheries Commission) Major Statistical Areas along the British Columbia coast.

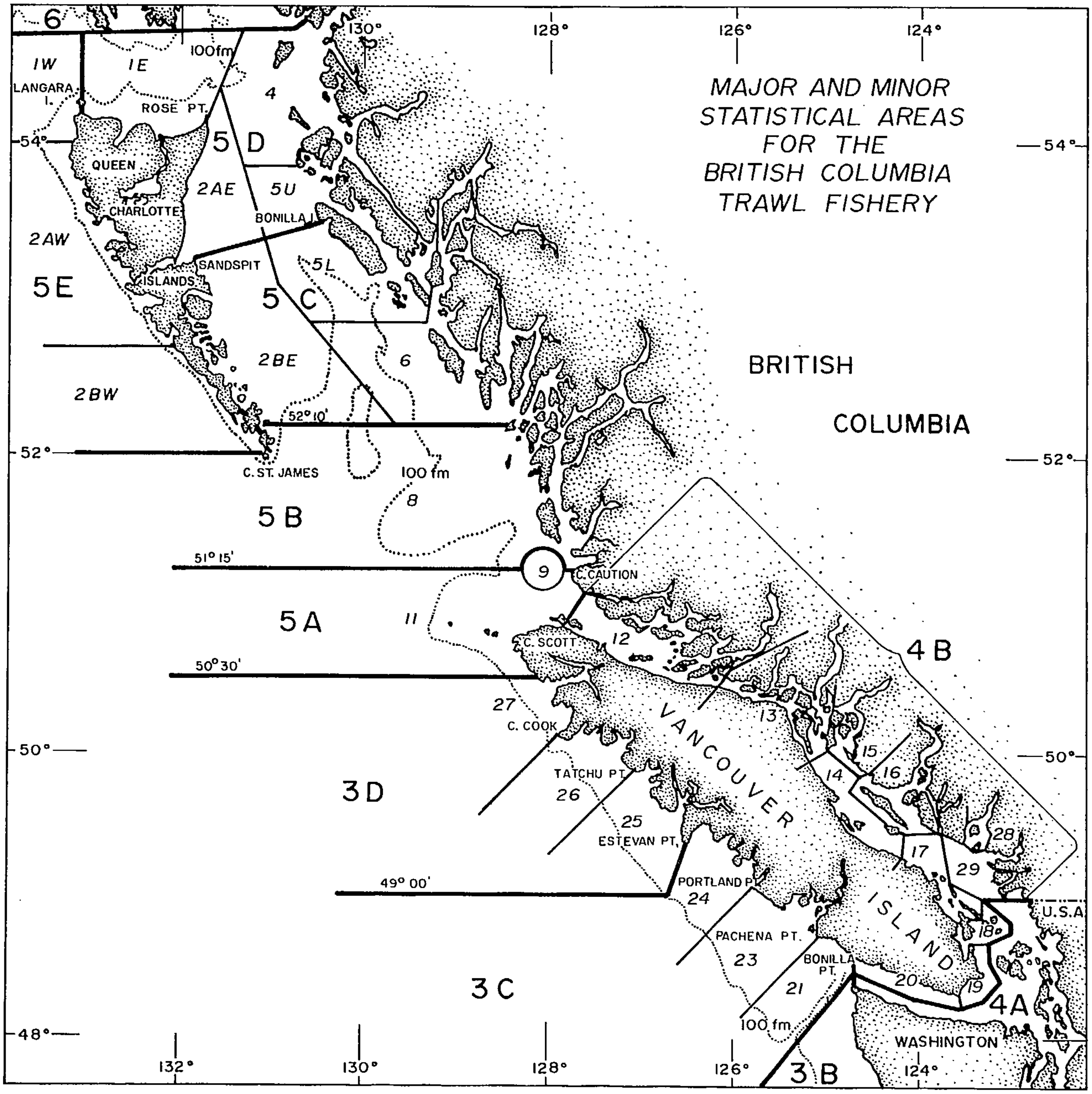

Fig. 1.2. International (Pacific Marine Fisheries Commission) Major and Minor Statistical Areas along the British Columbia coast.

Table 1.1. Summary of recommendations for 1987.

Area	Species	Management options
4B	Lingcod	1. Continue winter fishing closure Nov. 15-Apr. 15. 2. Introduce minimum size limit of 58 cm for sport-caught lingcod to protect young.
3C	Lingcod	1. Conservative-sustainable: 900 t quota 10,000 lb trip limit after 75% of quota taken. 2. Risk-sustainable: 1400 t quota, 20,000 lb/trip after 75% of quota taken.
3D, 5A, 5B, 5C, 5D, 5E	Lingcod	No options proposed.
4B	Pacific cod	No options proposed.
3C/3D	Pacific cod	Close Amphitrite Bank and safety margin to all trawling, January through March.
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod	1. Conservative-sustainable 900 t annual quota (half option 2) 2. Sustainable 1800 t annual quota. 3. Risk-sustainable. No quota, fishing effort self-regulating.
5E	Pacific cod	No options proposed.
4B	Flatfish	No options proposed.
3C/3D	Flatfish	No options proposed.

Table 1.1. Summary of recommendations for 1987 (continued)

Area	Species	Management options
5A/5B	Rock sole	1. Sustainable: 400 t (30,000 lb trip limit) 2. Risk-sustainable: no quota, fishing effort self-regulating
5C/5D	English sole	1. Conservative-sustainable: 400 t quota 2. Sustainable: 600 t quota (trip limit 20,000 lb) 3. Increase yield, codend mesh size regulated 5" internal measure) 4. Risk-sustainable: no quota, fishing effort self-regulating.
	Rock sole	1. Conservative-sustainable: area closure for 5D 2. Sustainable: 30,000 lb trip limit 3. Risk-sustainable: no trip limit, fishing effort self-regulating.
	Arrowtooth flounder	1. Sustainable: 4000 t quota 2. Risk-sustainable: 5000 t quota
5C/5D/5E	Dover sole	1. Sustainable: 800 t quota, 20,000 lb/trip permitted <u>after</u> the quota is reached. 2. Risk-sustainable : 1000 t quota 20,000 lb/trip permitted after the quota is reached.
Coastwide	Sablefish	1. Conservative-sustainable: 4100 t quota 2. Risk-sustainable: 4500 t quota,
4B	Walleye pollock	1. Conservative-sustainable: 2500 t quota 2. Risk-sustainable: 5400 t quota
3C/3D	Walleye pollock	Options not proposed.
5A/5B	Walleye pollock	Options not proposed.

Table 1.1. Summary of recommendations for 1987 (continued)

Area	Species	Management options
5C/5D	Walleye pollock	Open fishing option proposed
5E	Walleye pollock	Options not proposed
4B	Pacific hake	1. Conservative-sustainable: 10,000 t quota 2. Risk-sustainable: 15,000 t quota
3C	Pacific hake	Yield options to be presented at a later date when all current biological information is collated in the joint Canada-U.S. assessment algorithm.
4B	Dogfish	1. Pulse fishing--variable annual quota, see text. 2. Conservative-sustainable--2000 t annual quota 3. Risk-sustainable--3000 t annual quota
Coastwide	Dogfish	1. Pulse fishing--variable annual quota until non-nuisance abundance reached. 2. Conservative-sustainable: 15,000 t 3. Risk-sustainable: 25,000 t
Coastwide	Pacific ocean perch plus yellowmouth rockfish	1. Conservative-rebuilding: 2500 t 2. Sustainable 3100 t 3. Non-sustainable 3900 t
Coastwide	Rougheye rockfish	1. Conservative-sustainable: 100 t 2. Sustainable 250 t 3. Non-sustainable 400 t

Table 1.1. Summary of recommendations for 1987 (continued)

Area	Species	Management options	
3C	Pacific ocean perch	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	0 t 100 t 200 t
	Implementation of a non-directed, incidental only fishery should be considered.		
3D	Pacific ocean perch	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	250 t 350 t 500 t
3D/5A	Yellowmouth	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	200 t 350 t 500 t
5A/5B	Pacific ocean perch	1. Conservative-rebuilding 2. Sustainable 3. Non-sustainable	400 t 500 t 650 t
5C/5D	Pacific ocean perch	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	1700 t 2000 t 2500 t
5C/5D	Yellowmouth	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	200 t 250 t 300 t
5C/5D	Grouped Pacific ocean perch & yellowmouth	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	1900 t 2250 t 2800 t
5E-S	Pacific ocean perch	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	400 t 600 t 1000 t
5E-S	Yellowmouth	1. Conservative-sustainable 2. Sustainable 3. Non-sustainable	400 t 600 t 1000 t

Table 1.1. Summary of recommendations for 1987 (continued)

Area	Species	Management options
5E-S	Rougheye	1. Conservative-sustainable-- 100 t 2. Sustainable 250 t 3. Non-sustainable 500 t
5E-S	Grouped slope rockfish	January-June 1. Conservative-sustainable-- 300 t 2. Sustainable 500 t 3. Non-sustainable 900 t September-December 1. Conservative-sustainable-- 600 t 2. Sustainable 900 t 3. Non-sustainable 1300 t
5E-N	Experimental fishing: We recommend continuation of the experimental open-fishery area north of 54°00'N and west of 133°00'W until the end of 1987.	

Table 1.2. Yield options (t) for shelf rockfish (silvergray, yellowtail, and canary).

Area	Rockfish Species	Conservative	Sustainable	Non-sustainable
Coast	Silvergray	750	1500	2250
	Yellowtail	750	1500	2250
	Canary	650	1275	1900
	Canary and silvergray	1200	2400	3600
3C	Silvergray	non-directed	100	200
	Canary	n.d.	200	300[a]
	Canary and silvergray	n.d.	250	400[b]
3C+D	Yellowtail	n.d.	250	450
3D	Silvergray	150	350	700
	Yellowtail	n.d.	150	250
	Canary	300	550	800
	Canary and silvergray	400	800	1500
5A+B	Silvergray	400	750	1100
	Yellowtail	500	1500	2500
	Canary	250	500	750
	Canary and silvergray	500	1100	1700
5C+D	Silvergray	300	600	900
	Yellowtail	200	500	750
	Canary	150	300	600
5E(N)	Silvergray	--------------------	100[b]	---------------
	Yellowtail	--------------------	200[b]	---------------
	Canary	--------------------	200[b]	---------------
5E(S)	Silvergray	--------------------	350[b]	---------------
	Yellowtail	--------------------	200[b]	---------------
	Canary	--------------------	200[b]	---------------

[a]Joint international quotas recommended if catches exceed suggested non-sustainable levels.

[b]Little knowledge of resource status.

Table 1.3. Canadian views on current stock condition and abundance trends for groundfish species/species groups on the west coast of Canada.

Species or species group	TAC (1,000 t)	Current stock condition
Lingcod	0.900[a]	average
Pacific ocean perch & yellowmouth rockfish	2.50-3.90 (cons.-non sust.)[b]	low to average
Other rockfish	2.40-6.65 (cons.-non sust.)	average
Sablefish	4-5 (cons.-non sust.)	good
Pollock	2.5-[b] (cons.)	average
Pacific cod	1.7-[b]	low
Flatfish	-[c]	average

[a]No TAC recommended for some areas.

[b]TAC range is from conservative to non-sustainable yield options.

[c]Three species managed by mixture of area quotas and trip limits.

2.0 LINGCOD

by A. J. Cass

2.1 Coastwide

Yield options are not proposed on a coastwide basis.

2.2 Strait of Georgia

2.2.1 The Fishery

Lingcod in the Strait of Georgia are exploited by commercial and sports fisheries. Historically, the commercial fishery off British Columbia was centered in the Strait of Georgia. Lingcod underwent an intensive period of commercial handline exploitation beginning in the 1920s. The fishery has been declining since the early 1960s and now a small fishery is confined to a few localized areas within the Strait of Georgia. The sports fishery underwent a rapid expansion in the 1960s and now takes the greatest share of the catch.

2.2.2 Landing Statistics

Handline landings, as reported in sales slip records, have declined from an average of 1300 t/yr during 1951-62 to an average of less than 400 t/yr during 1973-85. The 1985 catch was the lowest on record at 102 t (Table 2.1). Landings for 1986 are not yet available.

The estimated sports landings of lingcod, as determined from the Strait of Georgia creel survey, averaged 106,000 pieces (164 t) during 1980-85. There is, however, considerable annual variation in the estimated landings (Table 2.2). Estimates of the 1985 landings are 77,000 pieces (120 t). Although this is a 44% decline from 1984, it is slightly higher than the 1983 landings.

2.2.3 Condition of the stock

We have been unable to estimate the current productivity of stocks due to the lack of a suitable time-series of sports fisheries data. The long-term decline in the commercial handline fishery indicates stocks are now at low levels. The reason for the decline in stock size is not known, however, over-fishing is suspected.

In an attempt to rebuild stocks, the winter fishing closure was extended in 1979 from December-March to November 15-April 14 to more suitably cover the pre-spawning aggregation, spawning and nesting periods (Low and Beamish 1978). Data are being collected to monitor year-class strengths. Results of larval and juvenile surveys (Cass and Scarsbrook 1984) and tagging studies (Cass et al. 1984; 1986) indicate that the abundance of young lingcod has been increasing. However, there is no evidence that an increase in the size of the adult stock components has occurred.

As reported in the 1985 and 1986 assessments (Cass 1985, 1986), tag recapture data and biological samples collected in 1983 indicate that a significant proportion of the sports landings consist of immature fish. Data collected in 1984 and 1985 support the 1983 results (Cass et al. 1986; Cass unpublished data).

2.2.4 Recommendations

Management recommendations remain unchanged from 1986. Specifically, we recommend that the present lingcod fishing closure be continued. We also recommend a minimum size limit for the sports fishery similar to the size limit for the commercial fishery. The rationale for this closure is presented in Cass (1985).

2.3 West Coast Vancouver Island

2.3.1 The Fishery

Lingcod are fished by commercial trawl and, to a lesser extent, commercial handline and troll methods. Comprehensive assessments have been conducted separately for southwest Vancouver Island (area 3C) and northwest Vancouver Island (Area 3D) (Cass 1985).

2.3.2 Landing Statistics

Our methods for estimating LPUE and fishing effort are reported in Cass (1985). Commercial landings off Vancouver Island have undergone marked fluctuations during 1956-85 primarily due to variable recruitment. Trawl landings and fishing effort in 1985 in Area 3C were the highest on record at 3415 t and 3579 h (Table 2.3). Trawl landings and effort in Area 3D were also above the long-term average at 380 t and 532 h, respectively (Table 2.4).

We have reviewed the performance of the 1986 trawl fishery to July 1. Because the lingcod trawl fishery usually lasts until September each year, the performance of the fishery to July 1 may not accurately reflect the performance over the entire fishing season.

Trawl landings and effort to July 1 1986 have declined from the same period in 1985 in both areas. Landings from Area 3C declined by 80%. Trawling effort in Area 3C declined by 43%. Estimates of LPUE in Area 3C for the same time period declined by 66% or from 402 kg/h to 137 kg/h between 1985 and 1986. This is the largest drop in LPUE for any stocks exploited by the lingcod trawl fishery in Canadian waters. Trawl landings in Area 3D declined by 56% between 1985 and 1986 and trawling effort declined by 51%. LPUE declined slightly (11%) from 254 kg/h to 225 kg/h.

2.3.3 Condition of the stocks

The large decline in LPUE in Area 3C between 1985 and 1986 indicates that stocks have declined substantially. Stocks may have been over-fished in

1985. Estimates of the long-term average sustainable yield using Deriso's (1980) delay-difference model ranged from 900-1400 t/yr for Area 3C (Cass 1985). Landings in 1985 were considerably higher.

The low landings from Area 3D in 1985 compared to our estimate of average sustainable yield (460-510 t/yr) and the slight decline in LPUE between 1985 and 1986 does not warrant concern for the Area 3D stock.

2.3.4 Recommendations

We are concerned that high levels of fishing effort in Area 3C in 1985 may have resulted in over-fishing. The high level of fishing effort in Area 3C in 1985 was, in part, due to a lessening of market limits that in the past have created a buffer against over-fishing. We therefore recommend the following yield options for Area 3C in view of the large decline in LPUE and the apparent higher demand for lingcod:

1) A conservative sustainable quota of 900 t to maintain landings at our lower range of long-term yield. The catch should be monitored and if 75% of the quota is taken we suggest a 10,000 lb trip limit be imposed to ensure an equal distribution of landings during the rest of the year.

2) A higher risk sustainable quota of 1400 t to maintain landings at our upper range of long-term yield. The catch should be monitored and if 75% of the quota is taken we suggest a 20,000 lb trip limit be imposed to ensure an equal distribution of landings during the rest of the year.

We are less concerned about the Area 3D stock. Our estimate of long-term sustainable yield suggests that stocks have generally been under-exploited. We therefore are not recommending a change in the management strategy for Area 3D.

2.4 Queen Charlotte Sound

2.4.1 The Fishery

Lingcod in Queen Charlotte Sound are fished primarily by commercial trawl. Minor landings are also taken by handline and troll vessels. Exploited stocks are located on the Cape Scott (Area 5A) and Goose Island grounds (Area 5B). Our last assessments were conducted separately for these areas (Cass 1985, Cass in press).

2.4.2 Landing Statistics

Estimates of LPUE and fishing effort were determined using the methods of Westrheim (1983) as reported in Cass (1985, 1986). Landings and LPUE from Queen Charlotte Sound have been above average since 1981 as a result of strong recruitment to the trawl fishery. Landings and LPUE to July 1, 1986 in Area 5A were higher than the same period in 1985 (Table 2.5). Landings increased by 35% and LPUE increased by 126% from 111 kg/h to 251 kg/h. The corresponding estimate of fishing effort declined by 35%. Landings from Area 5B to July 1 1986 were about the same for the same period in 1985 (Table 2.6). There was however, an 110% increase in trawling effort between 1985 and 1986 with a corresponding 35% drop in LPUE from 221 kg/h to 158 kg/h.

2.4.3 Condition of the Stock

The increase in LPUE and corresponding decline in trawling effort between 1985 and 1986 (to July 1) in Area 5A suggests that stocks are not over-exploited and are generally in good shape. The decline in LPUE with a corresponding increase in trawling effort between 1985 and 1986 in Area 5B suggests that stocks in that area have declined.

From our last comprehensive assessment (Cass 1985), estimates of the average long-term sustainable yields expected from Queen Charlotte Sound were 450 t/yr in Area 5A and 640-730 t/yr in Area 5B.

2.4.4 Recommendations

Our estimates of long-term sustainable yields for Queen Charlotte Sound indicate stocks have not been fully utilized during most years since 1956. We therefore are not making any recommendations to alter management strategies in Area 5A or Area 5B.

2.5 Hecate Strait

Yield options are not developed for lingcod in this area.

Table 2.1. Commercial handline/troll and trawl landings of lingcod (t) from the Strait of Georgia and vicinity (Area 4B), 1951-85.

Year	Handline/ troll[a]	Trawl[b]	Total
1951	1279.5	48.1	1327.6
1952	1488.8	54.0	1542.8
1953	1179.2	28.1	1207.3
1954	1449.4	68.0	1517.4
1955	1220.1	50.6	1270.7
1956	1512.1	55.7	1567.8
1957	1539.7	42.0	1581.7
1958	1445.6	74.6	1520.2
1959	1183.0	336.4	1519.4
1960	1250.6	184.1	1434.7
1961	1157.7	102.1	1259.8
1962	1272.9	75.4	1348.3
1963	989.3	39.6	1028.9
1964	870.4	90.3	960.7
1965	779.7	93.8	873.5
1966	771.3	53.7	825.0
1967	778.6	51.3	829.9
1968	728.1	83.9	812.0
1969	875.7	65.6	941.3
1970	788.6	48.0	836.6
1971	564.0	55.5	619.5
1972	513.4	34.5	547.9
1973	371.8	14.8	386.6
1974	363.7	49.4	413.1
1975	330.5	33.1	363.6
1976	315.5	43.4	358.9
1977	412.5	16.2	428.7
1978	452.6	42.5	495.1
1979	503.7	25.2	528.9
1980	350.5	33.5	384.0
1981	336.0	63.1	399.1
1982	388.2	79.0	467.2
1983	274.8	85.3	360.1
1984	185.7	42.0	224.8
1985	102.0	21.7	123.7

[a]Source: 1951-82. British Columbia Catch Statistics. Department of Fisheries and Oceans, Annual Reports. 1985: preliminary data.

[b]Source: 1951-53. British Columbia Catch Statistics, Department of Fisheries and Oceans, Annual Reports. 1954-84: PBS computer files.

Table 2.2. Number of lingcod landed (thousands) in the sport-line fishery in the Strait of Georgia by Minor Statistical Area, 1980-85.[a]

	Minor Area								
Year	13	14	15	16	17	18	19	28	29	Total
1980	44.3	14.1	2.5	21.8	19.3	8.8	15.6	4.2	6.1	136.7
1981	31.9	14.7	6.8	10.0	10.1	11.6	25.3	5.8	8.6	124.8
1982	16.0	6.1	1.6	20.1	9.6	7.5	12.6	6.4	5.4	85.3
1983	16.2	2.3	1.1	20.1	7.0	6.2	9.9	6.7	4.3	73.8
1984	39.7	11.4	1.7	28.7	16.4	7.1	15.4	8.9	8.1	137.4
1985	23.2	6.2	0.9	14.0	8.9	5.3	13.0	3.1	2.7	77.1

[a]Landings were estimated from results of the Strait of Georgia creel survey.

Table 2.3. Lingcod landing statistics for Area 3C, 1956-86.

Year	Landed catch: Trawl (t)	Landed catch: Line (t)	Landed catch: Total (t)	Trawl LPUE (kg/h)	Effort (h)
1956	1151	67	1218	263	4640
1957	1070	123	1193	226	5275
1958	1047	56	1103	286	3855
1959	1742	67	1809	274	6600
1960	1867	94	1961	251	7809
1961	1972	51	2023	288	7025
1962	890	66	956	141	6756
1963	609	58	667	198	3366
1964	1127	42	1169	397	2945
1965	1812	55	1867	302	6188
1966	2030	80	2110	332	6355
1967	1779	119	1898	446	4259
1968	1661	76	1737	566	3071
1969	1054	88	1142	267	4280
1970	703	132	835	271	3077
1971	979	127	1106	200	5538
1972	625	141	766	96	8009
1973	876	84	960	258	3724
1974	1029	93	1122	209	5367
1975	1630	86	1716	247	6933
1976	1205	118	1323	132	10052
1977	844	136	980	121	8112
1978	360	92	452	97	4668
1979	602	86	688	160	4287
1980	623	97	720	155	4644
1981	603	240	843	144	5840
1982	1510	220	1730	295	5856
1983	970	167	1137	234	4858
1984	1731	128	1859	371	4987
1985[a]	3415	164	3579	457	7832
1985 (to July 1)	1373	-	-	402	3415
1986 (to July 1)	269	-	-	137	1963

[a]Line landings are preliminary.

Table 2.4. Lingcod landing statistics for Area 3D, 1956-86.

Year	Landed catch: Trawl (t)	Line (t)	Total (t)	Trawl LPUE (kg/h)	Effort (h)
1956	164	124	288	316	913
1957	130	135	264	392	674
1958	110	120	230	211	1088
1959	64	93	157	529	297
1960	87	106	193	660	292
1961	200	115	315	400	786
1962	286	103	389	199	1959
1963	115	121	237	277	855
1964	226	85	310	391	794
1965	505	90	595	315	1886
1966	585	135	720	427	1686
1967	460	166	225	434	1442
1968	868	107	975	604	1616
1969	619	77	696	293	2371
1970	456	157	613	268	2285
1971	264	114	378	174	2173
1972	85	181	266	197	1346
1973	172	84	256	364	705
1974	242	113	356	559	634
1975	347	90	437	252	1733
1976	245	90	336	280	1199
1977	158	107	265	232	1141
1978	197	94	291	467	623
1979	105	76	180	178	1013
1980	86	70	156	87	1794
1981	75	108	183	206	887
1982	49	232	281	115	2430
1983	446	119	565	254	2220
1984	153	321	474	217	2184
1985[a]	380	152	352	381	1396
1985 (to July 1)	335	-	-	254	1318
1986 (to July 1)	146	-	-	225	649

[a]Line landings are preliminary.

Table 2.5. Lingcod landing statistics for Area 5A, 1956-86.

Year	Landed catch: Trawl (t)	Line (t)	Total (t)	Trawl LPUE (kg/h)	Effort (h)
1956	350	0.0	350	52	6792
1957	433	0.1	433	150	2896
1958	296	0.0	296	23	12883
1959	192	0.1	192	73	2648
1960	280	0.1	280	62	4521
1961	388	1	389	233	1669
1962	531	9	540	152	3548
1963	285	5	290	122	2380
1964	352	0.3	352	227	1555
1965	331	0.1	331	176	1886
1966	707	7	714	173	4118
1967	759	1	760	168	4510
1968	1227	1	1228	251	4889
1969	617	1	618	90	6853
1970	590	5	595	133	4475
1971	230	5	235	83	2829
1972	164	11	175	90	1946
1973	232	11	243	192	1261
1974	339	16	355	178	1993
1975	82	14	96	65	1481
1976	258	11	269	48	5619
1977	122	14	136	34	3997
1978	128	6	134	39	3465
1979	100	8	108	44	2435
1980	108	6	114	35	3262
1981	183	25	208	96	2167
1982	467	25	492	150	3282
1983	573	28	601	244	2462
1984	257	45	302	133	2270
1985[a]	407	15	422	185	2281
1985 (to July 1)	162	-	-	111	1459
1986 (to July 1)	123	-	-	251	491

[a]Line landings are preliminary.

Table 2.6. Lingcod landing statistics for Area 5B, 1956-86.

Year	Landed catch Trawl (t)	Line (t)	Total (t)	Trawl LPUE (kg/h)	Effort (h)
1956	250	3	253	78	3222
1957	170	2	172	118	1450
1958	277	1	278	119	2336
1959	429	1	430	203	2115
1960	378	12	390	127	3066
1961	323	31	354	113	3127
1962	407	28	435	146	2987
1963	357	25	382	155	2459
1964	335	7	342	122	2813
1965	566	9	575	150	3824
1966	827	20	847	211	4006
1967	901	24	925	247	3742
1968	1043	20	1063	275	3867
1969	517	12	529	86	6176
1970	390	32	422	55	7630
1971	415	11	426	72	5911
1972	476	36	512	47	10965
1973	349	11	360	29	12548
1974	532	19	551	683	6636
1975	429	22	451	47	9563
1976	346	30	376	48	7818
1977	257	12	269	59	4531
1978	162	10	172	42	4132
1979	242	11	253	48	5286
1980	300	10	310	46	6763
1981	548	24	572	153	3744
1982	579	29	608	190	3193
1983	772	26	798	255	3122
1984	455	31	486	183	2656
1985[a]	469	7	476	256	1859
1985 (to July 1)	127	-	-	221	575
1986 (to July 1)	191	-	-	158	1219

[a]Line landings are preliminary.

3.0. PACIFIC COD

S. J. Westrheim, R. P. Foucher

3.1. Coastwide

The species was not treated as a coastwide stock.

3.2. Strait of Georgia (Area 4B)

3.2.1. Introduction

Previous groundfish stock assessment reports contained no detailed assessment of Pacific cod stocks in Area 4B (Fig. 1.1 and 1.2). Principal reason was the lack of information on stock delineation, standardized landing statistics, and age composition of landings. All three deficiencies have been eliminated, to some degree, in a report by Westrheim and Foucher (in review), which dealt with stock delineation, standardized landing statistics, mortality rates (from landings-at-age), stock assessment, and yield per recruit. The following information is based largely on the aforementioned report.

3.2.2. The fishery

The on-bottom trawl fishery in Area 4B is seasonal, principally October-March, due to regulations and economics, and the statistical "year" has traditionally been from October to September (Westrheim 1980). Pacific cod is the principal species landed (51% during 1945-60; 54% during 1960-77), and English sole (<u>Parophrys vetulus</u>) ranks second (18 and 19%). During 1945-84, principal quarter-years of cod landings were January-March (48%) and October-December (30%). Principal sources of cod were Minor Statistical Areas (MSAs) 18 (33%), 19 (25%), 17 (16%), and 14 (12%) (Foucher and Giudici 1985 Table 1). Within MSA 17, Nanoose (17-N) accounted for 89% of the interviewed landings of cod from January-March (op. cit. 1985 Table 8).

Four stocks have been delineated, largely from results of extensive Canadian and U.S. tagging experiments (Westrheim 1982; Westrheim and Foucher 1985). Together they produce more than 90% of the cod landed from Area 4B (Fig. 3.1). These stocks are: MSA 14, Nanoose (MSA 17-N), Gulf Islands (17-S and 18), and MSA 19. The MSA 14 and Gulf Island stocks are largely resident year-round, but exploited seasonally. The Nanoose and MSA 19 stocks are seasonal itinerants, and are probably exploited elsewhere during other portions of the year. At Nanoose, the cod appear in late January, and depart in late March or early April. The area is only open to trawling during January-March. In MSA 19, cod are most prevalent during October-December, although in some years are fairly abundant in August or September. There are no regulatory restrictions on this fishery. The fishery began suddenly in 1974 and appears to have virtually terminated in 1985 (Table 3.4).

3.2.3. Landing statistics

Detailed landing statistics for the individual stocks are contained in Tables 3.1 to 3.4, respectively. Production histories are shown in Fig. 3.1.

Exploitation histories differed among the four important stocks. Abundance of the resident stocks in MSA 14 and the Gulf Islands fluctuated without trend throughout the study period. The rapid decline in landings from Nanoose, after 1971, was attributed to diversion of cod elsewhere, for unknown reasons. The 12-year rise and fall of cod landings from MSA 19 was attributed to the anomalous behaviour of adult herring inshore-bound to spawn in Area 4B (Westrheim and Pedersen 1986). Briefly, some of the inbound herring chose MSA 19, rather than the customary Gulf Islands area (17-S and 18), as a pre-spawning staging area.

LPUEs-at-age provided estimates of instantaneous total mortality rate (Z) for each stock (Z = 1.03 - 1.63) (Table 3.5), and instantaneous fishing (F) and natural (M) mortality rates for the MSA 14 stock (F= 0.45 - 0.75; M = 0.59) (Table 3.6). Among stocks, estimates of Z were lower for the resident stocks (Z = 1.03 - 1.41) than for the itinerant stocks (Z = 1.26 - 1.63), perhaps reflecting the additional fishing effort sustained elsewhere by the itinerant stocks.

3.2.4. Condition of the stocks

Based on standardized landing statistics and mortality rates, the four principal Pacific cod stocks exploited in Area 4B appear to be unaffected by the current fishery. The substantial decline in, and prolonged low level of, landings from Nanoose has been attributed to diversion of cod elsewhere, cause unknown (Westrheim and Foucher, in review). The rise and fall in cod landings from MSA 19 during 1974-85 has been attributed to the anomalous behaviour of adult herring inbound to spawn in Area 4B (Westrheim and Pedersen, in press). The general decline in cod landings from Area 4B since 1980 is a coastwide phenomenon, largely attributed to non-fishery-related factors (Westrheim and Foucher 1985).

Since recruitment overfishing does not appear to be a problem for Pacific cod in Area 4B, the next question to consider is growth overfishing (Westrheim and Foucher, in review). In other words, what is the optimal yield-per-recruit achievable. Westrheim and Foucher (in review) conducted yield-per-recruit (YPR) analyses using minimum mesh size (in lieu of age at recruitment), variable values of F(0.2- 1.2), M(0.4 and 0.6), and minimum commercial size (MCS= 41 and 46 cm) imposed by the processors (Fig. 3.2 to 3.5; Tables 3.7 and 3.8). Maximum YPR values were 810-817 g for M = 0.4 and 442-469 g for M = 0.6, the range depending on the MCS. Maximum YPR values required excessively large values of F(1.2) and mesh size ($\geq$6.5 - 8.0", internal measure), at least if M is constant after age 1.0, at 0.4 or 0.6, and MCS = 41 or 46 cm. Because of the extremely large F and mesh-size values required, it is not practical to maximize YPR.

Maximum catch-profitability indices (YPR/F) occurred, in all options, at F=0.2, an excessively small value. For instance, from Table 3.8, maximum YPR increases steadily from 257 g at F=0.2 to 469 g at F=1.2, but corresponding values of YPR/F decline steadily from 1285 (257÷0.2) at F=0.2 to 391 (469÷1.2) at F=1.2. YPR/F values calculated by dividing maximum YPR values by the corresponding F for selected mesh sizes (3.0 to 6.0") exhibited maximal values of M and MCS (Table 3.9). For conditions closest to the current fishery (M=0.6; F=.5-.7; mesh size = 4.0-4.5"), maximum YPR/F (520) was achieved at MCS = 46 cm, F = 0.5, and mesh size = 4.5" (YPR=260). However, if MCS= 41 cm, maximum YPR/F (698 at F=0.5 and mesh size = 4.5") was 34% larger. Furthermore, the 4.5" mesh would catch fewer small, unmarketable English sole.

3.2.5. Recommendations

No change in the current regulations is recommended at this time. The available evidence suggests that recruitment overfishing is not a problem, and current minimum mesh-size is reasonably satisfactory with respect to optimizing catch profitability.

3.3. West Coast of Vancouver Island (Areas 3C and 3D)

3.3.1. Landing statistics

For all areas except 4B, the cod "year" is April-March. Landings have been updated through March 31, 1986. The annual index of abundance is Canadian landings per hour trawled (LPUE) from Big Bank (Area 3C) during April-September (Westrheim and Foucher 1985).

Total landings for April-March 1985-86 were 439 t, the fourth consecutive year of small landings (439-838 t/y) (Table 3.10). A similar phenomenon occurred during 1958-63, when annual landings were 518-926 t. The sharp decline in annual landings after 1981-82 was due in part to regulations which restricted the fishery during the spawning season (January-March).

LPUE for 1985-86 was 13 kg/h, the fifth consecutive year of small LPUEs (13-66 kg/h) (Table 3.10). Similar phenomena occurred during 1967-70 (69-82 kg/h) and 1959-63 (21-63 kg/h).

3.3.2. Condition of the stock

Landings and LPUEs have remained at a relatively low level during the past 4 or 5 years, and some concern over possible recruitment overfishing is justified. However, the recent decline in cod abundance is a coastwide phenomenon, applicable equally to stocks with widely disparate exploitation histories, and has occurred coastwide in the past (Westrheim and Foucher 1985; Fig. 3.1).

A hopeful sign is the appearance coastwide (based on reports of trawl captains), of the relatively strong 1985 year-class, which will begin recruiting to the fishery during the spring of 1987. Absolute abundance of this year-class is unknown, and hence we cannot predict the amount of increase in abundance of marketable cod in 1987.

3.3.2. The fishery

Unfortunately, some of the pre-recruit cod are large enough to be caught in the trawl nets, and subsequently discarded dead at sea. To estimate the gain in yield accrued by not catching the fish until they reach a larger size, we have applied a dynamic pool analysis giving yield-per-recruit estimates. The growth rate and mortality rate parameters for this analysis were nearly the same as for the Hecate Strait stock. The reader is referred to Section 3.5.4 for a discussion of the results.

3.3.3. Recommendation

Because of the continued low abundance of mature fish we must recommend that Amphitrite Bank, and a safe margin around it, be closed to all trawling during January, February, and March, 1987. The closure is to protect cod during spawning, since they are particularly vulnerable to trawling on Amphitrite Bank during the spawning season. We presented evidence in 1985 that a fishery there during spawning could remove enough of the concentrated spawners to interfere with stock recovery.

3.4. Queen Charlotte Sound (Areas 5A and 5B)

3.4.1. Landing statistics

Landings from Queen Charlotte Sound continue to be low (Table 3.11). In 1984-85, 393 t were landed, and in 1985-86, 293 t.

3.4.2. Condition of the stock

In 1985 the LPUE index of abundance continued to be low, 62 kg/h, indicating a scarcity of marketable fish (Table 3.11). In better years, for example 1978 and 1979, the index was as high as 258 kg/hr and 276 kg/hr. While a new assessment has not been carried out, the 1984 assessment indicated there was little danger of recruitment overfishing because of extensive, rough bottom refuges from trawling (Westrheim and Foucher 1985).

3.4.3. Recommendation

No recommendation is made for the fishery in 5A/5B.

3.5. Hecate Strait (Areas 5C and 5D)

3.5.1. Landing statistics

Landings have declined since 1983-84, when 2292 t were brought in. In 1984-85, 1718 t were landed, and in 1985-86, only 1051 t. Annual landings in the 1970s ranged from 1182 t to 5500 t (Table 3.10).

3.5.2. Condition of the stock

Abundance. The index of stock abundance is standardized landings per unit effort (LPUE), during April-September (Westrheim and Foucher 1985). Like total landings, LPUE has decreased steadily since 1983: 400 kg/h, 1983-84; 322 kg/h, 1984-85; 148 kg/h, 1985-86 (Table 3.10).

Research trawling in Hecate Strait in June and October 1985 and February 1986 (Saunders et al. 1986; Fargo and Davenport 1986), as well as commercial fishermen's reports indicate that a moderately strong 1985 year-class is present on the grounds. Statistical studies of factors influencing year-class strength were carried out during the summer of 1985. Factors which tend to increase year-class strength include a high abundance of herring (presumably as feed) (Walters et al. 1986) and water temperatures during the spawning period (February) in the range from 6.5° to 7.5° (Tyler and Westrheim, in press). Factors which tend to decrease year-class strength include lack of feed, adverse temperatures, and a strong northward current during the spawning period. Such currents occur when there is persistent and strong wind from the south during winter.

<u>Yield-per-recruit (YPR) Analysis</u>. Procedures were the same as those employed for Pacific cod in Area 4B (section 3.2.4), except that an additional value for minimum commercial size (MCS = 51 cm) was added. Based on recent length-frequency samples, the most common MCS value is 51 cm during winter, and 46 cm during the remaining seasons. Apparently MCS is rarely, if ever, set at 41 cm. Figs. 3.6-3.8 present the yield isopleths for M = 0.4 and MCS = 41, 46, and 51 cm, respectively. At F = 0.4-0.7 (probably a realistic range for Hecate Strait), maximum YPR values vary inversely with MCS, and directly with mesh size. Results are the same at M = 0.6, although YPR values are smaller overall due to the greater natural mortality rate (Figs. 3.9-3.11). Since 4" mesh (internal measure) appears to be the most common size currently employed, growth overfishing is evident. Furthermore an additional exacerbating factor is MCS. A smaller MCS would also increase YPR, but economic factors may preclude any improvement in the current situation.

<u>Discards at sea</u>. The currently acute, but perennial, problem of discards at sea is receiving considerable attention, due to the relatively high abundance of the 1985 year-class of Pacific cod. The problem appears to be most serious in Hecate Strait, and two remedial regulations have been discussed by fishermen, managers, and scientists -- area closures and minimum mesh-size.

Area closures are readily discounted for two reasons. First, DFO does not have the capability to enforce area closures, as revealed by the rockfish management procedures. Second, juvenile cod are widely distributed in Hecate Strait, according to reports of fishermen, and hence suitable portions would be difficult to select.

Imposition of a minimum-mesh regulation implies that growth overfishing has been demonstrated. That is, landings would increase if less undersized cod were caught and discarded at sea. The preceding yield-per-recruit analyses suggest that this is true. The choice of an appropriate minimum mesh size is affected by two important factors -- minimum commercial size (MCS), imposed by the processors, and the effect of such a mesh size on other important species. Three alternatives are considered here: (1) the mesh size which will retain, on average, 50% of the cod equal in length to MCS; (2) the mesh size which will retain, on average, 75% of the cod equal to MCS; and

(3) a compromise mesh size which will optimize the production of important co-habitant flatfish species. Table 3.12 contains the data on 50% retention lengths for the species associating with cod.

The following text table summarizes the results, on other species, of selecting mesh sizes for cod to achieve options 1-3:

		50% RFL[a] (cm)		
Option	Mesh size	Dover sole (38 cm)[b]	English sole (35 cm)[b]	Rock sole (35 cm)[b]
1. 50% RFL=46 cm	6.5"	52.3	44.5	37.5
2. 75% RFL=46 cm	5.5"	44.2	38.1	31.8
3. "Compromise"	5.0"	40.4	34.3	29.2

[a]RFL is Retention Fork Length.

[b]MCS in parentheses.

A 6.5" mesh will, on average, retain 50% of the cod equal in length to the minimum commercial size (46 cm), but would permit the escapement of excessive numbers of marketable Dover, English, and rock soles. A 5.5" mesh will retain, on average, 75% of the cod 46 cm long, but would permit the escapement of too many marketable Dover sole and English sole, but few rock sole. A "compromise" mesh size of 5.0" would retain more than 75% of the marketable cod; release too many marketable Dover sole, retain approximately 50% of the marketable English sole, and too many unmarketable rock sole. In other words, no single mesh size is suitable for all the important shelf species listed above.

All three optional mesh sizes have the same defect -- gilling by other important species in Hecate Strait. Pacific ocean perch, redstripe, and <u>reedi</u> gill in mesh sizes > 3.0". Spiny dogfish allegedly gill in mesh sizes >4.0". Shelf rockfish and arrowtooth flounder also gill, but we have no information on the critical mesh size.

A further problem with respect to minimum mesh size regulation concerns trawl-mesh supply. Lead time at the manufacturing level is required to produce the desired mesh, as well as time for retailers and fishermen to "use up" their current supplies of "unsatisfactory" webbing. These problems may not be acute if mesh regulations applied only to the last 50 meshes of the cod-end, as is the case in Area 4B.

We have no evidence through the 1980 year-class to indicate that the cod fishery, and its accompanying discard at sea, has had any effect on the production of new year-classes, hence no recruitment overfishing. Also, evidence suggests that growth overfishing is occurring. That is, there is a long-term loss in production of marketable cod due to the premature capture (and death) of juvenile cod. Growth overfishing is no threat to the resource, but does result in a long-term loss of income to the fishermen and processors.

In summary, the ideal minimum mesh-size for Pacific cod in Hecate Strait is not satisfactory for most other important species. Furthermore, severe enforcement problems arise if any "reasonable" mesh-size regulation is imposed. However, perhaps the responsibility for eliminating, or at least substantially reducing, the discard at sea of undersized Pacific cod should be assumed by the chief beneficiaries -- the fishermen. They are in the best position to select the proper cod-end for each target species on the fishing grounds. There is adequate information available now to ensure that the discard at sea can be substantially reduced, if desired.

3.5.3. Recommendations

Conservative sustainable yield-option: 900 t catch limit.
Sustainable yield-option: 1800 t catch limit.
Risk sustainable yield-option: No quota, fishing effort self-regulating.

Our recommendations this year are the same as last year. The first risk yield option is based on the observation that during the previous periods when abundance was as low as at present, (1960-63, and 1969-72), landings averaging 1800 t did not interfere with the recovery of the stock. The second risk option was formulated on the basis that fishing effort has in the past been tied to the abundance of cod, so that less cod meant less effort and proportionately lower catch. The managers selected the risk option last year. The resulting catch in the 1984-85 cod year turned out to be 1718 t, indicating that self-regulation occurred without a closure.

We consider that there is some risk in choosing the second or third options for two reasons: (1) the spawning cod stock has never been recorded to be so low for so long a period (since 1977; Table 3.10), raising the possibility that the potential for rapid recovery is no longer as strong as it once was, (2) the relative abundance index (LPUE) is not as reliable when the fish are not abundant. Hence we cannot be certain of true stock abundance. Statistical testing of the effect of stock size on the production of young is correspondingly uncertain.

Table 3.1. Standardized landing statistics for Pacific cod from MSA 14, during October-September, 1954-55 through 1984-85 (from Westrheim and Foucher, in review, Table 6).

	Total		Interviewed[a]				
	Oct-Sep		Oct-Mar	Oct-Dec		Jan-Mar	
Year	Effort (h)	Land. (t)	LPUE (kg/h)	Land. (t)	Effort (h)	Land. (t)	Effort (h)
1954-55	947	252	266	43	147	124	481
1955-56	707	133	188	10	90	76	368
1956-57	701	141	201	6	38	73	356
1957-58	623	99	159	29	156	20	153
1958-59	594	136	229	6	46	69	282
1959-60	598	131	219	17	59	91	434
1960-61	338	79	234	4	11	21	96
1961-62	288	55	191	10	48	25	135
1962-63	220	48	218	13	56	18	86
1963-64	895	111	124	37	299	57	461
1964-65	224	35	156	3	18	17	110
1965-66	209	19	91	1	12	2	21
1966-67	305	29	95	2	31	10	95
1967-68	263	20	76	4	39	4	66
1968-69	218	17	78	-	5	5	59
1969-70	233	30	129	13	73	7	82
1970-71	471	80	170	46	230	20	158
1971-72	409	65	159	22	176	18	75
1972-73	691	152	220	52	239	25	111
1973-74	(70)[b]	58	(825)	-	-	33	40
1974-75	241	75	311	20	70	35	107
1975-76	274	83	303	22	77	44	141
1976-77	220	98	445	30	58	23	61
1977-78	388	130	335	14	69	48	116
1978-79	112	48	429	2	20	25	43
1979-80	319	105	329	41	111	6	32
1980-81	233	91	390	41	67	28	110
1981-82	332	95	286	40	139	36	127
1982-83	225	41	182	1	12	11	54
1983-84	233	30	129	1	11	3	20
1984-85	(958)	69	(72)	0.07	1	0.36	5

[a]Landings for which detailed records are collected by port liaison officers with respect to location(s) of catch, effort expended, and weight of each species retained for sale.

[b]Numbers in parentheses not acceptable.

Table 3.2. Standardized landing statistics for Pacific cod from <u>Nanoose</u> (MSA 17-N) during January-March, 1954-84 (from Westrheim and Foucher in review, Table 7).

Year	Total		Interviewed		
	Effort (h)	Land. (t)	LPUE (kg/h)	Land. (t)	Effort (h)
1954	309	108	349	102	292
1955	149	29	194	25	129
1956	274	87	318	76	239
1957	209	67	320	56	175
1958	538	197	366	165	451
1959	294	193	656	158	241
1960	668	181	271	129	476
1961	457	85	186	77	415
1962	260	63	242	43	178
1963	179	57	318	49	154
1964	419	85	203	62	306
1965	155	30	193	28	145
1966	UNK[a]	T[b]	(133)[c]	T	3
1967	198	132	667	126	189
1968	442	91	206	89	431
1969	158	18	114	17	149
1970	193	64	331	41	124
1971	525	303	577	286	496
1972	472	250	530	249	470
1973	299	121	405	34	84
1974	339	119	351	99	282
1975	111	32	287	25	87
1976	UNK	7	(333)	5	15
1977	UNK	1	(400)	T	1
1978	UNK	15	(667)	6	9
1979	95	36	378	14	37
1980	UNK	17	UNK	T	T
1981	UNK	10	UNK	-	-
1982	UNK	19	UNK	T	T
1983	UNK	7	UNK	-	-
1984	UNK	19	UNK	-	-

[a]UNK = unknown - could not be calculated.

[b]T = trace = <0.5t.

[c]Numbers in parentheses not acceptable.

Table 3.3. Standardized landing statistics for Pacific cod from the <u>Gulf Islands</u> (MSA 17-S & 18) during October - September 1954-55 through 1984-85 (from Westrheim and Foucher in review, Table 8).

	Total (17-S & 18)		Interviewed (18)				
	October-September		Oct-Mar	Oct-Dec		Jan-Mar	
Year	Effort (h)	Land. (t)	LPUE (kg/h)	Land. (t)	Effort (h)	Land. (t)	Effort (h)
1954-55	3215	627	195	101	440	269	1455
1955-56	2389	313	131	77	512	57	509
1956-57	1372	236	172	16	138	45	216
1957-58	1364	206	151	23	186	71	437
1958-59	1749	369	211	15	140	208	917
1959-60	2008	241	120	10	129	71	544
1960-61	1197	170	142	32	151	23	235
1961-62	1740	167	96	3	40	28	284
1962-63	3000	420	140	1	25	13	75
1963-64	2349	397	169	6	71	46	236
1964-65	1503	227	151	1	12	10	61
1965-66	913	94	103	1	41	23	193
1966-67	901	173	192	17	89	15	78
1967-68	1307	132	101	6	78	6	41
1968-69	1415	167	118	5	44	13	108
1969-70	1279	220	172	6	62	69	373
1970-71	1920	215	112	6	59	48	423
1971-72	960	214	223	29	142	21	82
1972-73	1034	210	203	10	31	37	200
1973-74	1297	271	209	-	-	24	115
1974-75	1284	262	204	9	71	42	179
1975-76	2508	499	199	24	158	97	451
1976-77	2045	450	220	T[a]	6	113	509
1977-78	2608	493	189	21	120	82	424
1978-79	894	295	330	7	34	52	145
1979-80	UNK[b]	333	(100)[c]	5	54	17	167
1980-81	UNK	330	(214)	-	6	9	36
1981-82	UNK	161	(122)	3	16	2	25
1982-83	UNK	127	(133)	-	-	T	3
1983-84	UNK	93	(480)	2	4	T	1
1984-85	UNK	(≤20)	UNK	-	-	-	-

[a]T = trace = <0.5t.

[b]UNK = unknown - could not be calculated.

[c]Numbers in parentheses not acceptable.

Table 3.4. Standardized landing statistics for Pacific cod from MSA 19, during October - September, 1954-55 through 1984-85 (from Westrheim and Foucher in review, Table 9).

	Total		Interviewed				
	Oct-Sep		Oct-Mar	Oct-Dec		Jan-Mar	
Year	Effort (h)	Land. (t)	LPUE (kg/h)	Land. (t)	Effort (h)	Land. (t)	Effort (h)
1954-55	UNK[a]	20	UNK	-	-	-	-
1955-56	UNK	10	UNK	-	-	-	-
1956-57	(16)[b]	8	(500)	1	2	-	-
1957-58	UNK	40	UNK	-	-	-	-
1958-59	UNK	95	UNK	-	-	-	-
1959-60	333	147	441	30	68	-	-
1960-61	576	99	172	31	180	-	-
1961-62	UNK	50	UNK	T[c]	8	-	-
1962-63	247	37	150	2	15	T	1
1963-64	UNK	74	UNK	-	-	-	-
1964-65	293	81	276	32	116	-	-
1965-66	1008	119	118	55	466	-	-
1966-67	102	23	225	9	40	-	-
1967-68	(144)	48	(333)	1	3	-	-
1968-69	155	23	148	9	61	-	-
1969-70	336	79	235	20	85	-	-
1970-71	250	47	188	25	133	-	-
1971-72	88	13	148	3	22	1	5
1972-73	57	12	211	4	19	-	-
1973-74	UNK	52	UNK	-	-	-	-
1974-75	1137	258	227	22	97	-	-
1975-76	1358	463	341	141	413	-	-
1976-77	570	244	428	71	166	-	-
1977-78	1939	696	359	292	787	42	143
1978-79	1859	554	298	168	550	46	168
1979-80	3865	804	208	119	564	24	123
1980-81	2728	851	312	224	854	105	200
1981-82	3375	928	275	377	1387	156	553
1982-83	2097	543	259	41	168	32	114
1983-84	1538	483	314	53	168	T	2
1984-85	526	244	464	52	112	-	-

[a]UNK = unknown - could not be calculated.

[b]Numbers in parentheses not acceptable (see text).

[c]T = trace = <0.5t.

Table 3.5. Estimates of Z, by method, for principal stocks of Pacific cod in Area 4B (from Westrheim and Foucher in review, Table 13).

		Stock				
		MSA14[a] (Jan-Mar)	Nanoose[a] (Jan-Mar)	Gulf Is.[a] (Jan-Mar)	MSA19[b] (Oct-Dec)	MSA20[a] (Jan-Mar)
1. Among years						
a. Mean A-F (regression)	$\hat{Z}$ (R^2)	1.03 (.97)	1.35 (.99+)	1.11 (.99+)	1.26 (.99+)	- -
2. Among year-classes						
a. Mean Z	$\hat{Z}$ (C.V., %)	1.34 (27)	1.50 (21)	1.28 (32)	1.63 (28)	- -
b. Mean A-F (regression)	$\hat{Z}$ (R^2)	1.24 (.99)	1.48 (.99+)	1.41 (.99+)	1.49 (.98)	- -
3. Among age-classes (regression)						
a. Jan-Mar 1966	$\hat{Z}$ (R^2)	- -	- -	- -	- -	1.16 (.91)
b. Jan-Mar 1982	$\hat{Z}$ (R^2)	- -	- -	- -	- -	1.32 (.93)

[a]Ages 3-6.

[b]Ages 2-5.

Table 3.6. LPUE-at-age (nos./h) for selected year-classes, and estimates of Z, M, q, and F for Pacific cod from MSA 14, January-March 1954-82 (from Westrheim and Foucher in review, Table 12).

Year class	LPUE (nos./h) at age: 3	4	5	6	Mean annual effort (h) (Oct-Sept)	$\hat{Z}$	F[a]
1952	45.1	16.2	7.2	0.3	745	1.59	1.02
1953	39.4	19.4	0.4	0.3	656	1.85	0.90
1954	38.2	2.6	1.5	1.4	629	1.05	0.86
(1955)[b]	(5.0)	(2.4)	(1.0)	(1.5)	-	(0.45)	-
1956	30.8	16.1	6.3	1.3	455	1.04	0.62
1957	24.3	14.5	4.2	1.4	361	0.98	0.50
1958	28.4	18.7	0.5	0.6	435	1.52	0.60
(1967)[b]	(8.9)	(7.6)	(0.0)	(6.7)	-	(0.09)	-
Mean	34.4	14.6	3.4	0.9	547	1.24	0.75

Note: For Z on effort:
$a = M = 0.59$
$b = q = 1.373 \times 10^{-3}$
$R^2 = 0.32$

[a] $F = q\bar{E}$.

[b]Not acceptable.

Table 3.7. Pacific cod yield (g) per age-1.0 recruit from Area 4B at: M=0.4, MCS=41 and 46 cm; and F=0.2-1.2 (from Westrheim and Foucher in review, Table 21).

Mesh size	Fishing mortality (F)										
(in)	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
Minimum commercial size = 41 cm											
3.0	447	491	500	490	467	442	416	402	380	355	342
3.5	450	508	516	507	479	465	437	424	409	388	369
4.0	460	523	540	535	521	509	482	472	458	438	422
4.5	480	542	566	566	556	551	535	521	505	497	486
5.0	492	562	586	599	596	589	582	574	569	562	550
5.5	503	584	622	640	653	647	653	647	638	641	635
6.0	503	596	638	674	683	690	692	703	695	693	689
6.5	499	600	659	681	705	721	729	741	739	735	735
7.0	496	600	661	701	722	742	748	772	774	772	774
7.5	477	594	662	704	730	754	772	783	793	805	804
8.0	470	582	651	695	726	749	779	791	794	813	817
8.5	434	554	625	675	707	736	757	780	790	800	805
9.0	410	514	599	647	680	713	731	759	767	780	794
Minimum commercial size = 46 cm											
3.0	387	409	404	382	347	314	284	265	240	214	201
3.5	390	425	418	393	355	334	298	279	260	238	216
4.0	400	439	439	419	390	368	334	316	297	272	251
4.5	421	461	467	451	428	409	384	363	339	324	306
5.0	438	487	495	490	474	457	438	420	407	395	376
5.5	460	524	546	552	554	535	532	517	500	497	485
6.0	470	548	579	601	603	600	594	598	586	577	567
6.5	475	568	615	631	648	657	660	667	659	651	649
7.0	481	578	635	672	687	703	704	725	723	719	718
7.5	470	584	650	689	713	735	750	759	769	778	777
8.0	467	579	647	690	721	744	773	785	787	806	810
8.5	434	554	625	675	707	736	757	780	790	800	805
9.0	410	514	599	647	680	713	731	759	767	780	794

Table 3.8. Pacific cod yield (g) per age-1.0 recruit from Area 4B at: M=0.6, MCS=41 and 46 cm; and F=0.2-1.2 (from Westrheim and Foucher in review, Table 22).

Mesh size	Fishing mortality (F)										
(in)	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
Minimum commercial size = 41 cm											
3.0	242	275	297	298	302	293	281	272	262	254	246
3.5	243	279	304	310	309	308	297	286	279	275	269
4.0	246	292	320	328	329	334	323	322	313	310	303
4.5	249	301	330	349	356	360	352	354	350	346	346
5.0	254	309	344	361	370	377	384	382	381	384	379
5.5	257	315	350	374	393	407	408	415	416	425	424
6.0	250	311	349	375	402	415	427	433	439	448	452
6.5	245	306	346	378	401	417	429	441	449	461	466
7.0	237	300	344	370	399	419	430	441	451	459	469
7.5	225	283	332	362	383	407	420	430	441	455	464
8.0	204	267	312	343	365	389	402	413	424	442	444
8.5	181	237	280	312	335	352	370	386	394	408	422
9.0	161	211	251	282	309	324	341	353	364	380	386
Minimum commercial size = 46 cm											
3.0	196	212	221	213	207	193	177	164	151	144	133
3.5	196	216	224	222	210	204	187	172	161	154	146
4.0	199	228	239	238	226	223	204	200	185	180	169
4.5	206	239	250	260	255	248	233	226	217	208	204
5.0	212	252	271	278	276	274	271	262	255	250	241
5.5	224	268	291	305	315	319	314	313	309	313	306
6.0	223	274	303	322	339	348	351	352	353	356	357
6.5	227	281	314	338	357	368	375	384	387	395	398
7.0	225	283	323	347	372	388	396	405	414	419	425
7.5	220	276	322	351	370	391	403	412	422	435	442
8.0	204	264	309	339	361	385	397	409	419	437	438
8.5	181	237	280	312	335	352	370	386	394	408	422
9.0	161	211	251	282	309	324	341	353	364	380	386

Table 3.9. Catch-profitability indices (YPR/F) for YPR maxima of selected mesh sizes, at M=0.4 and 0.6, and MCS=41 and 46 cm (from Westrheim and Foucher in review, Table 23).

Minimum commercial size (cm)		Mesh size (in)					
		3.0	4.0	4.5	5.0	5.5	6.0
					M = 0.4		
41	YPR/F[a]	1250	1350	1415	1198	1088	781
	YPR	500	540	566	599	653	703
	F	0.4	0.4	0.4	0.5	0.6	0.9
46	YPR/F	1363	1463	1168	1238	923	1005
	YPR	409	439	467	495	554	603
	F	0.3	0.3	0.4	0.4	0.6	0.6
					M = 0.6		
41	YPR/F	503	477	514	480	386	377
	YPR	302	334	360	384	425	452
	F	0.6	0.7	0.7	0.8	1.1	1.2
46	YPR/F	553	598	520	556	456	298
	YPR	221	239	260	278	319	357
	F	0.4	0.4	0.5	0.5	0.7	1.2

[a]YPR = yield (g) per age-1.0 recruit; F = instantaneous fishing mortality rate.

Table 3.10. Pacific cod landings and landings per unit effort (LPUE) from the West Coast of Vancouver Island and Hecate Strait, April-March, 1956-1985.

	Areas 3C + 3D		Areas 5C + 5D	
	LPUE (kg/h)	Landings (t)	LPUE (kg/h)	Landings (t)
Year	Qtrs. 2, 3	Total	Qtrs. 2, 3[a]	Total
1956-57	163	1485	1098	2016
1957-58	134	1674	872	3251
1958-59	111	798	1464	5701
1959-60	45	926	1248	3517
1960-61	63	565	590	2390
1961-62	21	518	374	1521
1962-63	39	827	608	2056
1963-64	126	1167	894	2658
1964-65	342	1991	1708	6324
1965-66	224	2678	1662	8927
1966-67	239	3230	1428	8996
1967-68	78	1810	1084	6115
1968-69	82	1069	367	3927
1969-70	69	936	246	2576
1970-71	139	1581	147	1182
1971-72	502	4903	220	1307
1972-73	519	5681	641	2899
1973-74	214	3038	1118	3822
1974-75	192	3879	1048	5247
1975-76	161	3502	627	5410
1976-77	179	3424	464	4168
1977-78	146	2512	348	3462
1978-79	167	1392	337	2298
1979-80	220	1568	459	5500
1980-81	124	1163	358	4227
1981-82	60	1519	198	2642
1982-83	35	608	393	2507
1983-84	66	838	400	2292
1984-85	33	507	322	1718
1985-86	13	439[b]	148	1051[b]

[a]Calculated by combining April-September LPUEs for 5C and 5D each weighted by landings from appropriate major area.

[b]Preliminary landings compiled for April 1985 through March 31 as of June 30, 1986.

Table 3.11. Pacific cod landings and landings per unit effort (LPUE) from the Queen Charlotte Sound, April-March, 1956-1985.

Year	LPUE (kg/h) Qtrs. 2, 3	Landings (t) Total
1956-57	175	1710
1957-58	665	2625
1958-59	138	1122
1959-60	225	936
1960-61	131	589
1961-62	69	259
1962-63	100	392
1963-64	88	702
1964-65	303	1255
1965-66	449	1983
1966-67	249	1811
1967-68	159	1486
1968-69	132	980
1969-70	76	652
1970-71	43	278
1971-72	81	944
1972-73	209	2416
1973-74	223	1862
1974-75	209	2236
1975-76	281	2467
1976-77	212	2265
1977-78	145	1316
1978-79	258	1939
1979-80	276	2018
1980-81	210	1270
1981-82	166	812
1982-83	115	579
1983-84	29	183
1984-85	69	393
1985-86	62	293

Table 3.12. Fork length (cm) at 50% retention, by mesh size, for Pacific cod, Dover sole, English sole, and rock sole.

Mesh size[a] (in)	Pacific cod FL (cm)	Pacific cod Age[b] (y)	Dover sole (cm)	English sole (cm)	Rock sole (cm)
3.0	24.4	0.8	24.1	21.6	18.4
3.5	27.6	1.0	28.2	24.8	21.0
4.0	30.9	1.2	32.3	27.9	23.5
4.5	34.0	1.4	36.3	31.8	26.7
5.0	37.2	1.6	40.4	34.3	29.2
5.5	40.5	1.8	44.2	38.1	31.8
6.0	43.6	2.0	48.3	41.3	34.3
6.5	46.8	2.3	52.3	44.5	37.5
7.0	50.0	2.5	56.4	-	-
MCS[c] (cm)	46/51		38	35	

[a]Measured between knots.

[b]Age 1.0 on March 1.

[c]MCS = minimum commercial size, imposed by processors.

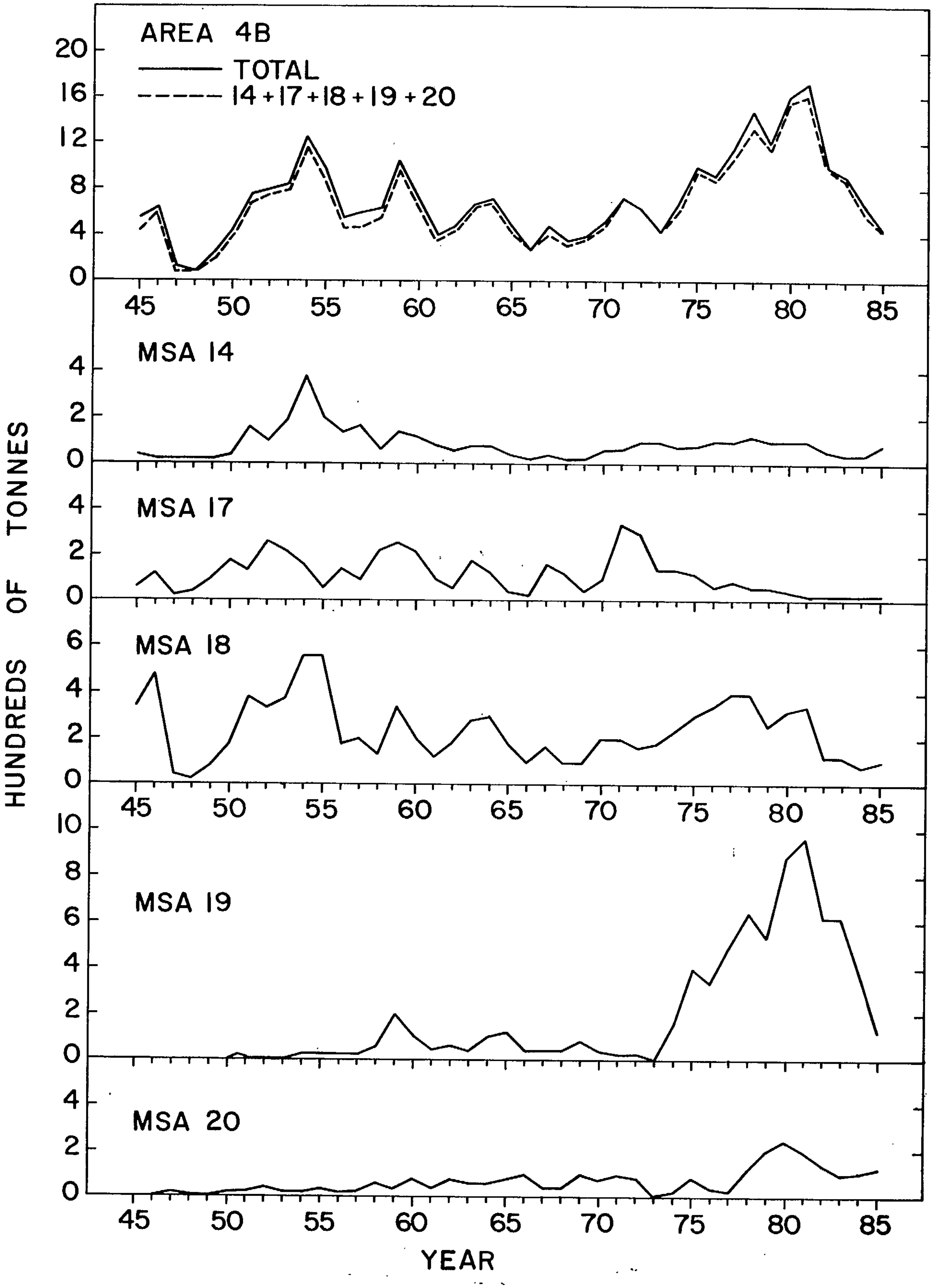

Fig. 3.1. Annual landings of Pacific cod from important MSAs in Area 4B, 1945-85.

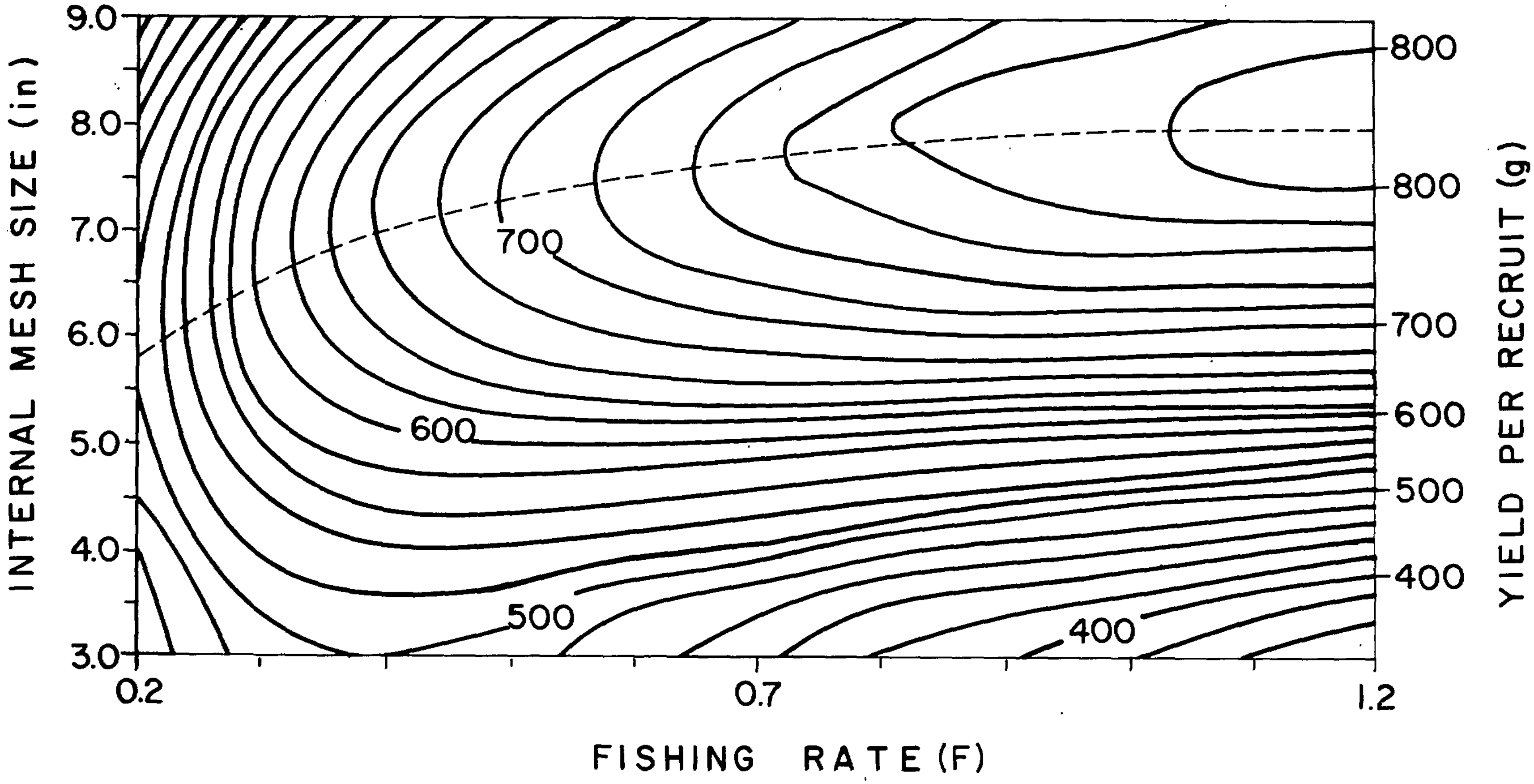

Fig. 3.2. Pacific cod yield (g) per age-1.0 recruit from Area 4B, at M=0.4, MCS= 41 cm, and F=0.2-1.2. (From Fig. 10 of Westrheim and Foucher, in prep.).

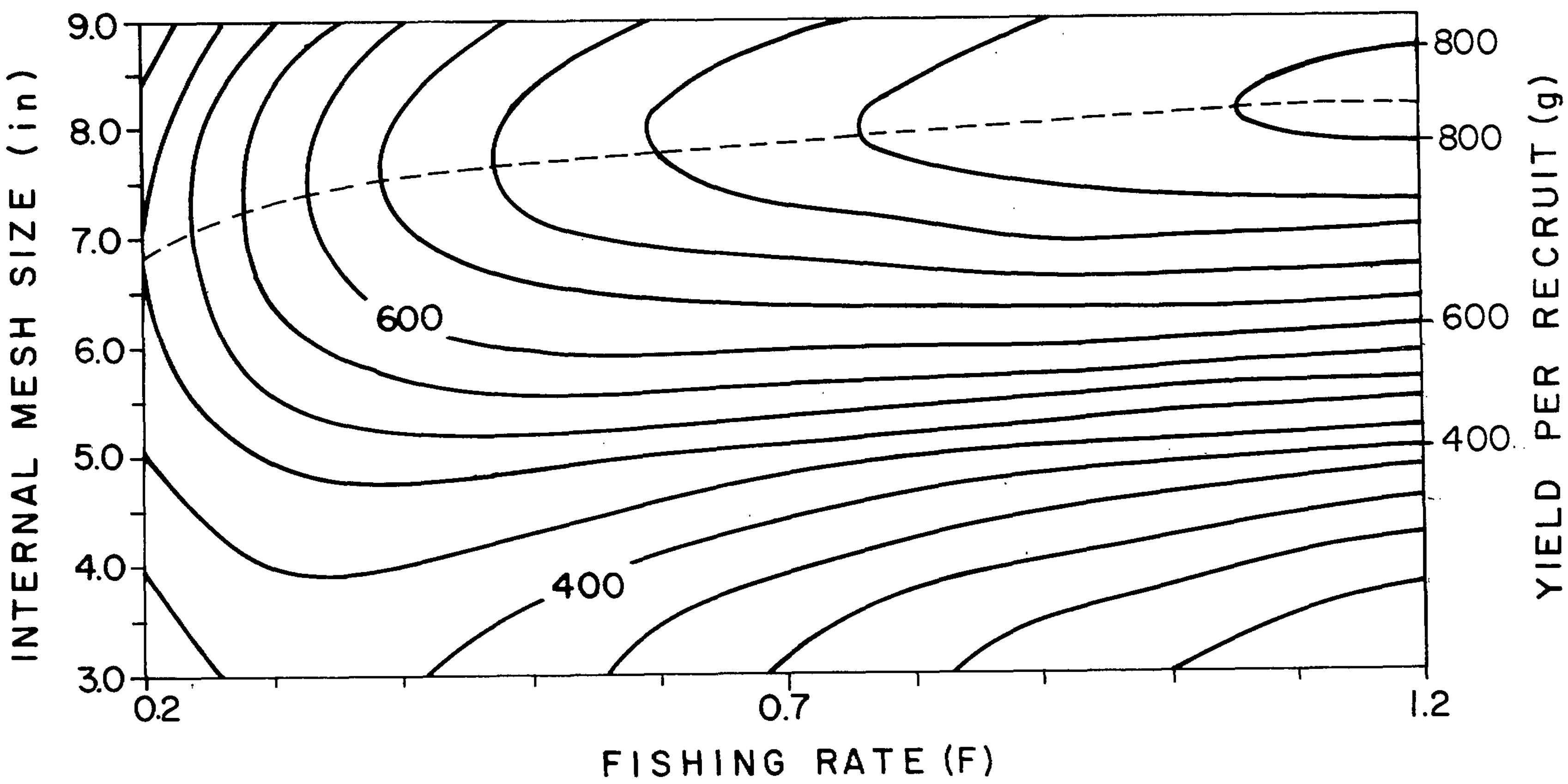

Fig. 3.3. Pacific cod yield (g) per age-1.0 recruit from Area 4B, at M=0.4, MCS=46 cm, and F=0.2-1.2. (From Fig. 11 of Westrheim and Foucher, in prep.)

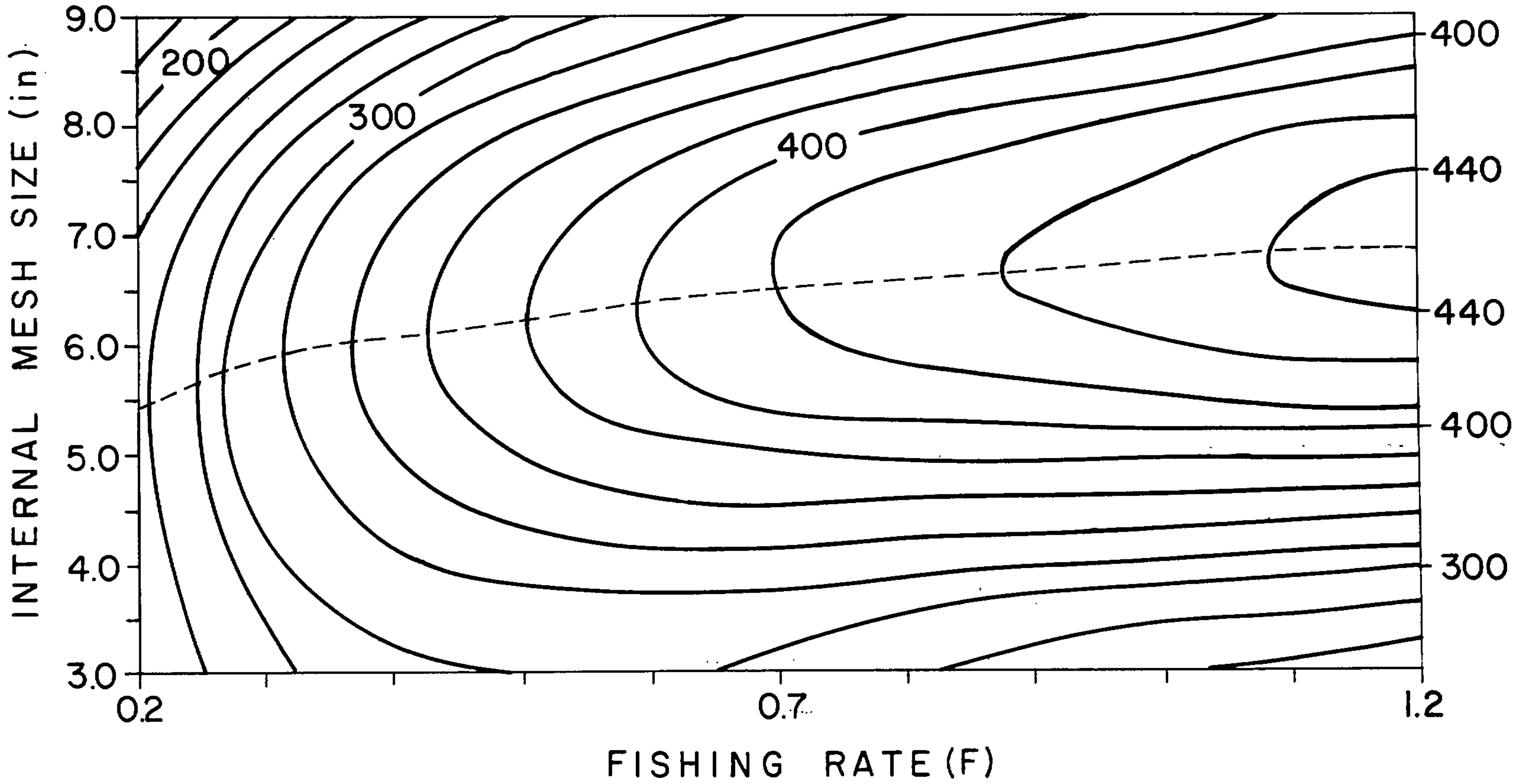

Fig. 3.4. Pacific cod yield (g) per age-1.0 recruit from Area 4B, at M=0.6, MCS=41 cm, and F=0.2-1.2. (From Fig. 12 of Westrheim and Foucher, in prep.)

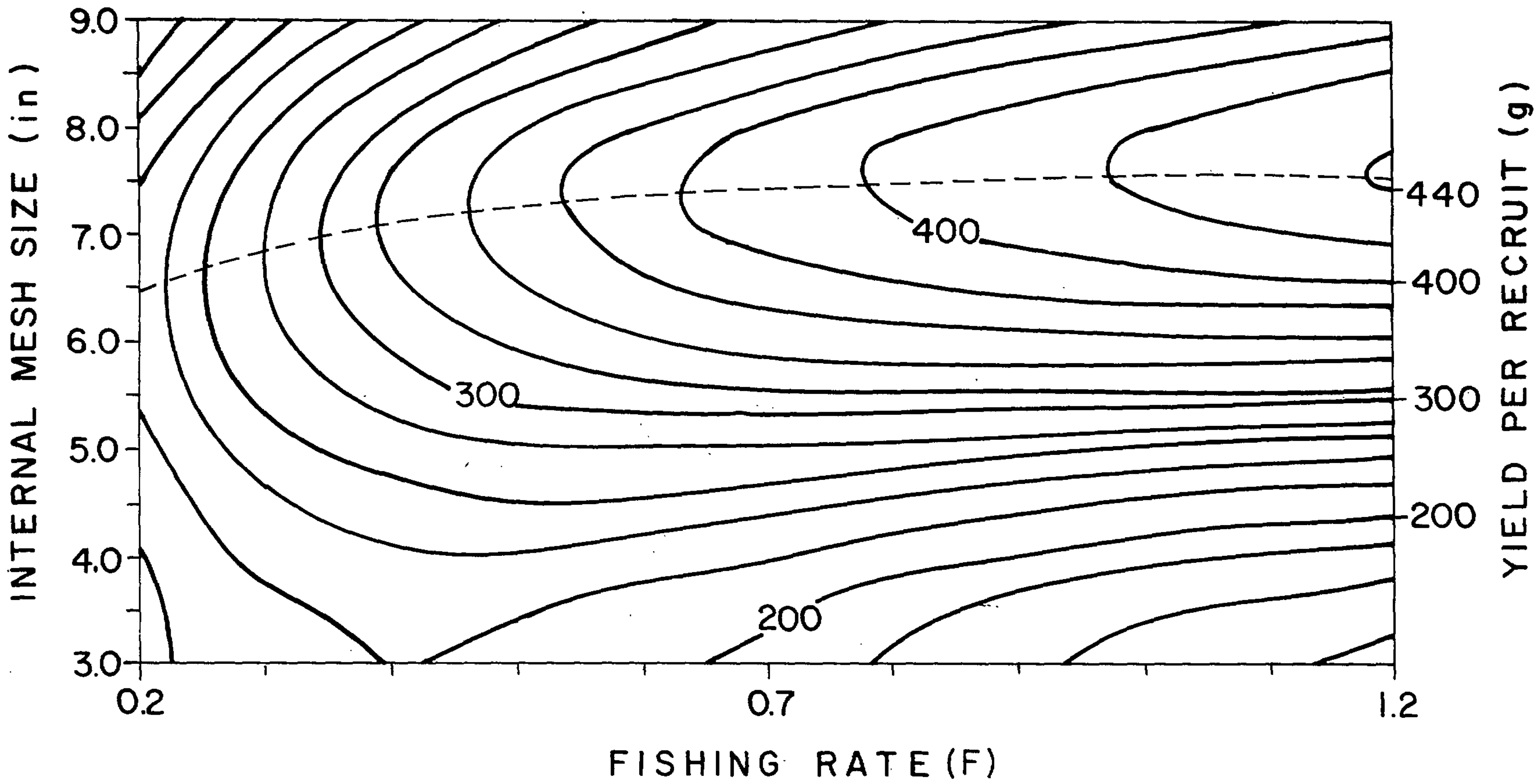

Fig. 3.5. Pacific cod yield (g) per age-1.0 recruit from Area 4B, at M=0.6, MCS=46 cm, and F=0.2-1.2. (From Fig. 13 of Westrheim and Foucher, in prep.)

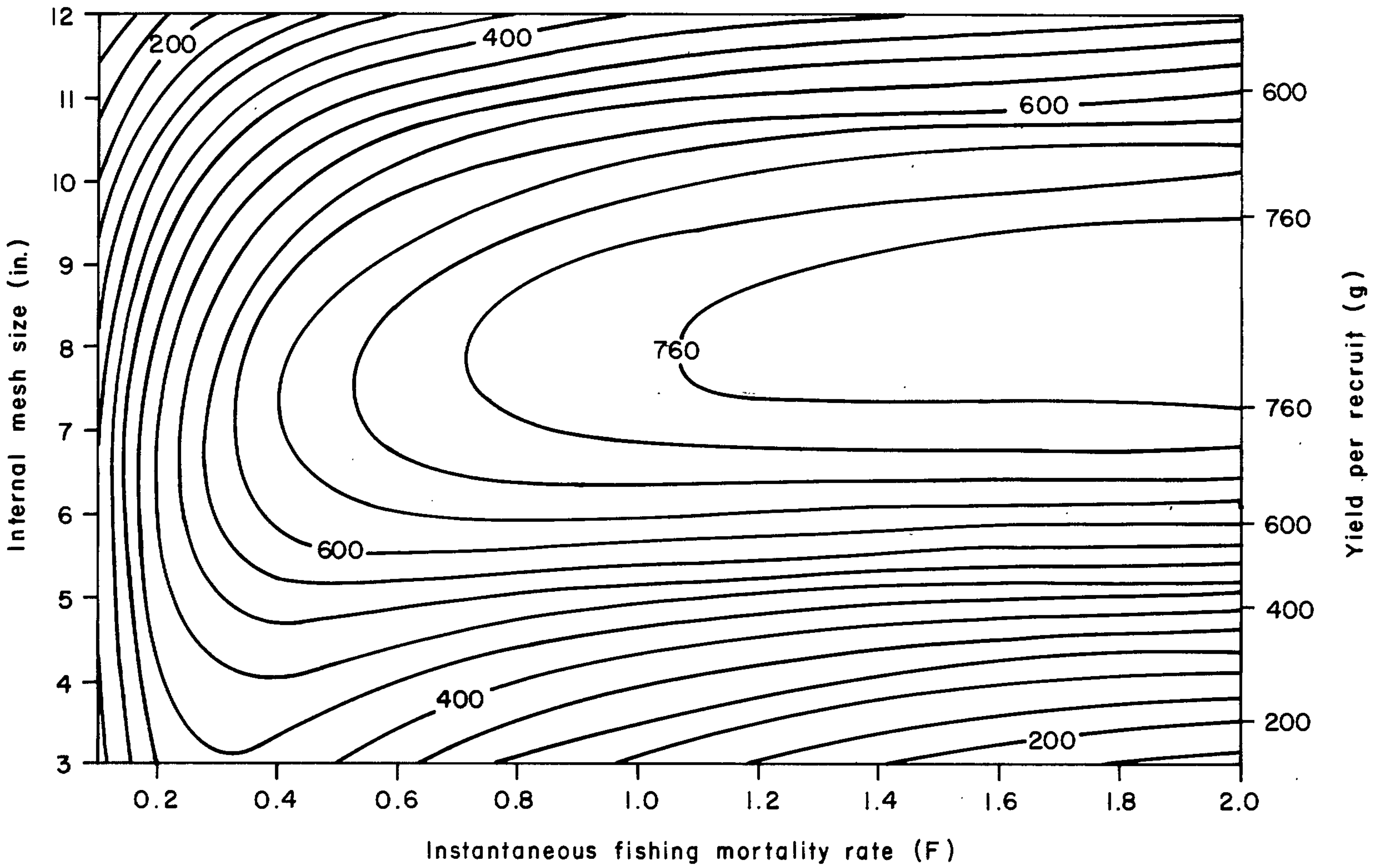

Fig. 3.6. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.4, MCS=41 cm, and F=0.1-2.0.

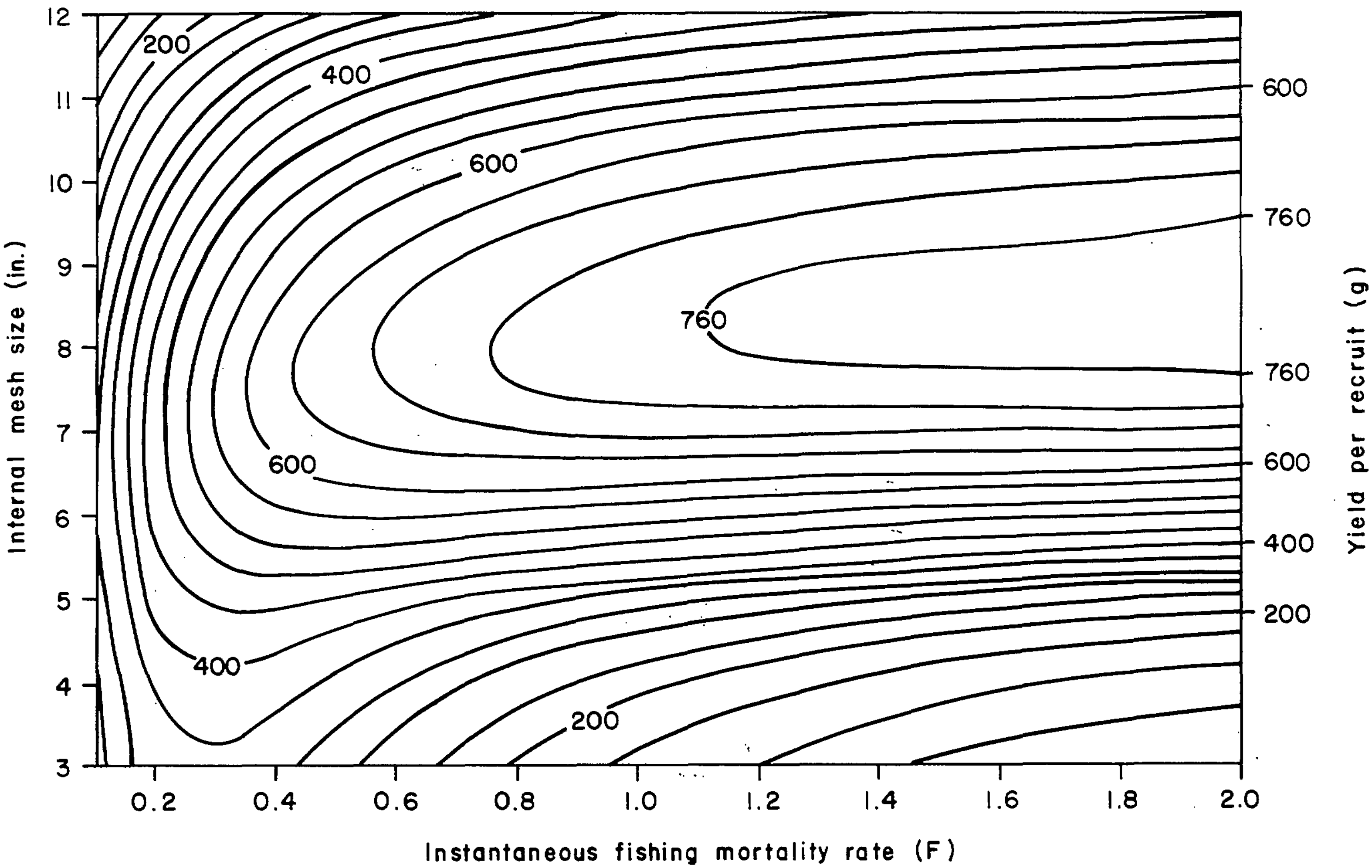

Fig. 3.7. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.4, MCS=46 cm, and F=0.1-2.0.

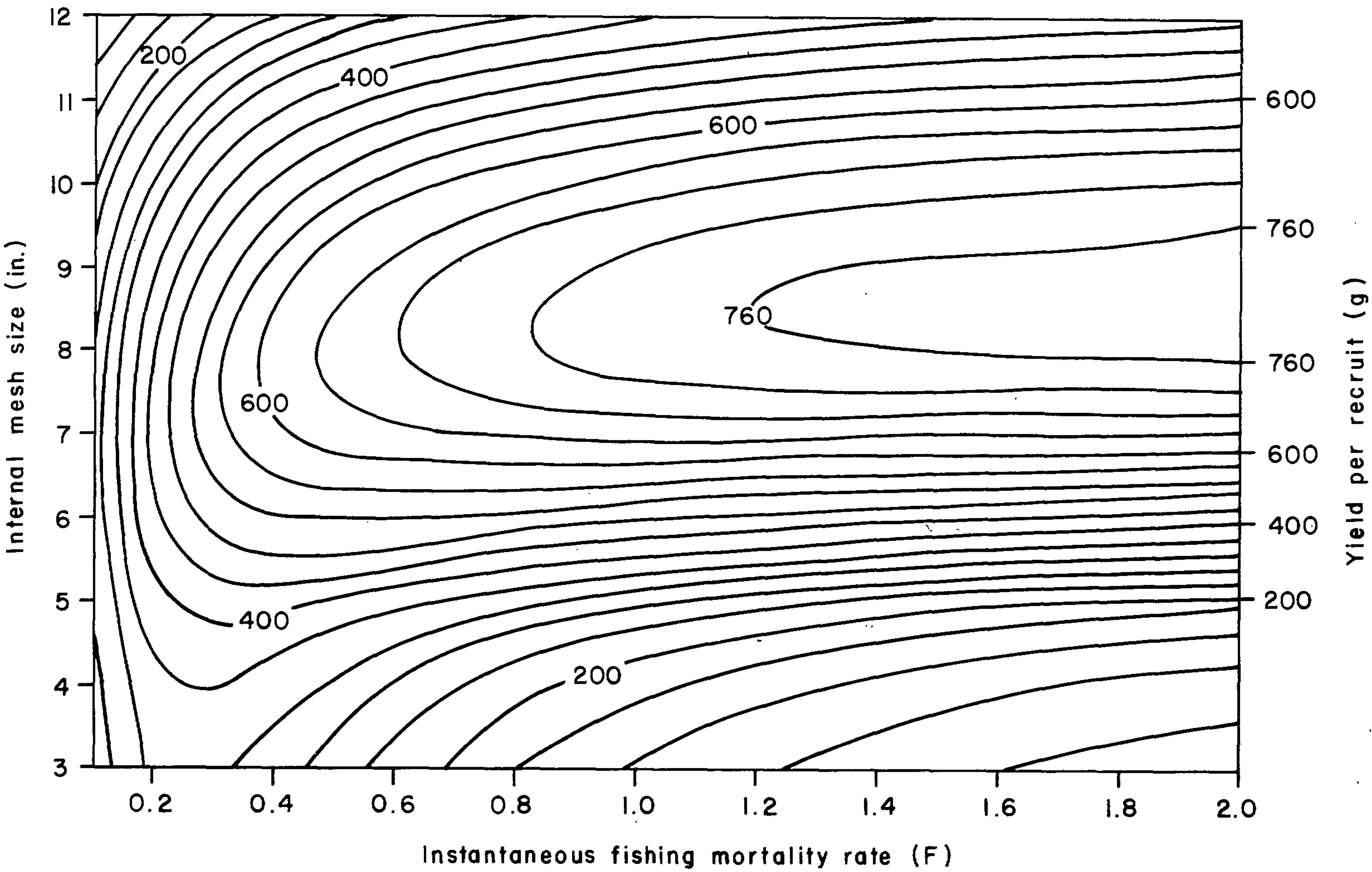

Fig. 3.8. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.4, MCS=51 cm, and F=0.1-2.0.

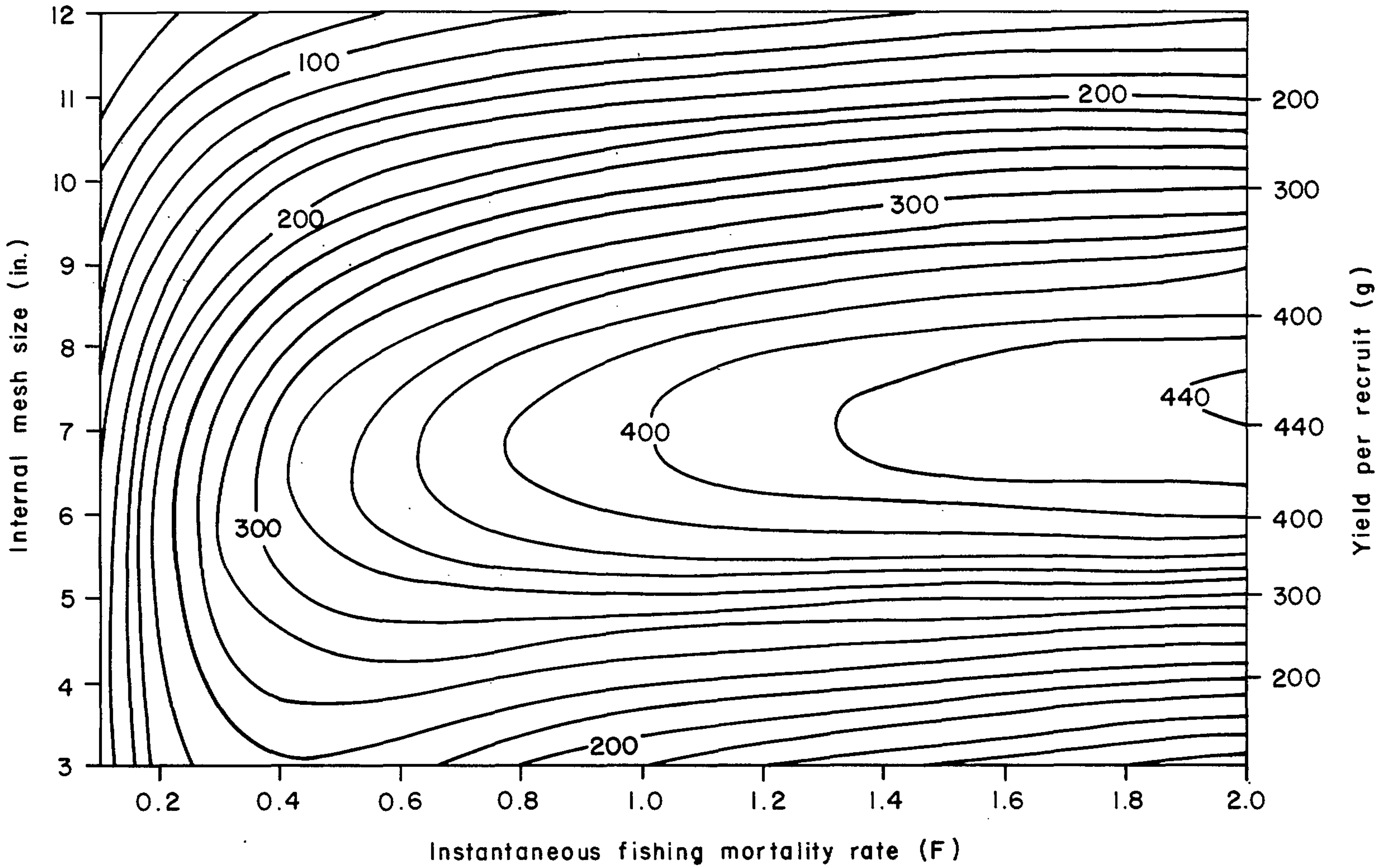

Fig. 3.9. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.6, MCS=41 cm, and F=0.1-2.0.

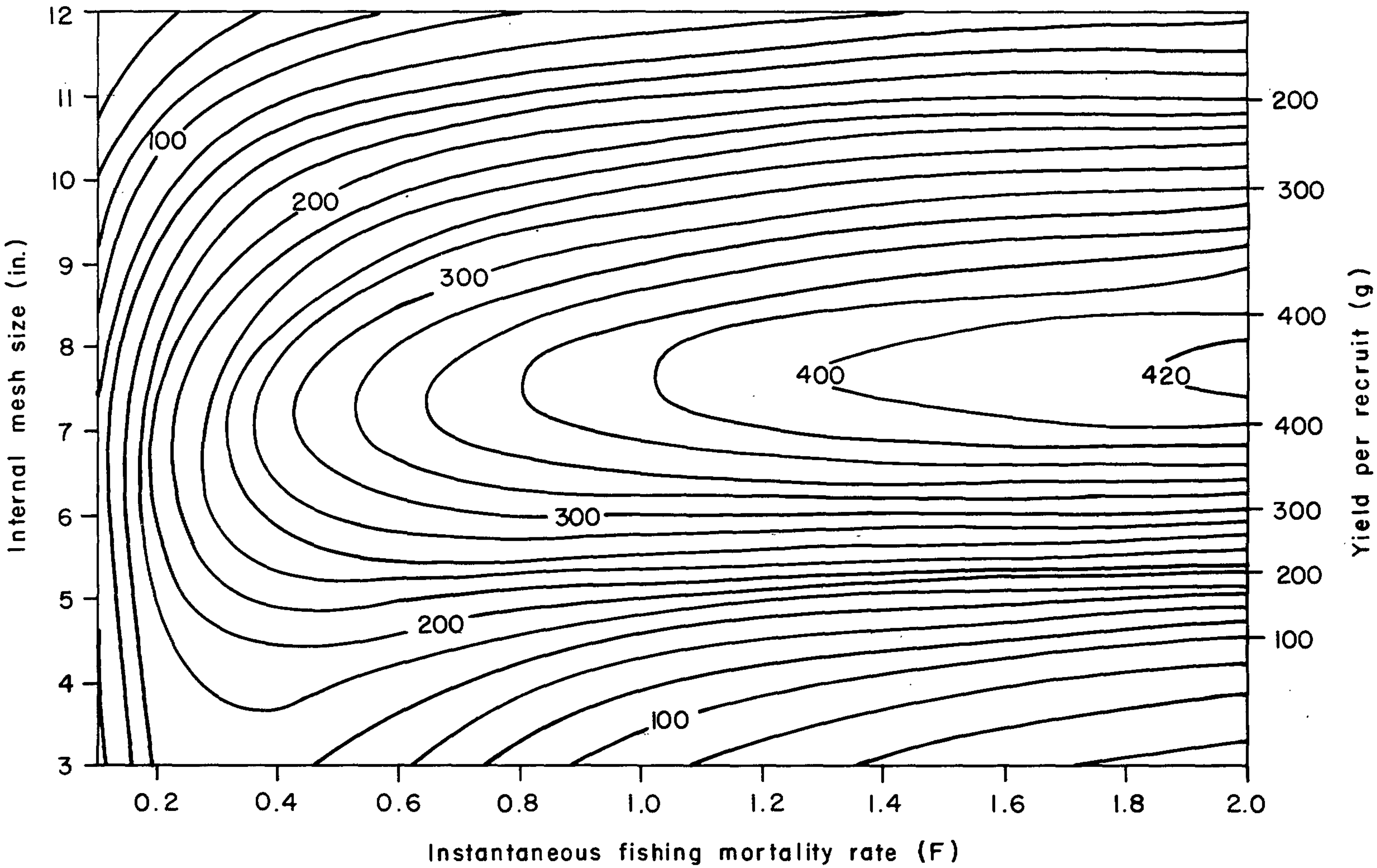

Fig. 3.10. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.6, MCS=46 cm, and F=0.1-2.0.

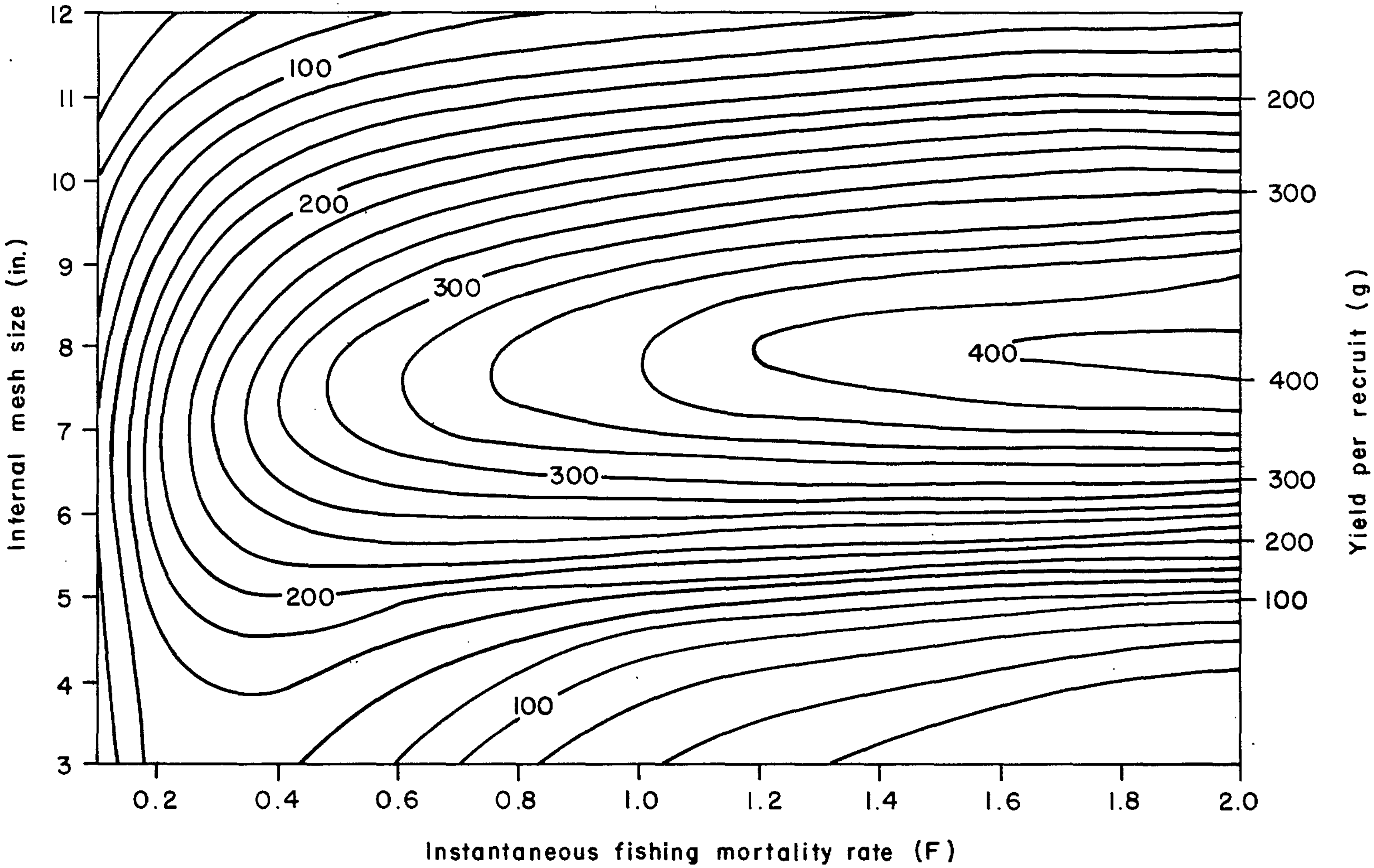

Fig. 3.11. Pacific cod yield (g) per age-1.0 recruit from Areas 5C and 5D, at M=0.6, MCS=51 cm, and F=0.1-2.0.

4. FLATFISH

by J. Fargo

4.1 Coastwide

Yield options are not proposed for flatfish species on a coastwide basis.

4.2 Strait of Georgia

Yield options are not proposed for flatfish for this region.

4.3 West Coast of Vancouver Island

No new assessments have been carried out for flatfish species in this region and yield options remain the same as those in 1985 (Fargo 1985).

4.4 Queen Charlotte Sound

4.4.1 Rock Sole

4.4.1.1 Area 5A Condition of the Stock

Standardized landing statistics are presented in Table 4.1. The landings for 1986 through July 11 are 12 t, compared with 42 t over the same period in 1985. LPUE is standardized using landings and effort from April-Sept. (Westrheim and Foucher 1985) and effort calculated from standardized LPUE and landings. It is, as yet, too early to compute effort and LPUE for rock sole in Area 5A for 1986. Catch and effort are particularly low in 1985-86 compared to earlier years (1979-82). This reflects the lack of emphasis on a shallow water fishery in Area 5A since the early 1980s due to a scarcity of Pacific cod. Fishing effort in Area 5A is currently being directed at the more lucrative rockfish fishery.

Length frequency data for 1985 indicates that recruitment is at low levels. No length frequency data is available yet for 1986.

4.4.1.2 Recommendations

Sustainable yield option: A yield of 200 t was sustained during the period 1972-85 (LPUEs for similar levels of effort are equivalent). The 30,000 lb trip limit currently in effect for Queen Charlotte Sound is consistent with this option. Analysis of landings for rock sole in Area 5A by trip category indicated that if rock sole trips >30,000 lb were eliminated, landings were never greater than 200 t for any year from 1956-85.

Non-sustainable option: Yields of >400 t in the past have been associated with declines in LPUE and possible declines in abundance for the stock.

4.4.1.3 Area 5B Condition of the Stock

Standardized landing statistics are presented in Table 4.2. Landings of rock sole in Area 5B to July 11, 1986 are 62 t. This compares to

48 t landed during the same period for 1985. It is still too early to compute effort and LPUE indices for 1986 (see Sect. 4.4.1.1.). There was a slight increase in LPUE in 1985 and a significant decline in effort compared to 1983-84. There has been little trend in LPUE since 1981 for the Area 5B stock of rock sole. This is interpreted as being due to a stable stock size over that tim$period.

Length frequency data for the stock indicates a low level of recruitment in 1985. Samples collected thus far in 1986 indicate no significant increase in recruitment to the fishery in 1986 over 1985.

4.4.1.4 Recommendations

Sustainable yield option: An average yield of 200 t was taken annually during the period 1981-85. We recommend this as a sustainable yield level at the present time. The 30,000 lb trip limit currently in effect for Queen Charlotte Sound is consistent with this option.

4.5 Hecate Strait

4.5.1 Rock Sole

4.5.1.1 Landing Statistics (Area 5C)

Landings for rock sole in Area 5C (Table 4.3.) from Jan. 1-July 11 in 1986 were 82 t. This is compared to 13 t for the same period in 1985. Effort and LPUE cannot be computed yet for 1986, but with effort levels as low as they have been to date 1986 (due to the scarcity of Pacific cod in this region), LPUE for rock sole in Area 5C in 1986 will probably be higher than in 1985.

4.5.1.2 Condition of Stock

Length frequency samples collected thus far in 1986 indicate no significant increase in recruitment to the fishery over 1985. Recruitment for the 5C stock is therefore, still considered to be at low levels as shown in the previous analysis (Fargo 1985). With recruitment at low levels, potential yield for the stock is considered to be low at the present time.

4.5.1.3 Recommendations

Sustainable yield option: With the current low recruitment mode the 30,000 lb landing limit for rock sole in Hecate Strait should be retained. This is consistent with keeping effort (and fishing mortality) at low levels to protect the stock from possible recruitment overfishing. The sustainable yield level at present is estimated at 100 t, equivalent to the average yield from 1981-85, a period of stable LPUE.

Risk yield option: To date there is no direct evidence that either the Area closure in 5C from (1980-83) or the 30,000 lb trip limit have had any effect on recruitment for the species. Therefore removal of the 30,000 lb landing limit can be considered. This option is, however, not recommended.

4.5.1.4 Landing Statistics (Area 5D)

Landings for rock sole in Area 5D (Jan. 1-July 11) were 63 t. Comparable landings for 1985 were 31 t. Effort and LPUE cannot be computed yet but the number of trips for rock sole in 1986 is down from the same period in 1985. If this trend continues, effort for 1986 would be down from 1985 while LPUE would be up.

4.5.1.5 Condition of the Stock

The LPUE index for rock sole indicates the Area 5D stock is at its lowest level in 1985 since monitoring of this fishery began. Recruitment surveys of Hecate Strait for rock sole as well as port sample length frequency data indicate extremely low levels of recruitment for this stock in recent years. The primary question for management is to what degree has the fishery been responsible for the decline in abundance of this stock. Results from analysis of tag recoveries for rock sole in Hecate Strait (Fargo and Westrheim, in press) indicate a significant increase in the natural mortality rate for the species in the early 1980s.

Fishery managers on Canada's east coast have examined the utility of fishing a stock at a level of fishing lower than the fishing rate that corresponds to MSY for the stock. ICNAF, in a special meeting in 1975, selected a level of fishing at $F_{0.1}$ and adopted this as a criteria for management of many East Coast fish stocks. The idea here was that the fishing rate for a stock which corresponded to the $F_{0.1}$ level would be sufficient to achieve a fairly high yield while at the same time not be high enough to cause overfishing of the stock. $F_{0.1}$ also leads to higher economic returns because the yield-per-recruit/F ratio is higher than the yield-per-recruit/F ratio at the maximum fishing rate (F and fishing costs are positively related). There are also a number of weaknesses inherent in an $F_{0.1}$ fishing policy (Berkson 1986). The $F_{0.1}$ statistic presented here for selected flatfish species is presented as a comparison to previous catch-at-age and LPUE analysis (Fargo 1985). It is not our intent to recommend a $F_{0.1}$ policy for flatfish species, but to give calculated levels for this option.

The $F_{0.1}$ fishing level for rock sole was determined according to Rivard 1982. $F_{0.1}$ for rock sole in Area 5D was calculated at 0.44 (Fig. 4.1). The average fishing mortality rate for rock sole as determined by cohort analysis results (Table 4.4) indicates that the fishing rate for rock sole in Area 5D was higher than $F_{0.1}$ in the mid to late 1960s and the mid 1970s. This combined with unfavourable ocean temperatures for recruitment as well as increases in the natural mortality rate in the early 1980s could have significantly reduced the rock sole stock size in Area 5D. The present fishing rate for rock sole in Area 5D is probably below $F_{0.1}$ levels.

Length frequency data for 1986 indicates no significant increase in recruitment for the Area 5D stock.

4.5.1.6 Recommendations

Re-building yield option - With effective fishing effort for rock sole in Area 5D at low levels at present, a closure of Area 5D would be the only option to produce a significant decrease in the fishing rate for rock sole. This is not recommended for the following reasons (1) ocean temperatures play a significant role in determining production success for rock sole in Area 5D (Fargo 1985) and at present, ocean temperatures are not favourable for recruitment for rock sole, (2) fishery production for English sole, Dover sole, and Pacific cod contribute to the major fishery production, and this production would cease under an area closure, (3) indications are that conditions other than the fishery have limited the size of the rock sole population in Area 5D, and (4) area closures in the past (see Sect. 4.5.1.4) have had no effect on rock sole recruitment and subsequent abundance.

Sustainable yield option - The current fishing rate for rock sole in Area 5D is below $F_{0.1}$ calculated for the stock. The 1986 LPUE observation indicates that abundance of rock sole in Area 5D may again be increasing. The 30,000 lb trip limit in effect for rock sole in Area 5D will help to achieve this option.

4.5.2 English Sole

4.5.2.1 Landing Statistics

Standardized landing statistics for English sole in Area 5D are presented in Table 4.5. Landings from Jan. 1-July 11 in 1986 were 258 t compared to 460 t for the same period in 1985. Unstandardized effort (25% qualified) for English sole in Area 5D from April-July is only 18% of the effort for the same period in 1985 while LPUE is 65% greater in 1986 than 1985. Standardized effort levels and LPUE for the Area 5D stock cannot be computed at the present time.

4.5.2.2 Condition of Stock

The length frequency anomaly calculated for 5D English sole females for 1985 indicates a significant increase in the proportion of younger fish (recruits) landed in 1985. Anomalies for recent years also indicate numbers of larger fish caught in the commercial fishery are declining.

$F_{0.1}$ (see Sect. 4.5.1.5) was calculated at F=0.41 (assuming M=0.2) for the Area 5D English sole stock (Fig. 4.2). The catchability coefficient for the stock was previously determined at q=.000183 (Fargo 1985). Using the formula $F=qE_t$ with E_t=2681 hr (1985 effort), F=0.49 in 1985. If the trend in effort for 1986 continues, F levels in 1986 will be lower than 1985.

4.5.2.3 Recommendations

Sustainable yield option - The current yield for English sole in Area 5D (500-600 t) is sustainable. Current levels of fishing are equivalent to the $F_{0.1}$ level. A catch limitation is not recommended under present levels of fishing effort.

Conservative yield option - The decrease in the proportion of larger, older fish in commercial landings could be a sign of fishing up for the stock. A catch limit of 400 t annually (~60-70% of sustainable yield) would increase survival of fish to older ages and be consistent with a stable age composition for the stock.

Increasing yield - Increases in production due to elimination of discards of juvenile English sole in Area 5D would effectively increase long-term yield up to 30% (Fargo 1985) given the current age structure for the stock. A codend mesh-size of 5" (internal measure) would ensure optimum yield per recruit (optimum escapement for fish <35 cm) for English sole in Area 5D.

4.5.3 Dover Sole 5C,D,E

4.5.3.1 Landing Statistics

Landing statistics for Dover sole are presented in Table 4.6 LPUE was standardized using a log linear least squares model (Stanley, in prep). Independent variables in the analysis were year and horsepower class. The model accounted for 29% of the variation in Dover sole LPUE from 1970-85. Landings of 5C,D,E Dover sole in 1986 from Jan. 1-July 11 were 498 t compared to 311 t for the same period in 1985. Effort over this time period in 1986 was up 15% from 1985. If this trend continues, LPUE for 1986 should be up significantly from 1985.

4.5.3.2 Condition of Stock

$F_{0.1}$ (see Sect. 4.5.1.5) calculated for 5C,D,E Dover sole was F=0.20 (Fig. 4.3). The current fishing rate for 5C, D, E Dover sole estimated from tagging data is F=0.15 (Fargo et al. 1985). The implication here ($F<F_{0.1}$) is that the stock is not being overfished at the present time.

Since 1976 LPUE for 5C, D, E Dover sole has shown no trend. This is taken as an indication of a stable stock size over this time period. The average yield from 1976-85 was ~740 t. Current yields appear to be sustainable for the 5C,D,E stock.

The estimate of MSY using Gulland's (1961) production analysis on standardized LPUE/effort data in Table 4.4 with k=3 is 837 t.

All three of the above analyses indicate that the 5C,D,E Dover sole stock is in stable condition, and that yields of 800 t annually are sustainable.

4.5.3.3 Recommendations

Sustainable yield option - 800 t - equivalent to the average sustainable yield over the last 10 years and MSY from the Gulland analysis. Allow retention of incidental catches (20,000 lb) when 800 t quota is reached. After monitoring LPUE for 2-3 years at the 800 t harvest level a decision can be made regarding raising the quota to 1000 t.

Risk option - 1000 t - Increasing yield may be possible with F=0.15 at present and $F_{0.1}$=0.20. This option is not recommended until Dover sole LPUE has been monitored at the 800 t harvest level for a period of 2-3 years.

4.5.4 Arrowtooth Flounder

4.5.4.1 Introduction

Arrowtooth flounder has never been very prominent in B.C. trawl landings, mostly because of its poor keeping qualities and weak markets for the species.

The species has a relatively wide bathymetric distribution (30-400 fath), with juveniles (age 1-4) generally occupying shallower (30-50 fath) depths than adults. The adults are fairly active predators feeding mainly on herring, euphausiids, and rockfish, pollock, and small sole. Our maximum recorded age for the species is 50 years and it is likely that the natural mortality rate for arrowtooth flounder is relatively low.

In recent years fishermen have expressed concern about possible negative interactions between the "growing" arrowtooth flounder population and other species in Hecate Strait. Arrowtooth adults are piscivorous and juveniles might be competitive.

4.5.4.2 The Fishery

The major portion of the commercial fishery for arrowtooth flounder in Hecate Strait has taken place at Two Peaks and Butterworth grounds at depths of 40-60 fathoms during quarters two and three. Landings of arrowtooth flounder have been coincidental with several species to date, the major species being English sole. To examine how selectively arrowtooth are being fished at present, landing statistics for which arrowtooth made up 50% or more of the total catch landed were examined. These results are listed in Table 4.8. The 50% qualified landings accounted for an average of 40% of the annual landings of arrowtooth flounder from Hecate Strait. Excluding years where less than 100 t of arrowtooth flounder were landed, English sole, the number two species in the landings, made up an average of only 9% of the total catch where arrowtooth flounder was the major species. Thus, there is some evidence that the fleet may be able to target on arrowtooth founder.

Catches from Two Peaks-Butterworth ground on an arrowtooth flounder biomass survey in 1980 (Fargo et al. 1981) are listed in Table 4.9, by 10 fath depth interval from 20-80 fath. On this survey, arrowtooth catches peaked at 50-59 fath and English sole catches were also highest here. At depth >59 fath, catches of English sole fell off more rapidly than arrowtooth catches, while at depth <50 fath, catches of arrowtooth fell off more rapidly than those of English sole.

4.5.4.3 Landing Statistics

The majority (70%) of arrowtooth landings in Hecate Strait have come from the Two Peaks-Butterworth area. Landings by utilization from 1956-1985 are summarized in Table 4.7. The fishery from 1956-70 was mainly for the mink food market and landings averaged about 200 t annually. From 1970-85 landings of arrowtooth were for human consumption almost exclusively and averaged about 500 t annually. This amount has fallen off in recent years, due to poor market conditions. Stanley (1985) estimated annual discards of arrowtooth in Hecate Strait at ~3000 t based on observer trips aboard commercial vessels in 1981-82.

4.5.4.4. Condition of Stock

Using the 1980 arrowtooth flounder survey catch rates (stratified by area/depth) a biomass estimate of 52,700 t was obtained using the area swept by the net and a catch coefficient of 1. A second biomass estimate of 45,000 t was obtained using the 1984 G.B. REED Hecate Strait species assemblage survey data (Westrheim et al. 1984) over a depth range of 30-80 fath. Using Gulland's (1970) relationship of $MSY=r(M)(B_0)$ estimates of MSY were calculated at 4000 t and 3400 t respectively, for biomass estimates assuming r=0.5 and M=0.15. This is a conservative figure considering the fact that the biomass estimates are almost certainly less than the arrowtooth virgin biomass in Hecate Strait, and that not all of the suitable habitat for arrowtooth was surveyed.

The arrowtooth flounder stock(s) in Hecate Strait is currently not being fully utilized. It is not yet known to what degree arrowtooth can be fished avoiding incidental catch of other species under catch limitations. Accordingly, unrestricted development of the arrowtooth fishery would be undesirable.

4.5.4.5 Recommendations

Sustainable yield option - At the present time catches of 4000 t annually (average of the two biomass estimates is 3700 t) are estimated to be sustainable. Catch limits are not recommended at the present time.

Risk yield option: Because of the uncertainties in the application of the Gulland formula and biomass estimates, a catch limit of 5000 t per year may be considered as a higher risk alternative to the sustainable option. Catch limits are not recommended at the present time.

Table 4.1. Standardized Canada-U.S. landing statistics for rock sole from Area 5A, January-December 1956-85.

Year	Landings (t)	Effort (h)[a]	LPUE (kg/h)[b]
1956	551	1328	415
1957	511	1780	287
1958	501	1920	261
1959	212	1293	164
1960	397	1640	242
1961	237	1139	208
1962	196	1719	114
1963	161	1288	125
1964	156	1642	95
1965	157	1040	151
1966	330	1803	183
1967	252	1292	195
1968	435	2042	213
1969	293	2203	133
1970	167	1144	146
1971	135	1000	135
1972	58	763	76
1973	57	722	79
1974	74	1451	51
1975	37	597	62
1976	182	3309	55
1977	83	1766	47
1978	79	1129	70
1979	202	1474	137
1980	238	1384	172
1981	114	726	157
1982	189	1512	125
1983	124	1824	68
1984	142	1214	117
1985	53	639	83

[a]Effort = (Landings)(1000)/LPUE.

[b]LPUE -- Area 5A, April-September.

Table 4.2. Standardized Canada-U.S. landing statistics for rock sole from Area 5B January-December 1956-85.

Year	Landings (t)	Effort (h)[a]	LPUE (kg/h)[b]
1956	307	853	360
1957	206	619	333
1958	379	1606	236
1959	344	1339	257
1960	503	1863	270
1961	416	1770	235
1962	531	2091	254
1963	517	1958	264
1964	482	2472	195
1965	568	2021	281
1966	772	2339	330
1967	741	2487	298
1968	392	1774	221
1969	652	2751	237
1970	245	1161	211
1971	368	2079	177
1972	382	2748	139
1973	324	5586	58
1974	371	7275	51
1975	408	4250	96
1976	368	4182	88
1977	188	3133	60
1978	217	2932	74
1979	208	2667	78
1980	410	1925	213
1981	220	2588	85
1982	155	3039	51
1983	206	2424	85
1984	87	2071	42
1985	159	1622	98

[a]Effort = (Landings)(1000)/LPUE.
[b]LPUE -- Area 5B, April-Sept.

Table 4.3. Standardized Canada-U.S. landing statistics for rock sole from Area 5C January-December 1956-85.

Year	Landings (t)	Effort (h)[a]	LPUE (kg/h)[b]
1956	397	570	699
1957	726	1396	520
1958	368	944	390
1959	249	1078	231
1960	471	1186	397
1961	110	350	314
1962	322	651	495
1963	155	451	344
1964	244	1179	207
1965	539	4115	131
1966	961	2921	329
1967	948	1992	476
1968	811	1940	419
1969	1053	4066	259
1970	694	2410	288
1971	376	1301	289
1972	134	388	345
1973	186	565	329
1974	288	1269	227
1975	383	2176	176
1976	277	1689	164
1977	272	1470	185
1978	356	1240	287
1979	647	2451	264
1980	482	2634	183
1981	126	2377	53
1982	70	1842	38
1983	60	1132	53
1984	64	362	177
1985	27	342	79

[a]Effort = (Landings)(1000)/LPUE.
[b]LPUE -- Area 5C, April-Sept.

Table 4.4. Annual estimate of fishing mortality rates (F) rock sole females Two Peaks-Butterworth, Area 5D, 1956-78. Virtual population analysis, 1956-78.

	Age									Mean
Year	4	5	6	7	8	9	10	11	12	F[a]
1956	0.13	0.23	0.67	0.69	0.72	0.82	0.50	0.74	0.51	0.49
1957	0.04	0.14	0.44	1.01	0.81	0.74	1.09	0.59	0.78	0.49
1958	0.03	1.03	0.98	0.79	1.76	2.30	0.48	5.36	0.25	0.92
1959	0.01	0.11	0.36	0.24	0.07	0.43	0.34	0.01	0.37	0.16
1960	0.01	0.22	0.81	0.66	0.70	0.26	3.60	3.01	0.33	0.48
1961	0.05	0.34	0.40	0.22	0.07	0.31	0.01	0.16	0.13	0.22
1962	0.01	0.12	0.35	0.24	0.12	0.18	0.10	0.01	0.25	0.17
1963	0.03	0.09	0.18	0.52	0.78	0.71	0.91	0.69	0.43	0.32
1964	0.05	0.12	0.11	0.26	0.49	0.37	0.20	0.60	0.37	0.21
1965	0.03	0.07	0.12	0.17	0.29	0.24	0.16	0.19	0.42	0.14
1966	0.04	0.50	0.72	0.83	1.12	1.66	1.84	1.76	1.08	0.64
1967	0.03	0.26	0.50	1.17	0.93	1.17	1.56	6.43	0.31	0.58
1968	0.14	0.31	0.88	0.65	0.56	0.51	0.98	5.06	1.10	0.51
1969	0.36	0.39	0.33	0.46	0.17	0.21	0.19	0.01	0.71	0.34
1970	0.02	0.15	0.52	0.71	0.50	1.00	0.94	6.80	0.56	0.38
1971	0.04	0.40	0.97	0.95	1.33	1.41	0.64	0.28	0.82	0.74
1972	0.07	0.15	0.27	0.39	0.75	0.83	0.85	0.66	0.75	0.33
1973	0.05	0.05	0.07	0.12	0.26	0.46	0.59	5.64	0.85	0.11
1974	0.15	0.28	0.03	0.02	0.04	0.10	0.18	0.01	0.74	0.10
1975	0.04	0.10	0.64	0.90	1.44	1.32	2.24	6.75	1.95	0.62
1976	0.17	0.33	0.68	0.48	0.25	0.37	0.01	0.01	1.86	0.39
1977	0.14	0.49	0.43	0.45	0.19	0.11	0.19	0.14	2.69	0.34
1978	0.07	0.27	0.48	0.54	0.61	0.70	0.80	2.04	1.15	0.39
Mean	0.07	0.27	0.48	0.54	0.61	0.70	0.80-	2.04	0.80	
C.V.	1.10	0.79	0.60	0.58	0.78	0.79	1.06	1.25	0.78	

[a]Ages 4-8.

Table 4.5. Standardized Canada-U.S. landing statistics for English sole, Area 5D, January-December 1956-85.

Year	Landings (t)	Effort (h)[a]	LPUE (kg/h)[b]
1956	935	1300	719
1957	539	1653	326
1958	674	2332	289
1959	901	2468	365
1960	1079	1505	717
1961	865	1676	516
1962	436	1232	354
1963	369	3101	119
1964	420	2308	182
1965	391	3491	112
1966	329	5141	64
1967	511	2077	246
1968	632	3144	201
1969	725	2571	282
1970	920	2402	383
1971	482	2708	178
1972	356	2211	161
1973	598	2265	264
1974	459	2318	198
1975	922	3415	270
1976	946	6757	140
1977	972	7594	128
1978	495	4714	105
1979	744	8651	86
1980	796	7044	113
1981	1148	7705	149
1982	401	3457	116
1983	396	2829	140
1984	606	3367	180
1985	547	2681	204

[a]Effort = (landings)(1000)/LPUE.

[b]LPUE -- Two Peaks-Butterworth, April-September.

Table 4.6. Standardized Canada-U.S. landing statistics for Dover sole, Areas 5C, D, E, 1970-85.

Year	Landings (t)[a]	Effort (h)[b]	LPUE (t/h)[c]
1970	965	1413	0.683
1971	903	1364	0.662
1972	922	1478	0.624
1973	768	961	0.799
1974	767	916	0.837
1975	882	1370	0.644
1976	1022	2349	0.435
1977	577	1826	0.316
1978	483	1121	0.431
1979	697	2723	0.256
1980	807	2431	0.332
1981	840	1791	0.469
1982	512	1347	0.380
1983	693	1227	0.565
1984	953	2015	0.473
1985	828	1687	0.491

[a]0% qualified Canadian landings, 5C, D, E.

[b]Effort (h) = landings (t)/LPUE (t/h).

[c]LPUE = 50% qualified landings -- Dundas standardized by log linear model.

Table 4.7. Arrowtooth flounder landings by utilization (Two Peaks-Butterworth) 1956-85.

Year	Food	Animal food	Reduction	Total
1956	-	355	-	355
57	-	33	-	33
58	-	62	-	62
59	-	134	-	134
1960	-	141	-	141
61	-	215	-	215
62	-	368	-	368
63	-	40	-	40
64	-	93	-	93
65	4	81	-	85
66	1	107	-	108
67	-	115	-	115
68	4	222	-	226
69	-	385	-	385
1970	4	152	10	166
71	-	19	-	19
72	34	44	-	78
73	166	17	-	183
74	103	-	-	103
75	212	-	-	212
76	189	-	-	189
77	611	-	-	611
78	1047	-	4	1051
79	878	-	-	878
1980	688	-	-	688
81	240	-	-	240
82	80	-	-	80
83	68	-	-	68
84	126	-	-	126
85	320	-	-	320
Total	4775	2583	14	7372

Table 4.8. Landings of arrowtooth flounder (50% qual.) and coincidental English sole in Area 5D, 1956-95.

Year	Turbot	English sole coincidental	English sole total	Percent coincidental
1956	393	86	716	12
57	87	9	254	4
58	55	3	404	1
59	132	19	552	3
1960	231	35	712	5
61	371	51	732	7
62	303	23	400	6
63	4	1	315	0
64	116	4	364	1
65	23	17	341	5
66	96	6	321	2
67	198	9	473	2
68	230	20	630	3
69	236	38	724	5
1970	98	16	916	2
71	4	2	480	0
72	33	3	355	1
73	65	11	654	2
74	30	7	458	2
75	129	10	921	1
76	433	37	943	4
77	250	13	972	1
78	782	29	495	6
79	381	17	745	2
1980	263	11	796	1
81	135	7	1154	1
82	21	1	401	3
83	10	0	393	0
84	42	6	606	1
85	152	12	572	2

Table 4.9. Catches (kg/haul) by species and depth (fath) during the arrowtooth flounder biomass survey of Hecate Strait, June 9-21, 1980.

	Depth (fath)					
Species	20-29	30-39	40-49	50-59	60-69	70-79
Arrowtooth flounder	-	22	514	1055	1178	655
Butter sole	-	163	14	50	241	-
Dover sole	-	-	83	105	130	373
English sole	-	279	1014	956	1088	84
Flathead sole	-	-	-	6	10	76
Rex sole	-	-	509	500	205	95
Rock sole	58	-	27	21	37	-
Sand sole	5	-	-	-	-	-
S. babcocki	-	-	-	-	-	2
S. brevispinis	-	-	-	3	-	-
S. flavidus	-	-	-	37	-	-
Lingcod	-	27	-	-	-	-
Pacific cod	13	815	-	251	23	25
Sablefish	-	282	737	449	1045	318
Walleye pollock	-	-	-	125	67	17
Ratfish	-	-	-	-	-	6
Skates	30	-	-	-	-	34
Spiny dogfish	9	-	53	50	116	-
Total						
No. of hauls	2	7	2	11	4	7

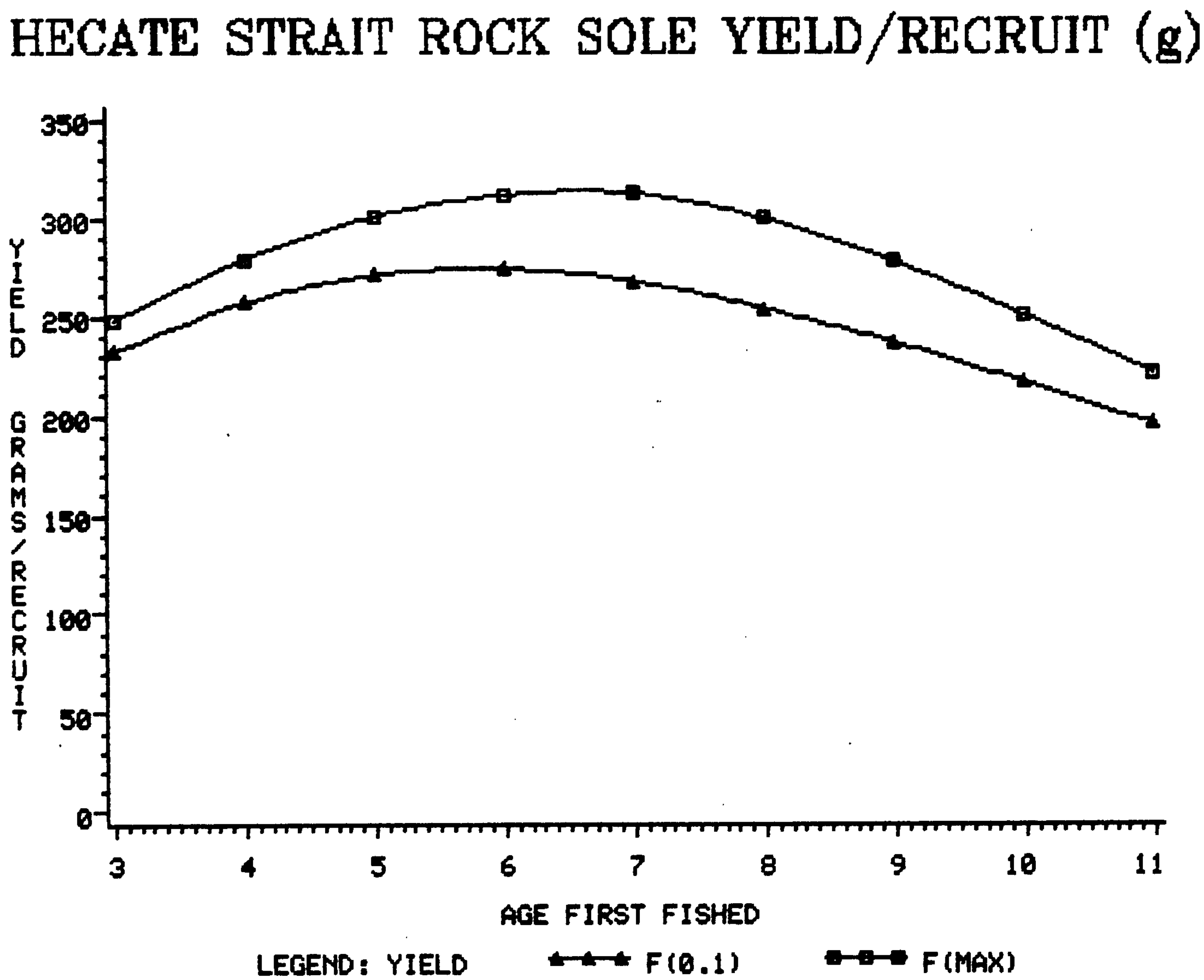

Fig. 4.1. Yield/recruit curve for Hecate Strait rock sole ($F_{0.1}$ = 0.44, F_{max} = 10.0).

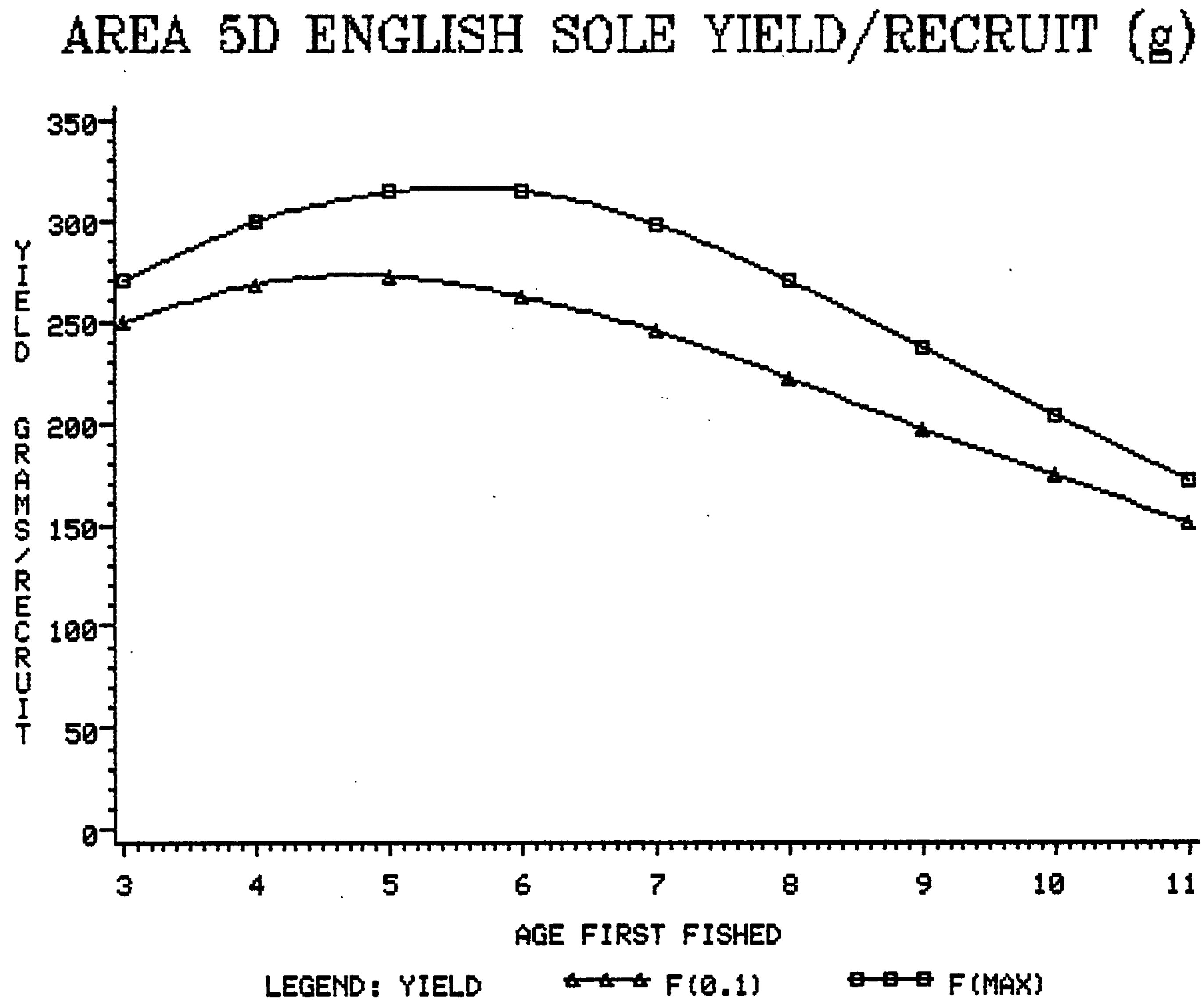

Fig. 4.2. Yield/recruit curve for Area 5D English sole. ($F_{0.1}$ = 0.41, F_{max} = 10.0)

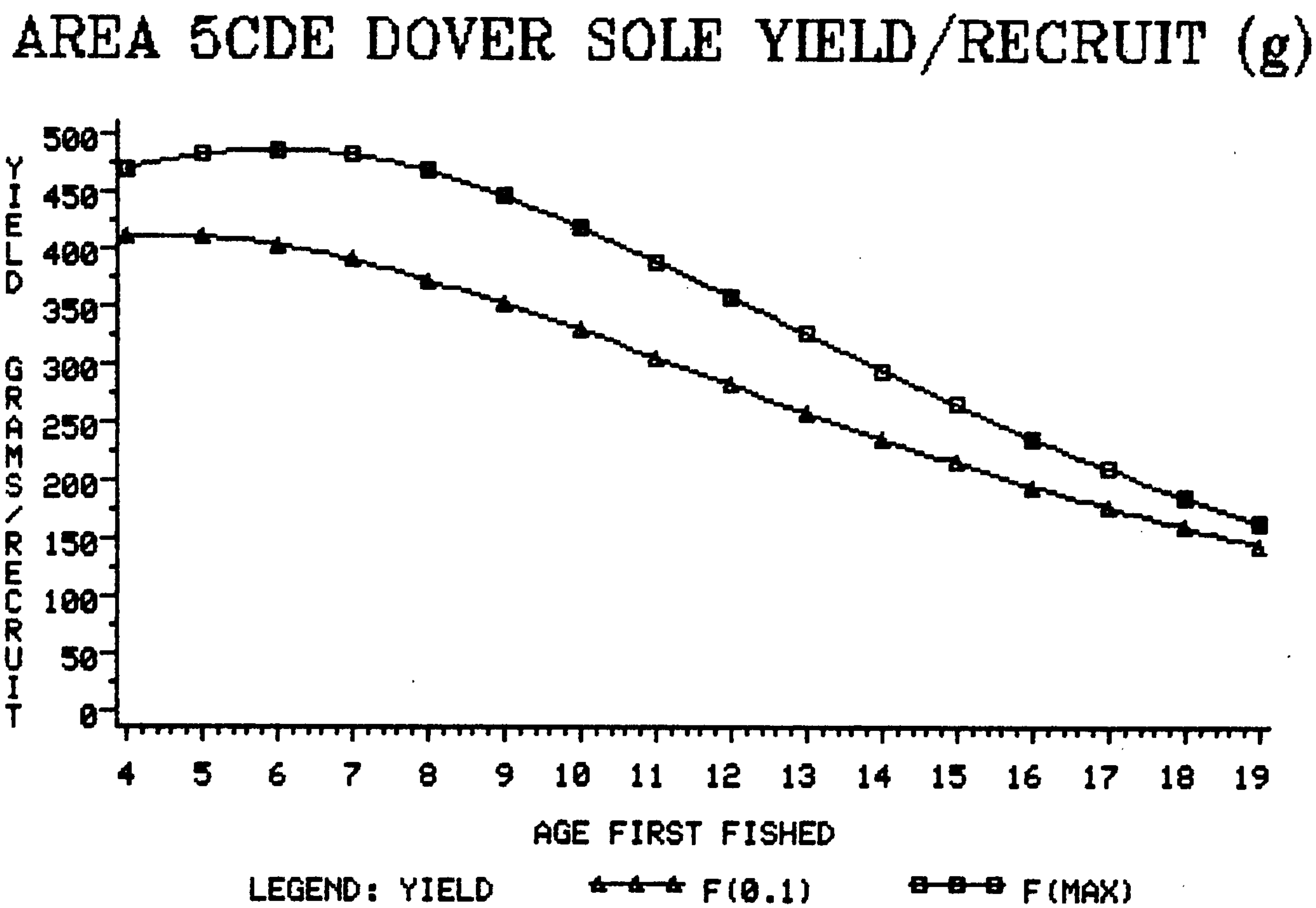

Fig. 4.3. Yield/recruit curve for Area 5CDE Dover sole ($F_{0.1}$ = 0.20, F_{max} = 8.16).

5.0 SABLEFISH

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5.1 Coastwide

5.1.2 Landing Statistics

In 1985 a total of 4189 t of sablefish were landed coastwide by trap, trawl, and longline. Preliminary landings during 1986 for all gears is 3896 t (to Aug. 20, 1986). Landings from the west coast of Queen Charlotte Islands and Hecate Strait decreased from 2301 t in 1984 to 2298 t in 1985 with the majority (81.1%) caught by trap (Table 5.1). Landings from the west coast of Vancouver Island increased to 1891 t in 1985 from 1520 t in 1984. The majority of fish were trap-caught (86.6%), up considerably from 78.2% in 1984 (Table 5.2). Trawl landings decreased from 120.0 t in 1984 to 94 t in 1985 from the west coast of Vancouver Island and increased from 65 t in 1984 to 135 t in 1985 from all other areas (Tables 5.1, 5.2).

In 1986, the coastwide LPUE decreased to 16.1 kg/trap from 17.3 kg/trap (Table 5.4). LPUE increased slightly (<1%) in Queen Charlotte Sound, while decreases of 9.7% and 28.3% occurred off the Queen Charlotte Islands and the west coast of Vancouver Island, respectively (Table 5.3).

5.1.4 Condition of the stock

LPUE continues to fluctuate over a wide range. The decrease in LPUE noted in 1986 (Table 5.4.) is believed to be the result of a number of new vessels with inexperienced skippers entering the fishery in 1986. Vessels with more experienced skippers maintained higher LPUE's. Effort standardizaton is currently underway and will be available for future assessments.

The approach taken in this assessment is identical to that reported in the 1985 assessment (McFarlane et al. 1985). A forward simulation model (Tyler 1982) was used to project sablefish biomass and yield from 1980 to 1995. The numbers at age used as the starting vector for the forward simulation were calculated using Virtual Population Analysis (VPA) (Gulland 1983).

The VPA was run using six years of age composition data, 1979-1984. Ages from the years 1977 and 1978 were not used due to small sample size and inadequate sampling coverage by area, respectively. Age data from 1984 are considered preliminary. The VPA was run with a number of estimates of instantaneous natural mortality rate (M) and terminal F's to investigate the sensitivity of the analysis to these starting parameters. As discussed by Gulland (1983), the numbers at age for the younger age-groups are not drastically affected by the terminal F value, however the estimate of natural mortality is critical, especially with a long-lived species such as sablefish. At each natural mortality rate, the numbers at age differ by less than two percent over the range of terminal F's while, at each terminal F level, the numbers at age for each natural mortality rate differ by a factor of more than two (Table 5.6).

The level of natural mortality assumed to be the most accurate was M = .1 (McFarlane et al. 1985). Work is currently underway on refining this estimate and it will be available for future assessments. The catch at age data used in the VPA are presented in Table 5.5. The annual estimates of numbers at age, fishing mortality rates (F), total mortality rates (Z), and exploitation rates from the VPA (M = .1), are presented in Tables 5.7, 5.8, 5.9, and 5.10, respectively, with totals reported in Table 5.11. The asterisked values in each of the tables may have errors associated with them. The cumulative F for the cohorts is less than 2.0 and according to Pope (1972) cannot be considered accurate. The numbers at age 4 in 1983 and 1984 (Table 5.7) indicate that the 1979 and 1980 year-classes are the same size as the 1977 year-class. Other evidence suggests that this is not the case and the possibility of sampling errors is currently under review.

Forward simulations (1980 to 1995) (Tyler 1982) were run with numbers at age for 1979 from VPA results at different levels of terminal F and M. The rates of natural mortality applied in the forward simulation were the same as that used in the VPA. Catches from 1980 to 1986 were included, and numbers recruiting at age 4 were taken from the VPA up to 1980. Beyond 1980 recruitment was assumed to be constant and the average of the numbers at age 4 in 1979 and 1980 (1975 and 1976 year-classes) was used. These year-classes are recognized as weak to moderate in strength. Beyond 1986 an F of 0.1 was used. This was assumed to be close to the current level of F based on F=qE, calculated using the average effort from 1979-1984 and the estimate of q from the VPA over the same years.

All projections showed the same general trends in biomass and yield levels over time. Biomass increased sharply until 1985, and then decreased as the effects of the 1977 year-class and above average year-classes in 1979 and 1980, declined (Figure 5.1.). The projected yields in 1987, using the numbers at age from the VPA runs are presented in Table 5.12. These results indicate that yields should remain at a level close to that recommended for 1986. Any increase should be cautious in light of the error associated with the assessment techniques applied here. Ulltang (1977) noted that violations of the basic assumptions that mortality is constant over all age-classes and that no stock migration is occurring, may result in considerable error in estimations of year-class abundance. Until firm estimates of natural mortality are available, the estimates of number at age, alone, may be in error by a factor of two.

Recent analysis (McFarlane and Beamish in press) indicates that the 1981 and 1983 year-classes may be of above average strength. If these year-classes recruit to the fishery at the same strength as indicated by juvenile abundance indices, it is anticipated that yields will remain above the long-term average (3500 t) into the 1990s.

5.1.5 Recommendations

Yield option		Yield (t)
Sustainable - low risk	-	4100 t
Sustainable - high risk	-	4500 t
Non-sustainable	-	> 4500 t

A low risk or conservative approach is recommended in view of the uncertainty associated with the VPA and the forward simulations. There exists a strong possibility that the high-risk or non-sustainable options could interfere with the future yield for the fishery.

Table 5.1. Canadian sablefish landings, by gear, from Queen Charlotte Sound, Hecate Strait, and the west coast of Queen Charlotte Islands, 1973-1986 (round wt, metric tonnes)[a], excluding dumped and discarded fish.

	Gear type								
	Longline		Trawl		Trap		Other[b]		
Year	Wt	%[c]	Wt	%	Wt	%	Wt	%	Total
1973	116.6	21.6	31.7	5.9	392.4	72.6	-	-	540.7
1974	39.0	16.1	38.1	15.7	165.6	68.2	-	-	242.7
1975	149.9	22.7	82.0	12.4	427.9	64.9	-	-	659.8
1976	47.7	10.4	154.2	33.7	255.8	55.9	-	-	457.7
1977	49.8	16.9	98.3	33.4	145.7	49.4	0.9	0.3	294.7
1978	39.0	8.2	40.4	8.5	395.1	83.0	1.4	0.3	475.9
1979	158.7	11.7	132.7	9.8	1067.6	78.5	-	-	1359.0
1980	179.7	9.5	228.6	12.0	1488.3	78.5	-	-	1869.6
1981	238.1	8.7	90.4	3.3	2412.6	88.0	-	-	2741.1
1982	181.8	6.3	88.3	3.1	2595.2	90.1	16.5[d]	0.5	2881.8
1983	108.4	3.5	116.5	3.7	2901.2	92.3	15.6[e]	0.5	3141.7
1984	153.9	6.7	64.8	2.8	2082.2	90.5	-	-	2300.9
1985	298.9	13.0	135.1	5.9	1864.1	81.1	-	-	2298.1
1986[f]	244.4	9.9	122.1	5.0	2098.0	85.1	-	-	2464.5

[a]Canada Department Fisheries B.C. Catch Statistics, 1951-1971 (converted from dressed weight to round weight by a factor of 1.5). Fisheries Research Board of Canada Catch and Effort statistics of the Canadian Groundfish Fishery of the Pacific coast, 1972-1981.

[b]Includes troll, handline, and sunken gillnet (1968 only).

[c]Percent of total landed by all gears within a year.

[d]Incidental to halibut longline.

[e]Includes troll, handline, sunken gillnet and catch incidental to halibut longline fishery.

[f]Preliminary landings to August 20, 1986.

Table 5.2. Canadian sablefish landings, by gear, from west coast of Vancouver Island, 1973-1986 (round wt, metric tonnes)[a], excluding dumped and discarded fish.

	Gear type								
	Longline		Trawl		Trap		Other[b]		
Year	Wt	%[c]	Wt	%	Wt	%	Wt	%	Total
1973	3.2	0.8	50.9	12.5	353.4	86.7	Tr		407.5
1974	2.3	0.9	83.7	33.6	161.5	64.8	1.8	0.7	249.3
1975	2.3	0.9	200.3	81.8	41.5	16.9	0.9	0.4	245.0
1976	41.7	13.3	224.8	71.5	47.6	15.1	0.1	0.1	314.2
1977	27.3	3.5	688.4	87.1	68.9	8.7	5.9	0.7	790.5
1978	18.2	5.1	89.9	25.4	239.5	67.7	6.4	1.8	354.0
1979	118.3	17.5	143.4	21.2	409.8	60.5	6.0	0.9	677.5
1980	69.1	3.6	106.8	5.6	1722.5	90.6	3.0	0.2	1901.4
1981	94.8	8.6	140.2	12.8	862.4	78.6	-	-	1097.4
1982	161.9	13.2	153.2	12.5	913.3	74.2	1.9[d]	0.2	1230.3
1983	343.1	27.1	146.7	11.6	777.0	61.3	-	-	1266.8
1984	211.2	13.9	120.0	7.9	1188.9	78.2	-	-	1520.1
1985	159.4	8.4	93.9	5.0	1637.2	86.6	-	-	1890.5
1986[e]	465.3	32.5	103.7	7.3	862.1	60.2	-	-	1431.1

[a]Canada Department Fisheries B.C. Catch Statistics, 1951-1971 (converted from dressed weight to round weight by a factor of 1.5). Fisheries Research Board of Canada Catch and Effort statistics of the Canadian Groundfish Fishery of the Pacific coast, 1972-1981.

[b]Includes troll, handline, and sunken gillnet (1968 only).

[c]Percent of total landed by all gears within a year.

[d]Incidental to halibut longline.

[f]Preliminary landings to August 20, 1986.

Table 5.3. Sablefish total trap landings and LPUE estimates for January 1-April 30 and for all months combined for the three major fishing areas during 1977-1986.

	Vancouver Island				Queen Charlotte Sound				Queen Charlotte Islands			
	1st Qtr.		All Qtrs.		1st Qtr.		All Qtrs.		1st Qtr.		All Qtrs.	
Year	Land. (t)	LPUE (kg/trap)	Land. (t)	LPUE (kg/trap)	Land. (t)	LPUE (kg/trap)	Land. (t)	LPUE (kg/trap)	Land. (t)	LPUE (kg/trap)	Land. (t)	LPUE (kg/trap)
1977	-	-	53.6	-	-	-	17.3	-	-	-	128.6	-
1978	-	-	141.3	25.2	-	-	77.6	11.6	-	-	326.4	20.1
1979	15.1	-	392.0	14.1	-	-	281.3	14.0	163.4	18.3	759.7	20.9
1980	275.7	16.9	1714.1	15.0	31.3	8.6	797.2	18.5	193.1	9.9	682.8	13.5
1981	240.1	12.5	860.6	10.3	198.7	22.4	1359.1	17.9	342.3	24.2	991.8	18.5
1982	222.0	12.6	913.3	11.8	369.1	16.8	1519.2	16.6	586.8	30.9	985.7	24.8
1983	87.7	16.3	770.0	13.7	18.7	11.6	1587.0	17.0	35.0	14.9	1285.2	17.9
1984	158.7	12.3	1188.9	11.7	340.3	22.6	1034.5	14.9	259.3	15.4	973.6	12.7
1985	513.9	20.5	1637.2	15.2	311.1	21.2	1054.2	20.3	404.3	31.0	710.3	19.6
1986[a]	551.4	9.7	862.1	10.9	592.7	20.6	1377.3	20.5	420.5	24.9	658.4	17.7

[a]Preliminary landings to August 20, 1986.

Table 5.4. Summary of sablefish total trap landings and LPUE estimates for January 1-April 30 and for all months combined in B.C. waters from 1977-1986.

	January 1-April 30		January 1-December 31	
Year	Total landings (t)	LPUE (kg/trap)	Total landings (t)	LPUE (kg/trap)
1977	-	-	214.6	-
1978	-	-	634.6	18.9
1979	181.7	18.3	1493.1	17.1
1980	502.1	12.4	3213.8	15.4
1981	781.3	18.8	3275.1	14.8
1982	1176.8	18.1	3342.6	16.5
1983	152.7	15.5	3678.0	16.5
1984	762.6	16.7	3275.4	13.0
1985	1271.7	22.1	3501.3	17.3
1986[a]	1565.1	16.0	2994.8	16.1

[a]Preliminary landings to August 20, 1986.

Table 5.5. Catch at age in numbers for sablefish from 1979 - 1984.

	Year					
Age	1979	1980	1981	1982	1983	1984
4	1542	53808	139134	86786	210165	141658
5	3085	21972	64619	220384	127076	202206
6	1542	31388	34929	90994	329421	178215
7	1542	35872	37840	42604	85043	285602
8	7711	37666	18629	45234	34213	47981
9	4627	41701	23868	51020	33235	33130
10	30846	44840	30272	38396	47898	23991
11	40100	62776	30854	57331	23460	26275
12	53980	74883	48319	45234	43988	11424
13	57065	82954	37258	48390	31280	22848
14	89453	65915	40169	38922	41055	15994
15	83284	58741	43661	52072	43010	15994
16	86369	70848	36676	29455	25415	9139
17	118757	59189	32018	21565	34213	6854
18	92538	48427	26197	25773	23460	2285
19	104876	46634	26779	17883	26393	13709
20	97165	45289	20957	17883	26393	3427
21	97165	43047	23868	18409	21505	2285
22	70946	33630	20957	9468	18573	1142
23	83284	22420	22704	9468	15640	3427
24	67861	16591	16300	7890	13685	1142
25	47811	17936	8732	10520	3910	1142
26	52438	19730	10479	5260	5865	2285
27	30846	11658	5822	7890	2933	2285
28	30846	15694	8150	2104	2933	1142
29	9254	7174	4657	2630	3910	1142
30	24677	14797	5239	2104	978	1142
31	13881	6278	1746	526	1955	1142
32	7711	3139	4657	1052	3910	1142
33	9254	2690	1746	1578	978	1142
34	1542	2690	1746	1052	978	1142
35	6169	1794	5239	526	978	1142

Table 5.6. Estimates of numbers of sablefish at age 4 (X 10^3) for the 1977 year-class based on Virtual Population Analysis runs at varying levels of Terminal F and natural mortality (M).

		Natural mortality (M)		
		0.05	0.1	0.2
Terminal F	0.05	3,387	4,556	8,787
	0.1	3,383	4,568	8,991
	0.2	3,447	4,637	8,915

Table 5.7. Annual estimates of numbers at age from Virtual Population Analysis (M= .1,Terminal F = .1).

Age	Year 1979	1980	1981	1982	1983	1984
4	573474	976909	4568026	2886863*	5093701*	4526924*
5	408115	517097	832467	4007965	2533091*	4418859*
6	408841	364833	448698	695335	3415362	2175229*
7	237958	368599	298700	371055	542766	2772723
8	375710	212748	299191	233475	296222	410214
9	290452	332662	156467	252498	168467	235358
10	358547	257336	261681	119444	179643	121390
11	334767	296504	189476	207914	71654	117526
12	339996	265359	209006	141715	133495	42600
13	297577	256964	168594	143311	85120	78654
14	322764	215702	154151	117624	84181	47203
15	298749	207105	131935	101112	69303	37647
16	265498	191063	131529	77735	41957	22436
17	277872	157844	105468	84106	42280	13884
18	243470	138086	86544	64964	55701	6149
19	232744	131931	78912	53581	34571	28219
20	217059	111584	74707	46260	31593	6473
21	194098	104888	58276	47817	24833	3957
22	154934	84615	54086	30342	25832	2373
23	133860	72662	44660	29051	18464	5880
24	127693	43015	44306	18839	17271	2117
25	96129	51230	23078	24556	9544	2758
26	93542	41975	29324	12577	12342	4952
27	71276	34778	19193	16622	6434	5650
28	69325	35165	20489	11833	7606	3043
29	52202	33731	17031	10884	8704	4136
30	63088	38394	23793	10989	7395	4207
31	35648	33649	20750	16600	7966	5770
32	21798	19170	24406	17160	14561	5336
33	84155	12475	14326	17698	14524	9441
34	26248	67317	8782	11329	14490	12254
35	68185	22220	58495	6265	9275	12225

*Subject to error.

Table 5.8. Annual estimates of fishing mortality rates (F) from Virtual Population Analysis (M = .1, Terminal F = .1).

	Year					
Age	1979	1980	1981	1982	1983	1984
4	0.00	0.06	0.03	0.03*	0.04*	0.03*
5	0.01	0.04	0.08	0.06	0.05*	0.05*
6	0.00	0.10	0.09	0.15	0.11	0.09*
7	0.01	0.11	0.15	0.13	0.18	0.11
8	0.02	0.21	0.07	0.23	0.13	0.13
9	0.02	0.14	0.17	0.24	0.23	0.16
10	0.09	0.21	0.13	0.41	0.32	0.23
11	0.13	0.25	0.19	0.34	0.42	0.27
12	0.18	0.35	0.28	0.41	0.43	0.33
13	0.22	0.41	0.26	0.43	0.49	0.36
14	0.34	0.39	0.32	0.43	0.70	0.44
15	0.35	0.35	0.43	0.78	1.03	0.59
16	0.42	0.49	0.35	0.51	1.01	0.56
17	0.60	0.50	0.38	0.31	1.83	0.72
18	0.51	0.46	0.38	0.53	0.58	0.49
19	0.64	0.47	0.43	0.43	1.58	0.71
20	0.63	0.55	0.35	0.52	1.98	0.80
21	0.73	0.56	0.55	0.52	2.25	0.92
22	0.66	0.54	0.52	0.40	1.38	0.70
23	1.04	0.39	0.76	0.42	2.07	0.94
24	0.81	0.52	0.49	0.58	1.73	0.83
25	0.73	0.46	0.51	0.59	0.56	0.57
26	0.89	0.68	0.47	0.57	0.68	0.66
27	0.61	0.43	0.38	0.68	0.65	0.55
28	0.62	0.62	0.53	0.21	0.51	0.50
29	0.21	0.25	0.34	0.29	0.63	0.34
30	0.53	0.52	0.26	0.22	0.15	0.33
31	0.52	0.22	0.09	0.03	0.30	0.23
32	0.46	0.19	0.22	0.07	0.33	0.25
33	0.12	0.25	0.13	0.10	0.07	0.14
34	0.07	0.04	0.24	0.10	0.07	0.10
35	0.10	0.09	0.10	0.09	0.12	0.10

*Subject to error.

Table 5.9. Annual estimates of total mortality rates (Z) from Virtual Population Analysis (M = .1,Terminal F= .1).

	Year					
Age	1979	1980	1981	1982	1983	1984
4	0.10	0.16	0.13	0.13*	0.14*	0.13*
5	0.11	0.14	0.18	0.16	0.15*	0.15*
6	0.10	0.20	0.19	0.25	0.21	0.19*
7	0.11	0.21	0.25	0.23	0.28	0.21
8	0.12	0.31	0.17	0.33	0.23	0.23
9	0.12	0.24	0.27	0.34	0.33	0.26
10	0.19	0.31	0.23	0.51	0.42	0.33
11	0.23	0.35	0.29	0.44	0.52	0.37
12	0.28	0.45	0.38	0.51	0.53	0.43
13	0.32	0.51	0.36	0.53	0.59	0.46
14	0.44	0.49	0.42	0.53	0.80	0.54
15	0.45	0.45	0.53	0.88	1.13	0.69
16	0.52	0.59	0.45	0.61	1.11	0.66
17	0.70	0.60	0.48	0.41	1.93	0.82
18	0.61	0.56	0.48	0.63	0.68	0.59
19	0.74	0.57	0.53	0.53	1.68	0.81
20	0.73	0.65	0.45	0.62	2.08	0.90
21	0.83	0.66	0.65	0.62	2.35	1.02
22	0.76	0.64	0.62	0.50	1.48	0.80
23	1.14	0.49	0.86	0.52	2.17	1.04
24	0.91	0.62	0.59	0.68	1.83	0.93
25	0.83	0.56	0.61	0.69	0.66	0.67
26	0.99	0.78	0.57	0.67	0.78	0.76
27	0.71	0.53	0.48	0.78	0.75	0.65
28	0.72	0.72	0.63	0.31	0.61	0.60
29	0.31	0.35	0.44	0.39	0.73	0.44
30	0.63	0.62	0.36	0.32	0.25	0.43
31	0.62	0.32	0.19	0.13	0.40	0.33
32	0.56	0.29	0.32	0.17	0.43	0.35
33	0.22	0.35	0.23	0.20	0.17	0.24
34	0.17	0.14	0.34	0.20	0.17	0.20
35	0.20	0.19	0.20	0.19	0.22	0.20

*Subject to error.

Table 5.10. Annual exploitation rates by age from Virtual Population Analysis (M = .1, Terminal F = .1)

	Year					
Age	1979	1980	1981	1982	1983	1984
4	0.00	0.06	0.03	0.03*	0.04*	0.03*
5	0.01	0.04	0.08	0.05	0.05*	0.05*
6	0.00	0.09	0.08	0.13	0.10	0.08*
7	0.01	0.10	0.13	0.11	0.16	0.10
8	0.02	0.18	0.06	0.19	0.12	0.12
9	0.02	0.13	0.15	0.20	0.20	0.14
10	0.09	0.17	0.12	0.32	0.27	0.20
11	0.12	0.21	0.16	0.28	0.33	0.22
12	0.16	0.28	0.23	0.32	0.33	0.27
13	0.19	0.32	0.22	0.34	0.37	0.29
14	0.28	0.31	0.26	0.33	0.49	0.34
15	0.28	0.28	0.33	0.51	0.62	0.42
16	0.33	0.37	0.28	0.38	0.61	0.41
17	0.43	0.37	0.30	0.26	0.81	0.49
18	0.38	0.35	0.30	0.40	0.42	0.37
19	0.45	0.35	0.34	0.33	0.76	0.49
20	0.45	0.41	0.28	0.39	0.84	0.53
21	0.50	0.41	0.41	0.38	0.87	0.58
22	0.46	0.40	0.39	0.31	0.72	0.48
23	0.62	0.31	0.51	0.33	0.85	0.58
24	0.53	0.39	0.37	0.42	0.79	0.54
25	0.50	0.35	0.38	0.43	0.41	0.41
26	0.56	0.47	0.36	0.42	0.48	0.46
27	0.43	0.34	0.30	0.47	0.46	0.40
28	0.44	0.45	0.40	0.18	0.39	0.38
29	0.18	0.21	0.27	0.24	0.45	0.28
30	0.39	0.39	0.22	0.19	0.13	0.27
31	0.39	0.19	0.08	0.03	0.25	0.20
32	0.35	0.16	0.19	0.06	0.27	0.21
33	0.11	0.22	0.12	0.09	0.07	0.12
34	0.06	0.04	0.20	0.09	0.07	0.09
35	0.09	0.08	0.09	0.08	0.11	0.09

*Subject to error.

Table 5.11. Annual estimates of numbers in stock, numbers landed, exploitation rates, mean F and Z values for ages 4-35, from Virtual Population Analysis (M = .1, Terminal F = .1).

Year	Nos. in stock	No. landed	Exploitation rate	Mean F	Mean Z
1979	6775774	1428167	0.21	0.38	0.48
1980	5697610	1102171	0.19	0.34	0.44
1981	8656547	834221	0.10	0.30	0.40
1982	9887519	1010403	0.10	0.34	0.44
1983	13078348	1284449	0.10	0.71	0.81
1984	15145587	1063576	0.07	0.41	0.51

Table 5.12. Projected yields (t) for 1987 from forward simulations (F=0.2), using numbers at age from VPA conducted at different levels of Terminal F and natural mortality (M).

		Natural mortality (M)		
		0.05	0.1	0.2
Terminal F	0.05	3,944	4,080	4,180
	0.1	3,900	4,132	4,134
	0.2	4,106	4,060	3,949

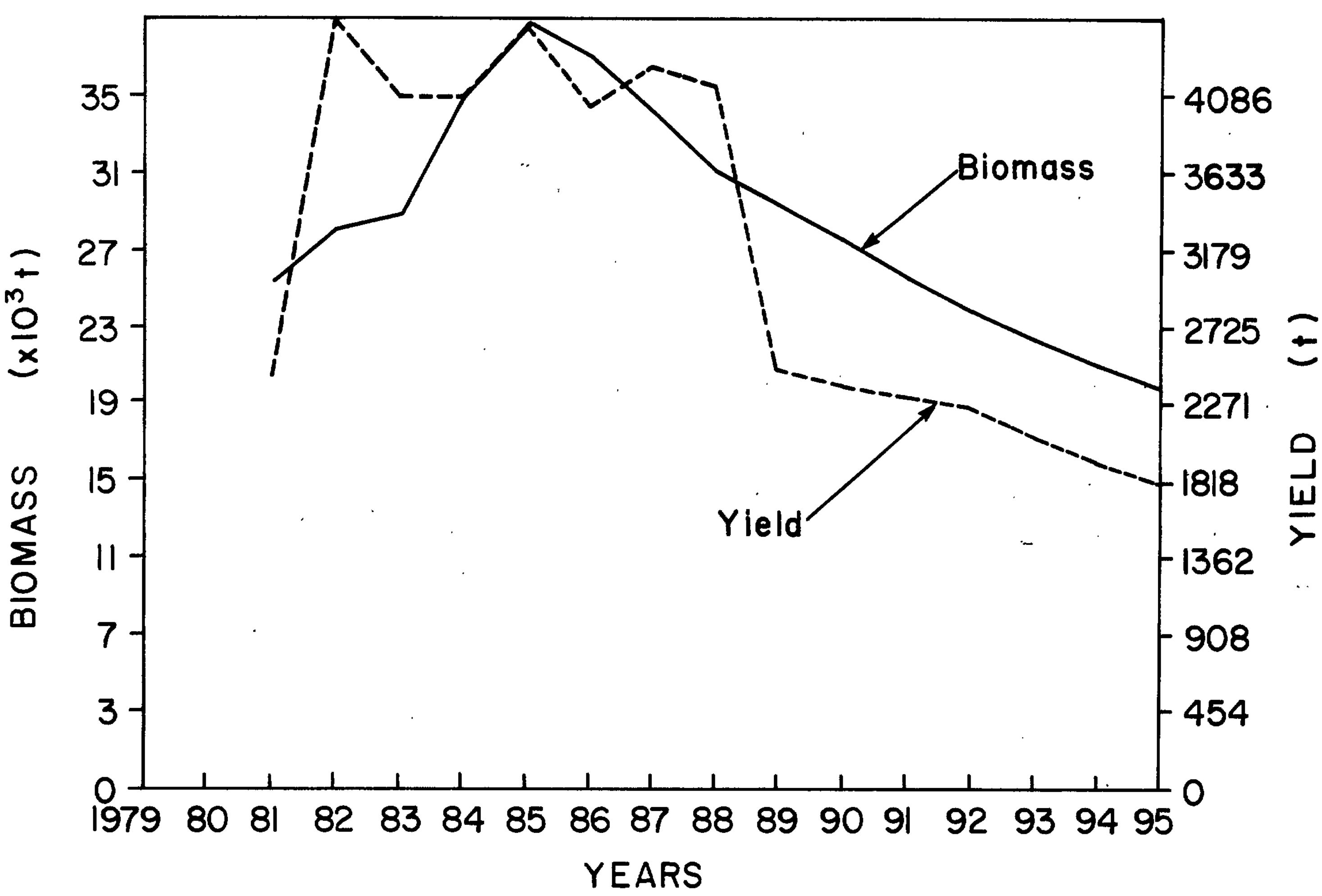

Fig. 5.1. Forward simulation of total biomass and yield using a recruitment level of 775,000 age-4 fish from 1980 to 1995. Fishing mortality was set at 0.1.

6.0 PACIFIC HAKE

by W. Shaw and M. W. Saunders

6.1. Coastwide

Yield options are not proposed on a coastwide basis.

6.2. Strait of Georgia

6.2.1. Landing statistics

During 1985, the fishery landed a total of 4976 t from the Strait of Georgia (Table 6.1). This total is an increase of 63% from the 1984 landings. Approximately 37% of the total was landed during the second quarter.

Preliminary 1986 landings indicate that, as in previous years, the majority of the catch comes from Minor Areas 14, 17, and 29 (Table 6.1). Until 1986, the catches were predominantly from Minor Area 17. In 1986 while second quarter catches remained at historic levels in Minor Areas 14 and 17, catches from Minor Area 29 have increased to 1030 t from 67 t in 1985 (Table 6.1). The total catch for Minor Area 29 in 1986 of 2711 t is well above the total catch for 1985 of 982 t (Table 6.1).

6.2.2. Condition of stock

There have been no new analyses conducted for the 1987 assessment. Sustainable yields have been calculated using Gulland's (1970) formula MSY = $a(M)(B_0)$.

LPUE has increased substantially (95%) in 1986 from 4.448 t/hr in 1985 to 8.675 t/hr (Table 6.2). Length frequencies collected in 1985 indicate little change in the size composition from the previous years. Modal sizes of hake ranged from 41-42 cm. Age composition data indicated that the 1978 year-class remains strong, contributing 28% to the catches.

Biomass estimates remain unchanged from those presented in the 1985 groundfish stock assessment (McFarlane and Shaw 1985).

6.2.3. Recommendations

Yield option 1: Sustained yield - low risk 10,000 t
Yield option 2: Sustained yield - high risk 15,000 t
Yield option 3: Unlimited yield
Risk is a function of the range in possible values for biomass and natural mortality used in Gulland's formula for MSY. At catch levels near or above the 10,000 t level, the reproductive response of the stock to exploitation must be carefully monitored.

6.3. West coast of Vancouver Island

6.3.1. Landing statistics

Reported landings by all nations in the Canadian zone were 24,962 t in 1985 (Table 6.3). This was a 41% decrease from 1984. This was a result of participation in the foreign fishery by Poland alone. As in the past, most of the catch was sold directly to foreign processing vessels. Canadian landings, as a part of a joint venture fishery with Polish fishermen, decreased to 13,237 t in 1985 from 28,906 t in 1984. Domestic landings reported during 1984 totalled 1192 t.

The accuracy of reported landings continues to be suspect. Catch figures depend on both the reliability of foreign factory production figures and on the accuracy of product to round conversion factors. Efforts to verify catches through direct observation have been hampered by decreasing coverage and the inexperience of the observers employed. Checking of the trans-shipped product has also proved difficult. The accuracy of future assessments will rely heavily on the accuracy of catch information.

6.3.2. Condition of stock

Stock dynamics of the offshore hake stock are presented in McFarlane and Francis (1985). Biological data collected in 1985 indicate that there is no change in the size composition of the offshore hake stock in the Canadian zone. The fishery continued to be supported by a series of strong year-classes. In particular, the 1980 and 1977 year-classes contributed about 26% and 32%, respectively, to the 1985 catch.

In order to determine yield options for 1987, landings from the 1986 fishery must be incorporated into the model currently in use, which is based on Walters (1969) model.

6.3.3. Recommendations

The 1987 yield options will be presented at a later date when all of the most current biological information has been collated and incorporated into the assessment.

Table 6.1. Pacific hake landings (t) for the second quarter and whole year by Minor Areas 14, 17 and 29, and Major Area 4B during 1977-1986.

	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986[a]	
Region	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr	Q_2	Yr
<u>Minor Area</u>																				
14	0	0	-	-	-	-	0	385	448	523	-	-	53	53	368	368	15	77	462	462
17	-	-	0	1	484	484	-	-	76	182	1927	2420	2208	2240	805	1736	1700	3718	1048	1120
29	-	-	0	0	2	2	0	5	810	1434	0	12	0	11	544	951	67	982	1030	2711
<u>Major Area</u>																				
4B	0	0	1	2	486	516	1	508	1364	2409	1927	2824	3078	3122	1717	3056	1827	4976	2541	4295

[a]Preliminary landings/cut-off August 20, 1986.

Table 6.2. Pacific hake landings, CPUE and effort from the Strait of Georgia (Major Area 4B), 1977-1986.

Year	Total catch (t)	CPUE[a] (t/hr)	Effort[b] (hr)
1977	0.04	0.00	0
1978	2	0.00	0
1979	516	10.207	51
1980	508	4.583	111
1981	2409	8.937	270
1982	2824	4.796	589
1983	3121	4.465	699
1984	4599	6.780	678
1985	4976	4.448	1119
1986[c]	4295	8.675	495

[a]CPUE @ 25% qualification level.

[b]Effort = Total catch/CPUE.

[c]Preliminary catch/cut-off August 20, 1986.

Table 6.3. Total landings (t) of hake off Canada (Area 3C) during 1978-1985.

		Total landings (t)			
Year	Nations	National	Joint venture	Domestic	Total
1978	Poland	589	1,814		
	USSR	700	0		
	Japan	3,364	0		
	Total	4,653	1,814	0	6,467
1979	Poland	4,263	3,102		
	USSR	0	1,131		
	Japan	3,637	0		
	Total	7,900	4,233	302	12,435
1980	Poland	4,456	4,560		
	USSR	78	4,300		
	Japan	817	0		
	Greece	0	3,355		
	Total	5,351	12,214	96	17,661
1981	Poland	3,189	4,779		
	USSR	227	7,342		
	Japan	187	0		
	Greece	0	4,927		
	Total	3,603	17,048	4,440	25,091
1982	Poland	10,357	10,222		
	USSR	0	9,391		
	Japan	2,237	0		
	Total	12,594	19,613	2	32,209
1983	Poland	13,177	13,464		
	USSR	0	14,192		
	Total	13,177	27,656	0	40,833
1984	Poland	13,203	9,214		
	USSR	0	19,692		
	Total	13,203	28,906	0	42,109
1985	Poland	10,533	13,237	1,192	
	Total	10,533	13,237	1,192	24,962

N.B. Catches reported in this fishery cannot be verified by weight tallies, as domestic catches are.

7.0 DOGFISH

by M. W. Saunders

7.1. Coastwide (not including Strait of Georgia)

7.1.1. Introduction

The offshore stock referred to in this assessment ranges from Alaska to California and does not include the Strait of Georgia-Puget Sound stock(s). The 1987 assessment remains unchanged from the previous assessment (Saunders 1986).

7.1.2. Landing statistics

Offshore landings of dogfish in 1985 continued to come from the trawl fishery (69.7%) in Major Area 3C (Table 7.1). The fishery is primarily (78.0%) during the first and second quarters (Table 7.2) when the large fish (> 80 cm) that processors demand are available to the fleet. Total landings have increased to 1959 t in 1985 (Table 7.1).

7.1.3. Condition of stock

The model of Wood et al. (1979) has been updated with catches to 1985 (Table 7.1, 7.3). The predicted pulse in abundance set in motion by the 1940's liver fishery (Saunders 1985) (Fig. 7.1.2 in Saunders 1985) is levelling out from the downward trend in abundance. At current harvest levels of less than 2000 t, the marketable biomass of dogfish is predicted to begin increasing (Fig. 7.1.3 in Saunders 1985) over the next two decades. The estimated biomass coastwide at the present time is approximately 300,000 t. If we assume that one-half to two-thirds of the stock resides off the coast of Canada, the biomass of fish in the Canadian zone is between 150,000-200,000 t.

7.1.4. Recommendations

An in-depth discussion of sustained yield and sustained effort management strategies is found in Saunders (1985) while possible strategies for periodic/pulse fishing are discussed in Saunders (1986).

Yield option 1: Unlimited yield
Yield option 2: Pulse fishing
Yield option 3: Sustained yield - low risk - 15,000 t
Yield option 4: Sustained yield - high risk - 25,000 t

The risk involved is based on ranges of compensatory mortality and starting stock sizes used to determine the sustainable yields. All options refer to coastwide (including U.S.) removals and no provision has been made for adjusting Canadian catches in the event of increased U.S. landings.

Table 7.1. Dogfish longline and trawl landings[a] (t) offshore, by Major Area and by gear for 1979-1985.

	3C			3D			5A			5B			5C			5D			5E			Total		
	LL[b]	Tr[c]	Tot.	LL	Tr	Tot.	LL	Tr	Tot.	LL	Tr	Tot	LL	Tr	Tot.	LL	Tr	Tot.	LL	Tr	Tot.	LL	Tr	Tot.
1979	4	279	283	1	15	16	5	10	15	-	5	5	1	11	12	26	70	96	-	-	-	33	390	423
1980	7	1732	1739	17	116	133	5	117	122	-	39	39	13	59	72	91	242	333	-	1	1	133	2306	2439
1981	10	285	295	-	17	17	-	25	25	-	-	-	-	9	9	10	32	42	-	-	-	20	368	388
1982	-	947	447	3	23	26	11	14	25	-	45	45	3	-	3	-	272	272	-	-	-	17	1301	1318
1983	77	451	528	-	54	54	16	-	16	-	9	9	-	3	3	-	17	17	-	-	-	93	534	627
1984	-	455	455	-	3	3	54	45	99	-	9	9	-	15	15	-	73	73	-	-	-	54	600	654
1985	-	1365	1365	60	74	134	360	52	412	38	2	40	-	-	-	4	4	8	-	-	-	462	1497	1959

[a]Interview and sales slip data from Smith 1980, 1981, Leaman 1982, 1983.

[b]LL = longline.

[c]Tr = trawl.

7.2. STRAIT OF GEORGIA--PUGET SOUND

7.2.1. Introduction

This assessment treats the Strait of Georgia and Puget Sound as a single stock. The 1987 assessment remains unchanged from the previous assessment (Saunders 1986).

7.2.2. Landing statistics

Longline landings were down to 439 t in 1985 from 1595 t landed in 1984, while trawl landings increased from 296 t in 1984 to 432 t in 1985 (Table 7.2).

7.2.3. Condition of stock

The model of Wood et al. (1979) has been updated to include 1985 catches. The model predicts that the downward trend in abundance has levelled off (Fig. 7.2.1 in Saunders 1985) and that at current harvest levels (approx. 3000 t) abundance should begin to increase sharply over the next ten to fifteen years (Fig. 7.2.3 in Saunders 1985). Current biomass levels are in the order of 69,000 t.

Trends in relative abundance as indicated by LPUE, differ between longline and trawl data (Table 7.4). The trawl LPUE has increased steadily from 1980 to 1985 while the longline LPUE has fluctuated and dropped significantly in 1985. The trend indicated by trawl LPUE compares favourably with the trend predicted by the model.

Length-frequencies of fish from trawl and longline landings show no change in mean length of fish or in the maximum size of fish landed.

Recommendations

The reader is referred to Saunders (1985) and Saunders (1986) for discussions regarding the implications of sustained yield, sustained effort or pulse fishing strategies.

Yield option 1: Unlimited yield
Yield option 2: Pulse fishing
Yield option 3: Sustained yield - low risk - 2000 t
Yield option 4: Sustained yield - high risk - 3000 t

The removals in yield option 3 and 4 refer to the Strait of Georgia only.

Table 7.2. Dogfish landings[a] (t) for Major Areas 4B and 3C, by gear and quarter for 1979 to 1985.

	Area 4B											Area 3C				
	Longline					Trawl						Trawl				
	Quarter					Quarter					Grand	Quarter				
	I	II	III	IV	Total	I	II	III	IV	Total	total	I	II	III	IV	Total
1979	747	206	419	2081	3453	9	7	106	669	881	4334	2	200	49	28	279
1980	806	482	23	229	1540	288	34	-	242	564	2104	512	1111	109	-	1732
1981	5	2	-	486	493	88	-	-	182	270	763	37	208	17	24	286
1982	302	67	6	464	839	100	28	120	171	419	1258	209	612	82	44	947
1983	273	128	55	336	792	81	111	70	173	435	1227	180	147	50	73	450
1984	353	260	347	635	1595	26	80	112	78	296	1891	239	127	67	22	455
1985	278	112	5	44	439	166	180	9	77	432	871	450	788	42	85	1365

[a]Includes sales slip information.

Table 7.3. Dogfish landings[a] (t) by gear from Washington State.

	Trawl	Longline	Other	Total
1983				
Inshore[b]	856	435		1271
Offshore[c]	21	5		26
1984				
Inshore	753	504	188	1445
Offshore	239	79	-	318
1985				
Inshore	469	363	139	971
Offshore	172	101	1	274

[a]From Technical Sub-committee, Washington State Status Reports, unpublished text.

[b]Major Area 4A.

[c]All Major Areas excluding 4A.

Table 7.4. Dogfish LPUE[a] in the Strait of Georgia[b] by year by gear.

	LPUE	
Year	Longline[c]	Trawl[d]
1979	.613	.409
1980	.651	.276
1981	.747	.317
1982	.671	.446
1983	.837	.542
1984	1.050	1.434
1985	.299	3.388

[a]Excluding dumped and discarded fish, 25% qualification level.

[b]Excluding Minor Area 12.

[c]t/1000 hooks.

[d]t/hr.

8.0 WALLEYE POLLOCK

by M. W. Saunders and W. Shaw

8.1. Coastwide

Yield options are not proposed on a coastwide basis.

8.2. Strait of Georgia

8.2.1. Landing statistics

Walleye pollock landings in the Strait of Georgia peaked in 1979 at 1,340 t. From 1982 to 1984, catches of walleye pollock in the Strait of Georgia dropped to less than 200 t. This was due to poor market conditions for the species. In 1985 total landings increased to 748 t (Table 8.1). The landings were predominantly from midwater trawlers, with approximately 54% of the landings occurring in April, and 45% in December. No landings were reported from Minor Area 18 (east of Mayne and Saturna Island area). There has been no demand for the pollock roe and all of the pollock catch was processed into frozen fillets.

8.2.2. Condition of stock

There have been no additional analyses conducted since the previous assessment (Shaw and Saunders 1986). The assessment is based on Gulland's equation (Gulland 1970) where MSY = $a(M)(B_0)$.

Little change has occurred in the length frequencies collected in 1985 compared with those from the previous years. Modal size has ranged from 40-43 cm. Presumably the stock has remained in a stable condition.

8.2.3. Recommendations

Sustainable yield options for 1987 may be chosen from:

Yield option 1: conservative level of 2500 t
Yield option 2: high risk level of 5400 t

8.3. West coast Vancouver Island

8.3.1. Landing statistics

Walleye pollock remained an incidental catch in the 1985 joint-venture Pacific hake fishery in Major Area 3C. The incidental catch of pollock in 1985 by the foreign fleet decreased slightly from the 1984 landings to 80 t (Table 8.2). The landings by the domestic fishery still remain very low with 4 t landed in 1985 (Table 8.3).

8.3.2. Condition of stock

Length-frequency samples suggest that the size composition of the stock in 1985 has remained unchanged from the previous years. This indicates the relative stability of the stock (Table 8.4).

Table 8.1. Walleye pollock landings by gear type and by quarter from the Strait of Georgia (Major Area 4B), 1976-1985.

	Major Area 4B			
Year	Quarter 1	Quarters 2,3	Quarter 4	Total
1976				
MWT[a]	-	-	-	0
BT[b]	3	<1	23	26
Total	3	<1	23	26
1977				
MWT	-	-	-	0
BT	24	1	26	51
Total	24	1	26	51
1978				
MWT	177	-	-	177
BT	142	20	41	203
Total	319	20	41	380
1979				
MWT	1033	-	3	1036
BT	283	1	20	304
Total	1316	1	23	1340
1980				
MWT	841	-	-	841
BT	189	3	23	215
Total	1030	3	23	1056
1981				
MWT	455	10	-	465
BT	99	1	5	105
Total	554	11	5	570
1982				
MWT	81	<1	-	81
BT	8	4	7	19
Total	89	4	7	100
1983				
MWT	19	-	-	19
BT	3	1	2	6
Total	22	1	2	25
1984				
MWT	8	57	90	155
BT	-	-	2	2
Total	8	57	92	157
1985				
MWT	401	4	319	724
BT	5	0	19	24
Total	406	4	338	748

[a] MWT = Midwater trawl.

[b] BT = Bottom trawl.

Table 8.2. Incidental catches of walleye pollock by foreign fleets participating in the offshore hake fishery off west coast Vancouver Island (Major Area 3C), 1980-1985. (Catch statistics from Offshore Division, Vancouver.)

		Landings (t)		
Year	Nations	National[a]	Joint venture	Total
1980	Poland	487	236	
	USSR	63	584	
	Japan	142	0	
	Greece	-	175	
	Total	692	995	1687
1981	Poland	131	205	
	USSR	26	299	
	Japan	9	0	
	Greece	-	285	
	Total	166	789	955
1982	Poland	468	222	
	USSR	0	149	
	Japan	38	-	
	Total	506	371	877
1983	Poland	13	6	
	USSR	-	-	
	Total	13	6	19
1984	Poland	1	66	
	USSR	-	41	
	Total	1	107	108
1985	Poland	2	78	
	Total	2	78	80

[a]"National" landings include landings from the supplementary fishery.

8.3.3. Recommendations

The yield option remains unchanged from last year's (Shaw and Saunders 1986).

Yield option 1: unrestricted yield

8.4. Queen Charlotte Sound

Yield options are not proposed for this region.

8.5. Hecate Strait

8.5.1. Landing statistics

Walleye pollock landings in Major Area 5D in 1985 were 1176 t (Table 8.3). This was an increase of 88% from the 1984 landings. As in the past, landings were primarily from the first and fourth quarters. First quarter landings increased slightly in 1985 with 379 t landed (Table 8.4). Fourth quarter landings in 1985 were 755 t, up 179% from 1984. The demand for pollock fillets in 1985 was greater than in 1984.

Landings in Major Area 5C remain low due to directed fishing effort on the more northern fishing grounds.

8.5.2. Condition of stock

Size composition of the 1985 landings has remained relatively constant compared with the previous years. Modal sizes remained the same at 50-53 cm. Age-frequency data indicate that 5 and 7 yr-old pollock dominated the catches in 1984.

8.5.3. Recommendations

The yield option proposed for 1987 is the same as for 1986 (Shaw et al. 1985) that is, unrestricted yield. The Canadian catch is currently limited by intermittent availability and/or weak market demand.

8.6. West Coast of Queen Charlotte Islands.

Yield options are not proposed for this region.

Table 8.3. Total landings (t) of walleye pollock by the domestic fleet by Major Statistical Area, 1954-85.

Year	Landings (t)									
	4B	3B	3C[a]	3D	5A	5B	5C	5D	5E	Total
1954	147	0	3	0	13	1	0	0	0	164
1955	418	0	5	0	1	0	0	3	0	426
1956	380	0	52	0	5	0	0	14	0	451
1957	248	0	4	0	3	0	0	7	0	262
1958	121	0	0	0	0.3	0	0	14	0	145
1959	260	0	8	0	0.4	0	0	2	0	270
1960	95	0	5	0	1	3	0	10	0	114
1961	115	0	0.1	0	1	0	0.3	7	0	123
1962	49	0	6	0	0	0	0	12	0	67
1963	13	0	7	0	6	0	0	4	0	29
1964	33	0	2	0	5	0	0	2	0	42
1965	26	0	10	0	0	0	0	9	0	45
1966	37	0	0.4	0	1	0.1	0.4	82	0	121
1967	33	1	0	0	1	0	7	48	0	90
1968	16	0	2	0	7	0	4	13	0	42
1969	30	0	14	0	33	0	0	47	0	125
1970	45	0	0	0	0	0	0	8	0	52
1971	80	0	5	0	0	0	0	0	0	85
1972	71	0	0.3	0	172	0	0	1	0	244
1973	9	0	0.1	0	62	9	0.4	13	0	93
1974	11	0	0	0	6	6	2	47	0	72
1975	1	0	0	0	21	10	1	70	0	104
1976	26	0	5	2	69	400	193	627	0.2	1,322
1977	50	0	10	0	61	175	16	568	12	891
1978	380	0	6	0.4	106	187	11	1,700	21	2,411
1979	1,341	0	31	0.3	72	71	238	1,566	67	3,385
1980	1,056	0	3	3	12	23	83	1,104	18	2,303
1981	570	0	8	1	2	10	80	563	22	1,255
1982	100	0	10	0	1	6	3	808	1	974
1983	25	0	3	1	11	10	6	986	28	1,070
1984	157	0	5	0	11	7	2	625	< 0.1	807
1985	748	0	4	0	0	1	0	1176	2	1,931

[a]Excludes incidental landings by the foreign fleet participating in the offshore Pacific hake fishery during 1980 to 1985.

Table 8.4. Walleye pollock landings by gear type and by quarter from Major Areas 5C and 5D, 1976-1985.

	Major Area 5C				Major Area 5D			
Year	Quarter1	Quarters2,3	Quarter4	Total	Quarter1	Quarters2,3	Quarter4	Total
1976								
MWT[a]	-	25	102	127	-	208	56	264
BT[b]	<1	19	47	66	5	141	214	360
Total	<1	44	149	193	6	349	270	625
1977								
MWT	-	-	-	0	<1	<1	-	<1
BT	1	14	1	16	34	509	24	567
Total	1	14	1	16	34	509	24	567
1978								
MWT	-	1	-	1	425	299	71	795
BT	1	7	2	10	107	657	141	905
Total	1	8	2	11	532	956	212	1700
1979								
MWT	-	-	-	0	593	52	11	656
BT	1	103	134	238	119	521	270	910
Total	1	103	134	238	712	573	281	1,566
1980								
MWT	-	<1	-	<1	201	261	9	471
BT	1	73	9	83	116	482	34	632
Total	1	73	9	83	317	743	43	1,103
1981								
MWT	-	-	-	0	61	-	79	140
BT	27	21	31	79	71	248	104	424
Total	27	21	31	79	132	248	183	563
1982								
MWT	-	-	-	0	2	-	607	609
BT	<1	3	<1	3	4	98	97	199
Total	<1	3	<1	3	6	98	704	808
1983								
MWT	-	-	-	0	-	34	784	818
BT	-	6	-	6	43	46	79	168
Total	0	6	0	6	43	80	863	986
1984								
MWT	-	-	-	0	301	-	266	567
BT	-	2	-	2	13	40	5	58
Total	0	2	0	2	314	40	271	625
1985								
MWT	-	-	-	0	369	0	754	1123
BT	-	-	-	0	10	42	1	53
Total	0	0	0	0	379	42	755	1176

[a]MWT = Midwater trawl.
[b]BT = Bottom trawl.

9.0 SLOPE ROCKFISHES

by B. M. Leaman

9.0.1 General Introduction to Rockfishes

In previous stock assessment documents, we have presented a number of yield and management options for shelf and slope rockfishes (Leaman and Stanley 1985). The five yield options are: (i) zero harvest; (ii) conservative or rebuilding harvest; (iii) sustainable harvest; (iv) non-sustainable harvest; and (v) unrestricted harvest. These options are described in the Introduction.

For several rockfish stocks, yield options are based on limited and/or poor quality information, and are not supported by detailed scientific analyses. Were rockfish stocks to have shown more resilience to exploitation we would, with the same data bases, be inclined to be more liberal in our identification of yield options, even at times to identify unrestricted harvest as an option so as to gather more baseline data. However we do not follow such a policy for rockfishes, since the exploitation histories of species such as Pacific ocean perch and widow rockfish argue forcefully that rockfish management should be highly conservative. This viewpoint contributes to the identification of yield options even for stocks where little fishing has occurred. In such cases a ceiling or threshold level of yield is identified which will, should a significant fishery suddenly develop, prevent a drastic over-harvest. Holding the landings to such a level would permit some opportunity for assessment and orderly development of the fishery.

Within the general framework outlined above, we present an additional option for management of some rockfish species and stocks. Using cluster analysis and analysis of covariance, rockfish catches have been examined to determine if they can be segregated into assemblages of species that persist over periods sufficiently long to be useful as management units. Results indicate that relatively stable units exist within shelf and slope groups in some areas over the full year, or within segments of the year, long enough to be useful for management (Nagtegaal 1983).

It should be understood that management precision is decreased due to the relatively dynamic composition of assemblages among years. While this is unavoidable, the option is presented because the precision of single-species management is dependent on the ability of fishermen to target on specific stocks and quotas. Assemblages are presented in recognition of this reality. Additionally, assemblages may be suggested where individual yield options are so small as to make enforcement of them impossible.

In some instances, the total for an assemblage unit will be less than the sum of the species contributing to the assemblage. This reflects variability in the proportional composition of the assemblage and the possibility that a substantial portion of the total might, on occasion, be obtained from only one species of the unit. In these instances, we have suggested a lower unit figure under each option with the provision for review of the composition of the catch at this figure, and increases if the total is distributed among species according to projections. The use of assemblage units ignores the "minor" species and it is the intent that such species would not contribute to quota catches, should this option be chosen. The catches of these species would, of course, have to be monitored, primarily to help us resolve the structure of assemblages for future use.

In the following sections we present management options by yield levels [options (ii)-(v)] and by species clusters (single species (A), partial clusters (B), and full clusters (C)). Not all options will be appropriate for all species and areas. Finally, we add a cautionary note in consideration of a review of the achievement of management objectives that were based on the yield options identified for rockfishes in recent years. In several instances quotas have been divided in areas and the result has been greater total overruns. The extent to which quotas have been exceeded seems to be independent of the quota itself. Thus, if a quota is divided into two areas it appears this leads to twice the overrun for the overall area. If within assemblage management the overruns consistently exceed sustainable levels, then we suggest using individual species quotas so that the impacts of over-exploitation can be limited to specific stocks.

Rockfishes have been divided into slope (Section 9) and shelf (Section 10) groups in recognition of natural distribution and biological affinities.

9.0.2 Introduction to Slope Rockfishes

No extensive analytical assessments have been conducted during 1986; Tables 9.1-9.14 provide updated statistics of slope rockfish fisheries, through July 11, 1986. However, the recommended yield options of Table 9.15 contain some significant changes from those presented in 1985. Irrespective of changes in assessments, the figures in Table 9.15 are higher than the 1985 figures because the latter were reduced by 30% from the estimated biological yields as a suggested approach to management imprecision, caused by non-cooperation in logbook coverage of landings. The 30% reduction reflected the degree of noncooperation experienced in 1985. The 1987 figures are complete estimates of available yield, so as not to restrict management prerogative.

During 1986 several stock reviews which resulted in changes to recommended yield options, were completed. They are briefly summarized below.

9.1 Coastwide quotas - Slope rockfish (S. aleutianus, S. alutus, S. reedi)

For the 1986 fishing year we introduced the option of coastwide slope rockfish quotas, based in the concept of core-area management (Leaman 1986). The objective of this option was to provide a quota that could be enforced on a coast-wide basis yet that would potentially achieve some stock management goal(s). In that case the goals addressed were the management of

Queen Charlotte Sound/Moresby Gully as a core production area for S. alutus/ S. reedi, and Area 5E(s) as a core production area for S. aleutianus. All coastwide catches were to be applied to the core production area quotas, and the coast closed for directed fishing when they were achieved. Coastwide quotas thus proposed were 3650 t for S. alutus/S. reedi and 250 t for S. aleutianus. We noted in 1985 that there was no question that yields under the coastwide option had to be much lower than the sum of the individual area quotas, in order to avoid having all stocks degrade to some lowest denominator yield level.

Management chose not to accept the biological recommendations for the 1986 fishing year and instead adopted a 5000 t coastwide quota for slope rockfishes (S. aleutianus, S. alutus, S. reedi) coupled to a 200,000 lb trip limit (shelf + slope rockfish) until 60% of the quota was attained. We predicted that such a tactic would result in a concentration of fishing effort in those areas offering acceptable catch rates, which were closest to the major ports (Vancouver, Prince Rupert). Indeed, such a concentration did take place, with major increases in fishing effort for slope rockfishes occurring in the 3D-5A and 5E(s) areas. Concomitantly, catches from major stock units accumulated disproportionately to available yield. Moresby Gully and Area 3D-5A Pacific ocean perch landings were notable in this regard, with yields being undersubscribed by 67% for the former and being oversubscribed by 150% for the latter. Continuation of such exploitation patterns will result in an undesirable deterioration in coastwide slope rockfish productivity.

For the 1987 fishing year we again present a coastwide yield option for slope rockfishes, based on the same concept of managing a core production area as we outlined in 1985. Conservative and sustainable yields for a combined S. alutus/S. reedi coastwide option are 2500 and 3100 t, respectively. For S. aleutianus, the comparable figures are 100 and 250 t (Table 9.15). As in 1985, we urge managers to consider this coastwide option only after examining the cost/benefit ratio of stock-specific vs. coastwide management, imperfect as the former might be.

9.2 Strait of Georgia

Yield options are not developed for this area.

9.3 Southwest Vancouver Island Pacific ocean perch (Sebastes alutus)

9.3.1 Introduction

Both Canada and the United States conducted biomass surveys of S. alutus in portions of the INPFC Vancouver Area during 1985. These surveys were replicates of 1979 surveys and, in the case of Canada, followed a short-term, controlled over-exploitation experiment. The results of these surveys and recent performance of the fishery were considered for the 1986 assessment.

9.3.2 Landing Statistics

Table 9.1, 9.2, and Figures 9.1-9.3 detail the variable fishing effort but decreasing landings and LPUE of the domestic fishery in recent years. Of particular concern is the LPUE, which has declined precipitously since the fishery was re-opened in 1980. While qualified LPUE increased in 1986, it was associated with a 90% reduction in qualified effort and does not provide an adequate index.

9.3.3 Condition of the Stock

The 3C S. alutus stock is in poor condition. The 1979 surveys by the U.S. and Canada showed an estimated S. alutus biomass of ~9730 t in the 3C area. The 1985 surveys showed a combined biomass of only ~3880 t, of which the Canadian zone contained approximately 1850 t. The decline in S. alutus biomass in the Canadian zone from 1979-1985 was 56% and that for the U.S. zone was over 63%. LPUE declines for the Canadian fishery (Table 9.2) between 1979 and 1986 are also of this magnitude (49%). In the Canadian zone this decline was associated with a deliberate, short-term over-fishing experiment, while in U.S. waters it was associated with excessive harvest arising from what we believe to be an incorrect estimate of natural mortality. The net result in both cases was harvest well in excess of the sustainable yield. If the decrease in biomass suggested by the two most recent surveys is correct it is also apparent that recruitment to this stock has been minimal in the 1979-1985 interval; mean age continues to be less than 15 y.

9.3.4 Recommendations

It is apparent that the 3C S. alutus stock is in serious need of rehabilitation. U.S. scientists are recommending a 0 t quota for 1987 in the INPFC Vancouver Area (U.S.) in order to initiate the rehabilitation of this stock. Our 1985 biomass survey suggests a sustainable yield of approximately 100 t under a F_{opt}=M policy (Table 9.15). It is unlikely that such a yield could be controlled in a directed fishery and a non-directed fishery should be considered.

9.4 Queen Charlotte Sound

9.4.1 Queen Charlotte Sound/Northwest Vancouver Island yellowmouth rockfish (Sebastes reedi)

9.4.1.1 Landing Statistics

With the exception of 1977, the domestic fleet has expended little directed (i.e. $\geq$25% qualification level) fishing effort for S. reedi in this area, until 1982. Qualified effort was generally <50 h/yr, although most of the landings did fall into the qualified category. Domestic landings have increased recently but qualified LPUE is well below peak levels (Table 9.6). In a previous assessment document (Westrheim 1980) we indicated that the major Japanese fishery of 1971-1979 was estimated to have caught a maximum of 5500 t of S. reedi in 1974 but the catch had dwindled to only 1300 t in the last year (1976) of unrestricted fishing by this fleet. The major removals from this stock have thus been by foreign trawlers.

Closures of traditional fishing areas in Queen Charlotte Sound during 1985 resulted in a diversion of fishing effort for S. reedi to the northern segment of Area 3D (minor areas 26 and 27), where catch rates were higher (Table 9.4). This trend was further accentuated in 1986 because of the coastwide quotas adopted by management. Vessels began fishing in the spring of 1986 on spawning aggregations of S. reedi in northern Area 3D and Area 5A, south of Triangle Is. While catch rates were relatively high (qualified LPUE = 1.98t/h), they were not as high as the previous, winter fisheries at the mouth of Queen Charlotte Sound (2.4-4.1 t/h), especially considering the normal density of spawning aggregations. Distributional evidence from surveys and from commercial fishery patterns suggests a common stock of S. reedi from the mouth of Queen Charlotte Sound and south to Quatsino Sound, if not Cape Cook.

9.4.1.2 Condition of the Stock

No analytic assessments of this stock have been conducted due to the paucity of useful catch or biological data. A single hydroacoustic estimate of biomass (2000 t) was produced in 1978 and is assumed to be conservative. Previous assessments have treated the yield from such a biomass estimate as the minimum sustainable. However, the lowered level of LPUE at harvests above this yield causes some concern, particularly considering the major decrease in directed effort over the 1983-1985 period.

The shift in effort to the northwest coast of Vancouver Is. (Area 3D) appears to be largely an artifact of the coastwide management plan and the associated closure of the mouth of Queen Charlotte Sound, where LPUE was much higher for S. reedi. We believe that the recommended quotas for Areas 5A/B should apply to this northern Area 3D for an additional period sufficiently long to permit evaluation of their validity.

While biological data for this stock are limited, we did examine the gross estimation of Z by comparing recent biological samples with simulated length frequencies for various Z values generated using the method described by Stanley (1985). These comparisons indicate overall Z values for this stock are presently in the 0.08-0.12 range. In turn this suggests present levels of F ($F \approx M \approx 0.06$) for this stock are appropriate.

9.4.1.3 Recommendations

In consideration of the all-nation catch history and low level of LPUE relative to recent years, we recommend that yield levels for conservative and sustainable options remain as in 1985, i.e. 200 and 350 t. Future assessments should examine the LPUE and Z indices for stability or positive changes under the yield options chosen, although the limitations of LPUE as an indicator of abundance for rockfishes, particularly concerning mid-water trawling, must be acknowledged.

9.4.2 Queen Charlotte Sound Pacific ocean perch (*S. alutus*)

9.4.2.1 Introduction

Harvests of *S. alutus* from the Goose Is./Mitchell's stock have been considerably above recommended levels for the past decade. This situation has been exacerbated by the 1983-1985 winter fisheries on spawning females which removed approximately 1.6 times the reproductive capacity of the stock, as would the same yields from the traditional summer fishery. Previous analysis of this stock have been extensive and this report merely provides an updated projection of yields associated with various levels of fishing mortality.

9.4.2.2 Condition of the Stock

The 1977-1985 trawl fisheries on this stock resulted in very high levels of F (0.08-0.20) relative to the projected optimum of F=0.05-0.06. Over 9000 t of *S. alutus* has been removed from the stock since 1977, at which time biomass was estimated analytically to be about 13,000 t. Clearly, recruitment would have had to be substantial to offset such removals, but age frequency spectra of 1985 samples indicate no strong cohorts recruiting during that period. If recruitment had been on the order of natural mortality (5%/yr) over the 1977-1985 interval, then stock biomass might be estimated at approximately 9000 t in 1986. Unfortunately, we have little information on recruitment at low stock levels for this species. If recruitment had been largely a failure over this interval then a minimum stock estimate would be approximately 4000 t. A biomass survey of the Goose Is. stock in 1984 produced a biomass estimate of ~6800 t.

Using the 1985 age spectrum of the Goose Is. gully stock as a starting point we simulated the behaviour of the stock to various fishing mortalities over 10, 20, 30, 100, and 200 yr periods, with the model described by Archibald et al. (1983) (Table 9.16; Figs. 9.4, 9.5). Due to the nature of the population and the manner in which recruitment is modelled (stochastic Ricker function), these projections are less meaningful for periods very close (<10 yr) to the starting point. Nonetheless it is evident that yield from the present biomass is considerably below that derived from the 1977 biomass. Long-term (200 yr) yield continues to identify F=0.05-0.06 as the F_{opt}, although substantive rehabilitation over a 30 yr horizon occurs only for F=0.0.

9.4.2.3 Recommendations

In view of the continued decline of the Goose Is./Mitchell's gullies stock of *S. alutus* we have reduced the estimated conservative and sustainable yields to 400 t and 500 t, respectively (Table 9.15).

9.5 Hecate Strait

Recommendations follow Leaman 1985; also see Table 9.15 for Area 5C.

9.6 Dixon Entrance slope rockfish (Areas 5E(N))

9.6.1 Introduction

In 1983 an open-fishing experiment for slope rockfishes was initiated in Area 5E(N); it was anticipated that the duration of the manipulative segment of the experiment would last 3-5 yr. While data capture problems relative to the accuracy necessary for interpretation have occasionally been significant we have continued with the experiment. The fishery will return to normal yield scenarios beginning in 1988. For this report we provide a brief update on the progress of this experiment.

9.6.2 Landing Statistics

Total rockfish catch in Area 5E(N) has increased substantially since this experiment was initiated (Fig. 9.6; Table 9.17). However, the species composition of this catch (Fig. 9.7) has not changed in direct proportion. S. alutus and S. aleutianus proportions of the catch have decreased while those of S. proriger and S. reedi have increased. The former has occurred despite steadily increasing nominal and qualified effort for these two species. LPUE values for the major species of this fishery have decreased since the start of open-fishing (Figs. 9.8-9.10) while effort has increased (Figs. 9.11-9.13; Tables 9.12-9.14).

9.6.3 Condition of the Stock

The 5E(N) rockfish stocks remain at a low level of abundance. The shift in species composition from alutus to reedi/proriger despite increased effort for the former endorses this lowered abundance. This shift has occurred despite lower LPUE for these alternate species. Since this experiment began the percentage of S. alutus ≥40 cm has dropped from 44.5% to 7.5%, indicating a major change in the population. Age spectra for S. alutus in the area show no sign of incoming strong cohorts and the stock will probably remain depressed until the experiment is completed.

9.6.4 Recommendations

We recommend that the open-fishing experiment for this area be continued through 1987, following which another assessment of the stock will be conducted and new yield options identified.

Table 9.1. Estimated Pacific ocean perch landings from the INPFC Vancouver area, 1956-1986.

	Landings (t)				
Year	U.S.	Canada	Foreign	JV[a]	Total
1956	1,084	-	-	-	1,084
1957	1,154	-	-	-	1,154
1958	675	-	-	-	675
1959	968	-	-	-	968
1960	1,575	-	-	-	1,575
1961	2,479	6	-	-	2,485
1962	3,854	3	-	-	3,857
1963	3,767	2	-	-	3,769
1964	2,048	47	-	-	2,095
1965	2,961	7	500	-	3,468
1966	2,283	3	14,000	-	16,286
1967	783	7	12,678	-	13,468
1968	526	1	9,865	-	10,392
1969	528	2	2,827	-	3,357
1970	1,170	309	2,368	-	3,847
1971	627	230	2,738	-	3,595
1972	468	118	1,981	-	2,567
1973	308	0	3,479	-	3,787
1974	255	3	1,186	-	1,444
1975	308	6	504	-	818
1976	729	1	521	-	1,251
1977	897	16	T	-	913
1978	958	56	-	-	1,014
1979	616	125	-	-	741
1980	397	430	-	8	835
1981	234	548	5	3	790
1982	309	514	6	1	830
1983	266	837	44	-	1,147
1984	541	744	-	6	1,291
1985	227	616	Tr	Tr	843
1986[b]	N/A	671	N/A	N/A	671

[a]Joint-venture.

[b]To July 11, 1986.

Table 9.2. Canadian interviewed landings (t), effort (h), and LPUE (t/h) of Pacific ocean perch (Sebastes alutus) from Area 3C.

Area 3C[a]							
		Interviewed					
		0% Qualification			25% Qualification[b]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1967	4.47	4.47	6.5	0.687	4.28	4.5	0.951
1968	0.12	0.12	6.3	0.018	-	-	-
1969	-	-	-	-	-	-	-
1970	298.84	296.77	444.8	0.667	273.11	293.2	0.932
1971	206.99	201.14	552.0	0.364	190.50	333.7	0.571
1972	72.24	13.25	21.3	0.624	12.67	14.3	0.889
1973	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-
1975	5.46	5.46	166.5	0.033	1.46	7.0	0.208
1976	1.29	1.29	5.0	0.257	0.87	1.0	0.869
1977	15.04	13.81	447.5	0.031	8.67	42.3	0.205
1978	48.88	48.57	57.8	0.841	47.51	32.0	1.485
1979	80.62	79.91	147.1	0.543	77.14	44.9	1.718
1980	285.59	284.77	448.2	0.635	277.93	234.9	1.183
1981	381.54	364.99	750.8	0.486	341.61	430.5	0.794
1982	395.23	372.29	740.3	0.503	342.56	430.7	0.795
1983	373.97	179.30	348.3	0.515	167.71	143.3	1.171
1984	406.17	317.39	481.9	0.659	316.86	478.8	0.662
1985	275.82	255.55	1079.6	0.237	235.35	783.2	0.301
1986[c]	130.16	63.61	227.8	0.279	55.87	80.0	0.698

[a]Includes minor area 25.

[b]At least 25% of landing must be S. alutus for inclusion of data.

[c]To July 11, 1986.

Table 9.3. Canadian interviewed landings (t), effort (h), and LPUE (t/h) of <u>S</u>. <u>alutus</u> from Area 3D.

		Area 3D[a]					
		Interviewed					
		0% Qualification			25% Qualification[b]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1967	2.55	2.55	10.0	0.255	2.55	10.0	0.255
1968	0.41	0.04	66.5	0.001	-	-	-
1969	2.49	2.49	40.5	0.062	1.26	12.5	0.101
1970	5.38	5.38	150.6	0.036	-	-	-
1971	11.39	11.39	82.0	0.139	10.32	67.0	0.154
1972	45.02	-	-	-	-	-	-
1973	-	-	-	-	-	-	-
1974	2.92	2.92	59.0	0.050	-	-	-
1975	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-
1977	1.13	1.13	7.3	0.155	0.14	4.0	0.034
1978	7.05	4.48	18.9	0.237	3.45	6.9	0.499
1979	44.24	44.24	53.9	0.820	43.89	40.8	1.076
1980	144.26	143.50	300.9	0.477	126.80	190.1	0.667
1981	165.97	165.97	353.4	0.470	163.40	283.4	0.577
1982	112.86	112.13	200.8	0.558	109.92	124.3	0.884
1983	463.33	214.39	574.3	0.373	182.58	281.6	0.648
1984	337.40	236.03	441.8	0.534	231.60	353.3	0.656
1985	339.99	289.81	506.2	1.396	247.56	358.4	0.691
1986[c]	540.88	534.23	519.7	1.028	491.82	306.9	1.603

[a]Minor area 25 not included.

[b]At least 25% of landing must be <u>S</u>. <u>alutus</u> for inclusion of data.

[c]To July 11, 1986.

Table 9.4. Total landings (t) and statistics of the nominal and qualified (25%) fishery for yellowmouth rockfish (Sebastes reedi) off the northwest coast of Vancouver Is. (minor statistical areas 26 and 27). Effort in hours (h) and LPUE in tons/h (t/h), 1983-1986.

		Areas 26 and 27					
		0% Qualification			25% Qualification[b]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1983	20.41	4.65	9.3	0.503	0	0	0
1984	114.34	114.34	116.4	0.982	112.83	84.5	1.335
1985	412.09	285.06	441.6	0.646	254.34	160.8	1.582
1986[a]	807.37	695.31	790.9	0.879	609.98	307.9	1.981

[a]to July 11, 1986

[b]At least 25% of landings must be S. reedi for inclusion of data.

Table 9.5. Total landings (foreign and domestic) of Pacific ocean perch, standardized LPUE and calculated total effort on the principal fishing grounds of Queen Charlotte Sound. (Fishery changed to winter fishery on spawning females in 1983.)

	Goose Island Gully			Mitchell's Gully		
Year	Total landings (t)	Standard LPUE (t/h)	Calculated effort (h)	Total landings (t)	Standard LPUE (t/h)	Calculated effort (h)
1959	1,890	0.836	2,261	-	-	-
1960	1,679	0.698	2,405	-	-	-
1961	1,199	0.797	1,504	-	-	-
1962	1,838	1.161	1,583	-	-	-
1963	3,712	1.457	2,548	-	-	-
1964	3,450	1.134	3,042	57	-	-
1965	7,478	1.491	5,015	488	0.780	626
1966	20,752	1.441	14,401	1,369	0.815	1,680
1967	12,119	1.068	11,347	5,319	1.157	4,597
1968	10,213	1.045	9,773	2,556	1.137	2,248
1969	6,872	0.763	9,007	2,945	0.995	2,960
1970	6,489	0.672	9,657	1,296	1.010	1,283
1971	3,455	0.526	6,568	813	0.954	852
1972	5,645	0.829	6,809	995	0.854	1,165
1973	3,755	0.773	4,858	2,264	1.351	1,676
1974	7,269	0.773	9,404	1,917	0.974	1,968
1975	4,209	0.507	8,302	1,151	0.989	1,164
1976	2,442	0.733	3,332	576	0.673	856
1977	1,693	0.660	2,565	256	0.551	465
1978	865	0.821	1,054	375	0.817	459
1979	951	0.799	1,190	480	0.670	716
1980	1,226	0.932	1,316	305	0.862	354
1981	801	0.760	1,054	680	4.474	152
1982	570	0.514	1,110	286	2.648	108
1983	1,215	1.257	967	31	0.929	33
1984	841	2.017	417	19	0.594	32
1985	759	0.615	1234	80	0.149	537
1986[a]	374	0.767	487	-	-	-

[a]To July 11, 1986.

Table 9.6. Yellowmouth rockfish (S. reedi) interviewed and total landings (t), effort (h) and LPUE (t/h) in Goose Island and Mitchell's gullies.

Year	Total landings	Interviewed					
		0% qualification			25% qualification[a]		
		L	E	LPUE	L	E	LPUE
1971	5.35	5.35	31.5	0.170	-	-	-
1972	-	-	-	-	-	-	-
1973	176.65	176.65	37.0	4.774	176.21	32.5	5.422
1974	78.91	78.91	23.0	3.431	78.91	23.0	3.431
1975	1.08	1.08	34.5	0.031	-	-	-
1976	12.29	12.29	10.0	1.229	12.29	10.0	1.229
1977	335.89	335.89	466.0	0.721	331.29	226.3	1.464
1978	16.54	16.54	110.0	0.150	10.86	16.0	0.679
1979	10.25	10.25	102.0	0.101	6.49	9.7	0.669
1980	27.92	27.92	97.5	0.286	24.77	32.7	0.758
1981	4.74	4.74	25.6	0.185	0.07	2.0	0.033
1982	191.86	176.94	167.5	1.056	163.42	39.8	4.111
1983	528.64	455.57	492.2	0.926	367.12	151.4	2.424
1984	343.93	87.25	288.7	0.302	69.45	130.1	0.534
1985	304.82	52.84	413.3	0.128	37.67	43.7	0.863
1986[b]	182.68	127.67	101.3	1.260	109.15	63.8	1.711

[a]At least 25% of landing must be S. reedi for inclusion of data.

[b]To July 11. 1986.

Table 9.7. Pacific ocean perch interviewed landings, effort, and LPUE (t/hr) from Moresby Gully.

Year	Interviewed			Total landings
	Landings (t)	Effort (hr)	LPUE (t/h)	
1966	-	-	-	0.33
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	2.00	10.0	0.200	1.50
1972	-	-	-	-
1973	-	-	-	-
1974	10.12	11.3	0.896	10.12
1975	93.64	91.3	1.026	96.75
1976	39.67	109.0	0.364	43.40
1977	3.71	8.5	0.436	41.13
1978	162.30	155.3	1.045	162.30
1979	223.83	215.9	1.037	225.35
1980	2145.76	1540.4	1.393	2432.59
1981	1479.57	1019.5	1.451	2166.30
1982	2711.59	1346.0	2.015	3561.99
1983	1491.27	641.4	2.325	2204.22
1984	1274.35	820.6	1.553	2042.18
1985	1311.35	1006.2	1.303	1939.39
1986[a]	442.55	714.5	0.619	442.78

[a]To July 11. 1986.

Table 9.8. *Sebastes reedi* interviewed and total landings (t), effort (h), and LPUE (t/h) in Moresby Gully.

		Interviewed					
	Total	0% qualification			25% qualification[a]		
Year	landings	L	E	LPUE	L	E	LPUE
1978	91.94	91.94	54.3	1.693	84.65	45.2	1.873
1979	20.48	20.48	37.6	0.545	-	-	-
1980	20.13	20.13	28.7	0.702	1.50	5.5	0.272
1981	109.67	40.95	116.6	0.351	-	-	-
1982	417.32	325.15	711.6	0.457	228.75	202.1	1.132
1983	202.04	78.24	329.7	0.237	15.22	39.8	0.383
1984	338.09	106.12	308.1	0.344	34.73	50.2	0.692
1985	231.79	177.29	342.2	0.518	113.98	85.1	1.340
1986[b]	98.91	98.91	216.2	0.457	64.46	72.5	0.889

[a]At least 25% of landing must be *S. reedi* for inclusion of data.

[b]To July 11, 1986.

Table 9.9. Canadian landings (t), effort (h), and LPUE (t/h) of S. alutus, from Area 5E, south of 54°.

		Area 5E					
		Interviewed					
	Total	0% qualification			25% qualification[a]		
Year	landings	L	E	LPUE	L	E	LPUE
1976	78.78	78.78	59.0	1.335	78.78	59.0	1.335
1977	1549.42	1475.24	1041.5	1.416	1321.29	651.4	2.028
1978	2413.70	2346.93	1043.9	2.248	2255.89	724.4	3.114
1979	839.28	839.28	557.4	1.506	823.09	376.1	2.188
1980	876.96	472.90	496.2	0.953	449.31	332.5	1.351
1981	599.21	432.73	235.7	1.836	412.99	172.5	2.394
1982	614.11	606.73	443.1	1.369	550.38	308.8	1.782
1983	835.17	762.67	629.8	1.211	721.46	403.8	1.787
1984	840.88	457.92	344.8	1.328	434.90	215.9	2.015
1985	830.04	605.36	691.5	0.875	564.34	453.8	1.243
1986[b]	632.54	464.41	711.2	0.653	331.96	272.9	1.216

[a]At least 25% of landing must be S. reedi for inclusion of data.
[b]To July 11, 1986.

Table 9.10. Canadian landings (t), effort (h), and LPUE (t/h) of S. reedi, from Area 5E, south of 54°.

		Area 5E south					
		Interviewed					
	Total	0% qualification			25% qualification[a]		
Year	landings	L	E	LPUE	L	E	LPUE
1976	-	-	-	-	-	-	-
1977	1256.74	1256.74	583.0	2.156	1226.64	438.2	2.799
1978	1104.64	1104.64	600.4	1.840	858.89	296.3	2.899
1979	388.54	388.54	356.5	1.090	328.72	204.7	1.606
1980	499.91	477.23	321.5	1.484	477.23	321.5	1.484
1981	922.41	380.12	192.2	1.978	350.89	129.9	2.701
1982	414.39	351.87	335.9	1.048	307.98	191.9	1.605
1983	588.21	556.22	575.5	0.966	501.10	356.7	1.405
1984	441.08	212.33	336.2	0.632	169.75	178.9	0.949
1985	497.31	346.48	609.8	0.568	221.23	257.8	0.858
1986[b]	555.03	528.56	469.6	1.126	463.25	240.1	1.930

[a]At least 25% of landing must be S. reedi for inclusion of data.
[b]To July 11, 1986.

Table 9.11. Canadian landings (t), effort (h), and LPUE (t/h) of rougheye rockfish (S. aleutianus) from Area 5E, south of 54°.

Area 5E south							
		Interviewed					
	Total	0% qualification			25% qualification[a]		
Year	landings	L	E	LPUE	L	E	LPUE
1976	-	-	-	-	-	-	-
1977	76.28	76.28	134.5	0.567	74.69	66.0	1.132
1978	139.49	139.49	396.9	0.351	105.17	118.3	0.889
1979	192.09	192.09	347.7	0.552	159.51	137.1	1.163
1980	51.42	51.42	60.0	0.857	50.31	23.0	2.187
1981	9.93	9.93	46.2	0.215	5.13	7.2	0.713
1982	274.38	274.38	269.3	1.019	262.55	156.2	1.681
1983	74.16	61.37	324.1	0.189	26.70	22.0	1.214
1984	100.85	73.31	215.3	0.341	21.49	24.2	0.889
1985	160.56	118.37	411.9	0.287	70.41	151.2	0.466
1986[b]	275.71	168.50	369.1	0.457	89.89	155.8	0.577

[a]At least 25% of landing must be S. aleutianus for inclusion of data.

[b]To July 11, 1986.

Table 9.12. Canadian landings (t), effort (h), and LPUE (t/h) of S. alutus, from Area 5E, north of 54°.

Area 5E north							
		Interviewed					
		0% qualification			25% qualification[a]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1976	-	-	-	-	-	-	-
1977	1.42	1.42	19.7	0.072	0.7	2.3	0.304
1978	22.22	22.22	151.1	0.147	6.65	16.8	0.396
1979	227.49	227.49	177.5	1.282	223.83	108.5	2.063
1980	84.56	84.56	119.3	0.709	64.80	39.5	1.641
1981	109.22	63.58	32.4	1.962	53.15	24.1	2.205
1982	342.23	218.48	144.1	1.516	194.18	109.3	1.777
1983	291.98	226.43	401.8	0.564	208.28	193.5	1.076
1984	2173.86	1819.93	1213.5	1.500	1779.38	980.0	1.816
1985	1938.46	1838.86	1908.7	0.963	1728.49	1514.5	1.141
1986[b]	2090.64	2068.97	2265.4	0.913	2040.59	1912.9	1.067

[a]At least 25% of landing must be S. alutus for inclusion of data.

[b]To July 11, 1986.

Table 9.13. Canadian landings (t), effort (h), and LPUE (t/h) of *S. reedi* from Area 5E, north of 54°.

Area 5E north							
		Interviewed					
		0% qualification			25% qualification[a]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1976	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-
1979	16.86	16.86	69.9	0.241	4.08	4.1	0.995
1980	-	-	-	-	-	-	-
1981	2.34	2.34	4.9	0.478	2.34	4.9	0.478
1982	67.88	54.58	70.3	0.776	52.36	36.5	1.435
1983	52.23	18.36	44.5	0.413	3.48	9.0	0.387
1984	72.84	63.05	468.3	0.135	15.79	14.9	1.061
1985	180.31	174.03	1008.3	0.173	55.12	40.5	1.360
1986[b]	484.05	483.14	1530.2	0.316	335.59	466.4	0.720

[a]At least 25% of landing must be *S. reedi* for inclusion of data.

[b]To July 11, 1986.

Table 9.14. Canadian landings (t), effort (h), and LPUE (t/h) of *S. aleutianus* from Area 5E, north of 54°.

		Area 5E north					
		Interviewed					
		0% qualification			25% qualification[a]		
Year	Total landings	L	E	LPUE	L	E	LPUE
1976	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-
1979	13.99	13.99	139.5	0.100	9.73	64.1	0.152
1980	2.58	2.58	42.5	0.061	-	-	-
1981	98.08	98.08	26.0	3.772	94.20	23.0	4.100
1982	69.09	69.09	74.4	0.929	65.66	34.8	1.887
1983	127.46	84.01	271.5	0.309	43.39	44.3	0.979
1984	226.21	207.86	824.7	0.252	93.50	134.3	0.696
1985	465.37	464.95	1344.4	0.346	317.35	397.2	0.799
1986[b]	179.38	179.38	1110.4	0.162	63.44	67.8	0.936

[a]At least 25% of landing must be *S. aleutianus* for inclusion of data.

[b]To July 11, 1986.

Table 9.15. Yield options for slope rockfishes (*S. alutus*, *S. reedi*, *S. aleutianus*). Yields in tonnes.

Area	Species	Cluster options	Conservative	Sustainable	Non-sustainable
3C	*S. alutus*	A	0	100[a]	200
3D	*S. alutus*	A	250	350	500
5A/B	*S. alutus*	A	400	500	650
Goose Is.	*S. reedi*	A	200	350	500
& Mitchell's gullies)	Slope rockfish	C	600	850	1150
5C	*S. alutus*	A	1700	2000	2500
(Morseby	*S. reedi*	A	200	250	300
Gully)	Slope rockfish	C	1900	2250	2800
5E(S)	*S. alutus*	A	400	600	1000
	S. reedi	A	400	600	1000
	S. aleutianus	A	100	250	500
Jan-June	Slope rockfish	C	300	500	900
Sept-Dec	Slope rockfish	C	600	900	1300
5E(N)	*S. alutus*	A	b	b	b
	S. aleutianus	A	b	b	b
	Slope rockfish	C	b	b	b
Coastwide	*S. alutus*/*S. reedi*		2500	3100	3900
	S. aleutianus		100	250	400

[a]non-directed fishery.

[b]Open-fishery experiment.

Table 9.16. Simulated yield and biomass of Goose Is. S. *alutus* stocks, starting from 1986 age composition.

Years into future	F	Yield (t)	Biomass (t)
10	0.0	-	7890
	0.03	190	6660
	0.05	320	6640
	0.07	410	6260
	0.08	520	6120
	0.11	580	5700
	0.13	560	4970
20	0.0	-	11960
	0.03	180	8380
	0.05	240	7140
	0.07	270	5980
	0.08	300	5280
	0.11	300	4560
	0.13	260	3440
30	0.0	-	21350
	0.03	300	12340
	0.05	370	9520
	0.07	380	7070
	0.09	390	5650
	0.11	330	3970
	0.13	260	2870
100	0.0	-	72030
	0.03	1150	45800
	0.05	1120	27440
	0.07	770	14400
	0.09	420	6290
	0.11	190	2390
	0.13	80	910
200	0.0	-	71910
	0.03	1280	49830
	0.05	1440	35590
	0.07	1150	20900
	0.69	480	7290
	0.11	100	1250
	0.13	50	530

Table 9.17. Catches and percentages of total rockfish catch for the major species in the fishery north of 54°00'N (minor area 35), 1976-1986.

Year	Total rockfish	aleutianus	alutus	brevispinis	proriger	reedi
1976	0	0	0	0	0	0
1977	5.51	0	1.42/25.8	0	0	0
1978	48.22	0	22.22/46.1	15.70/32.6	0	0
1979	287.27	13.99/4.9	227.49/79.2	7.77/2.7	4.76/1.7	16.86/5.9
1980	105.05	2.58/2.5	84.56/80.4	15.45/14.7	0/0	0/0
1981	376.13	98.08/26.1	109.22/29.0	2.26/0.6	0.33/0.1	2.34/0.6
1982	691.53	69.09/9.9	342.23/49.5	37.57/5.4	13.27/1.9	67.88/9.8
1983	568.18	127.46/22.4	291.98/51.4	16.32/2.9	18.44/3.2	52.23/9.2
1984	2995.78	226.97/7.6	2186.33/72.9	248.34/8.3	110.85/3.7	72.8/2.4
1985	3230.61	465.37/14.4	1938.46/60.0	244.68/7.6	259.00/8.0	180.31/5.6
1986[a]	3740.08	180.64/4.8	2084.02/55.7	135.99/3.6	630.12/16.8	476.25/12.7

[a]To July 11, 1986.

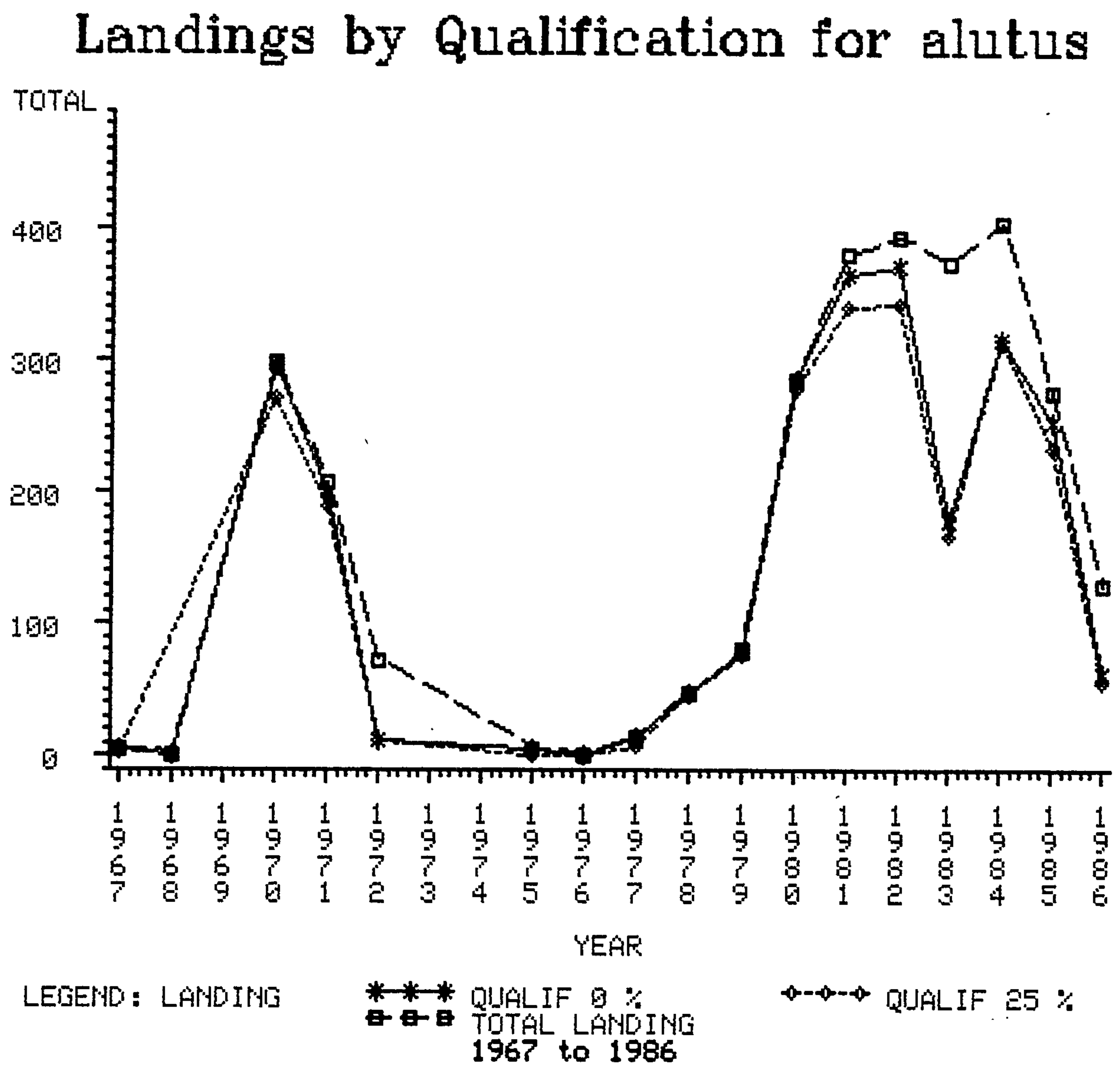

Fig. 9.1. Total, interviewed (0% qualification) and 25% qualification landings (t) of Pacific ocean perch (<u>Sebastes alutus</u>) for the southwest coast of Vancouver Island (Area 3C-N), 1967-1986.

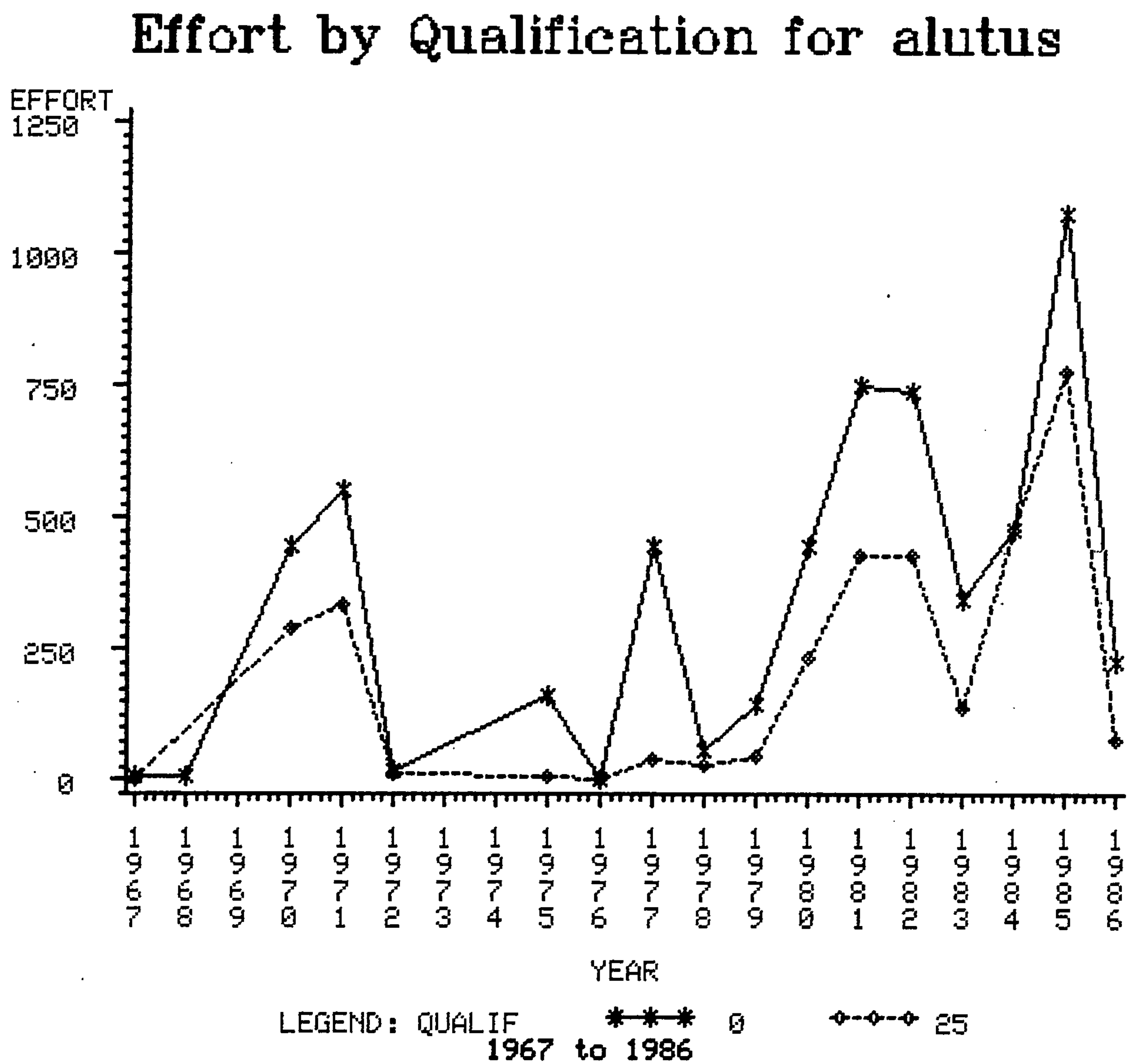

Fig. 9.2. Nominal and qualified (25%) effort (h) for the Pacific ocean perch (Sebastes alutus) fishery off southwest Vancouver Island (Area 3C-N), 1967-1986.

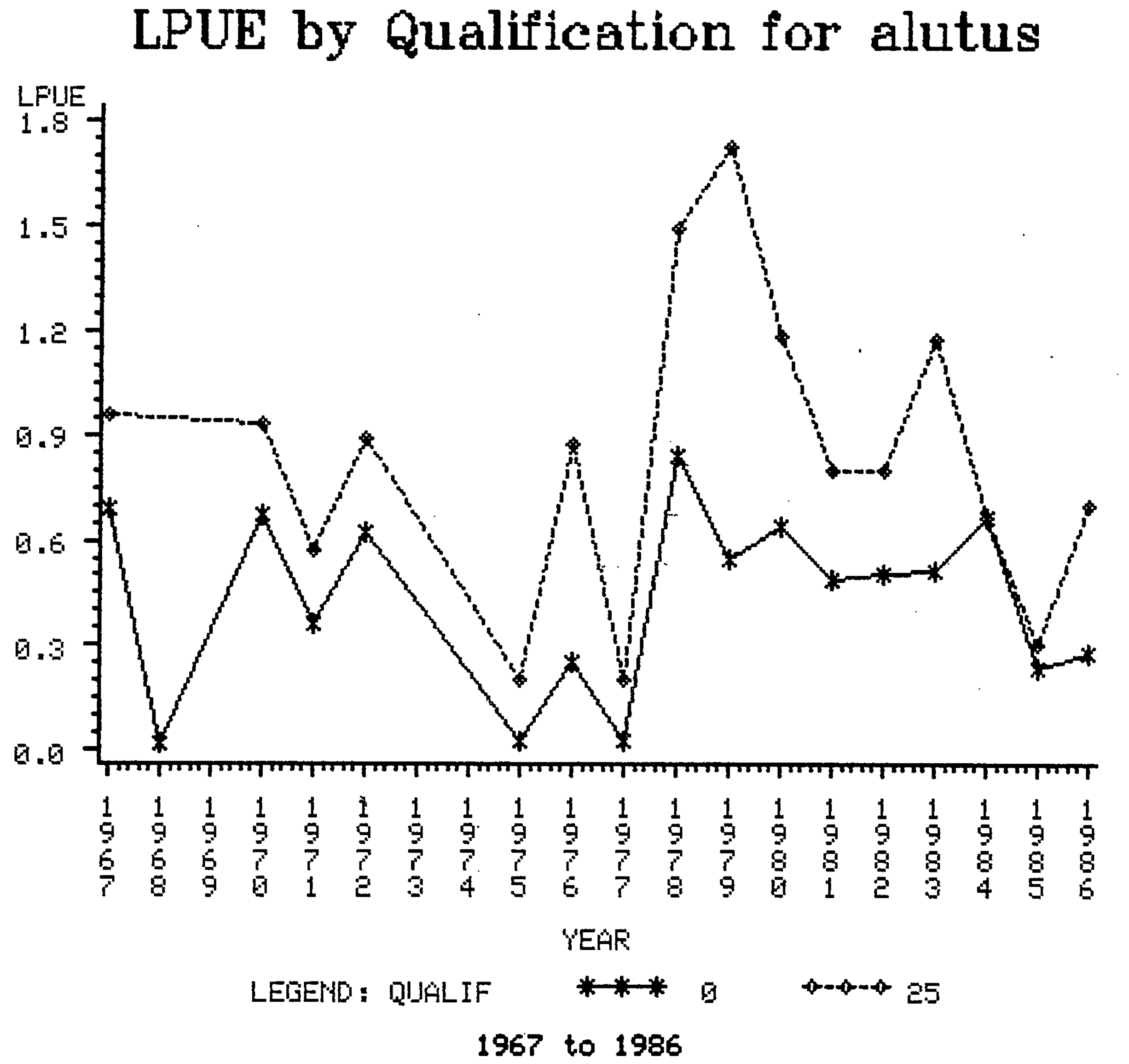

Fig. 9.3. Nominal and qualified (25%) LPUE (t/h) for the Pacific ocean perch (Sebastes alutus) fishery off southwest Vancouver Island (Area 3C-N), 1967-1986.

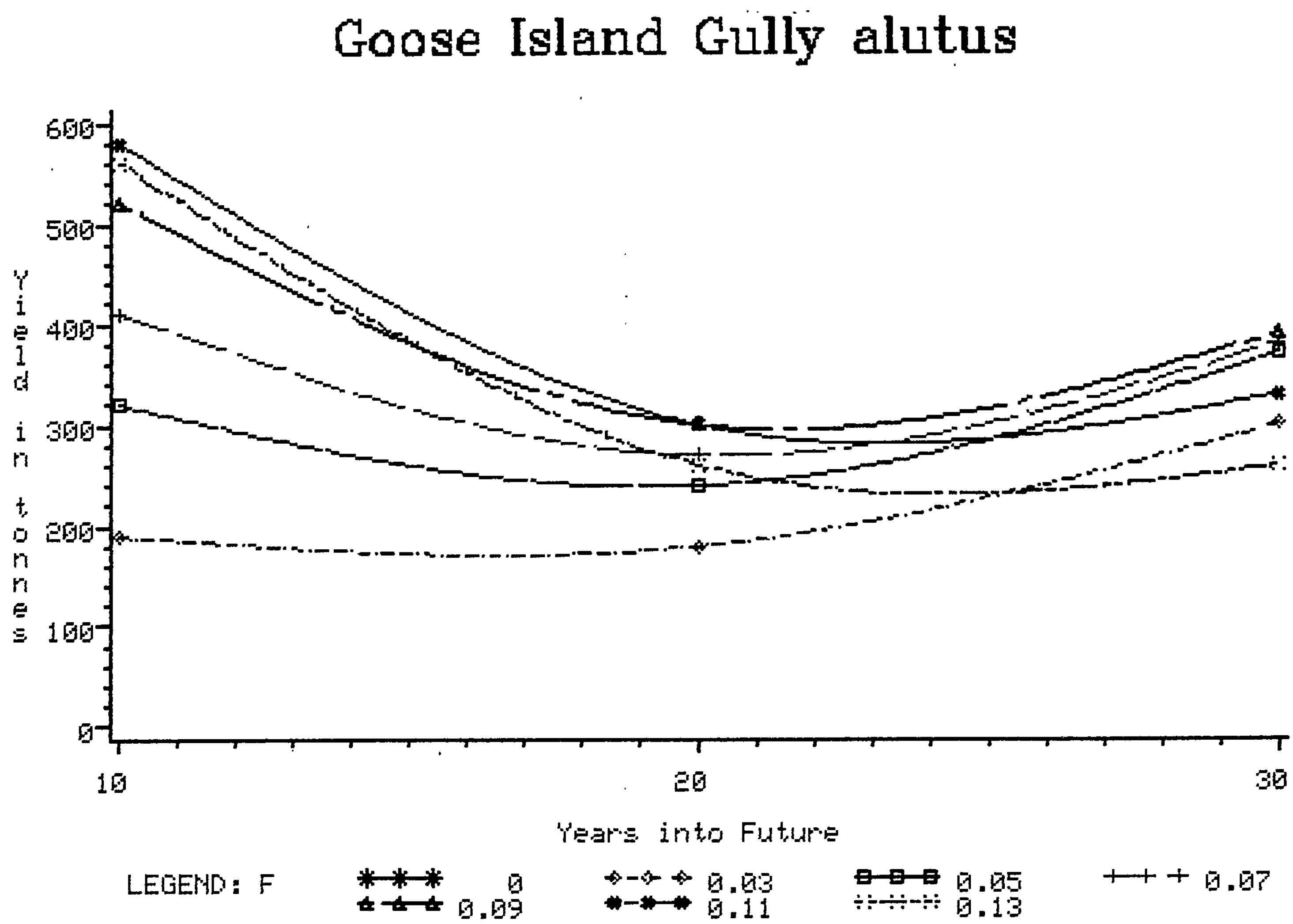

Fig. 9.4. Simulated yield (t) of Goose Is. Gully Pacific ocean perch (<u>Sebastes alutus</u>) at various levels of fishing mortality (F), with year 1 = 1985.

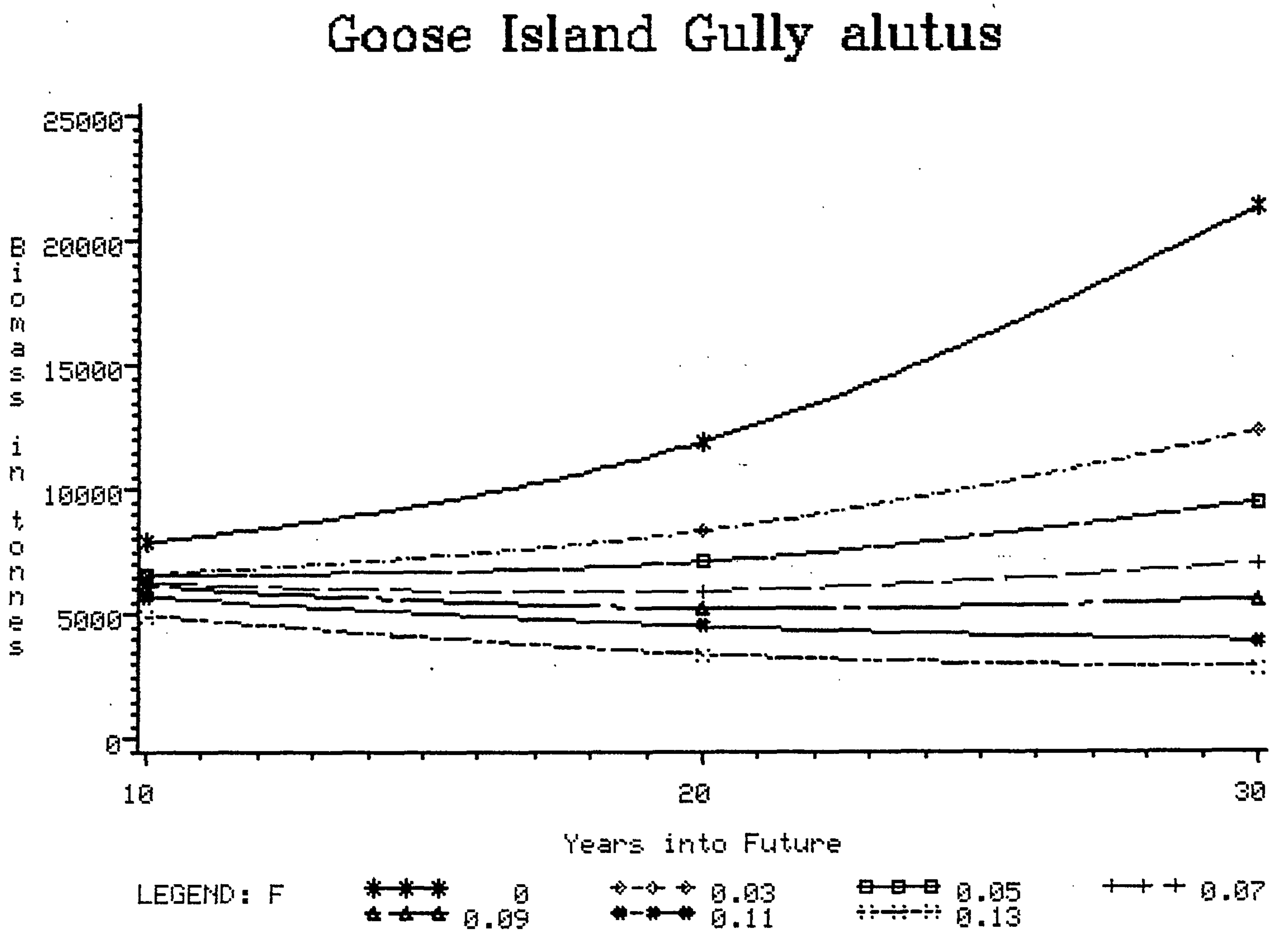

Fig. 9.5. Simulated biomass (t) of the Goose Is. Gully Pacific ocean perch (Sebastes alutus) stock at various levels of fishing mortality (t), with year 1 = 1985.

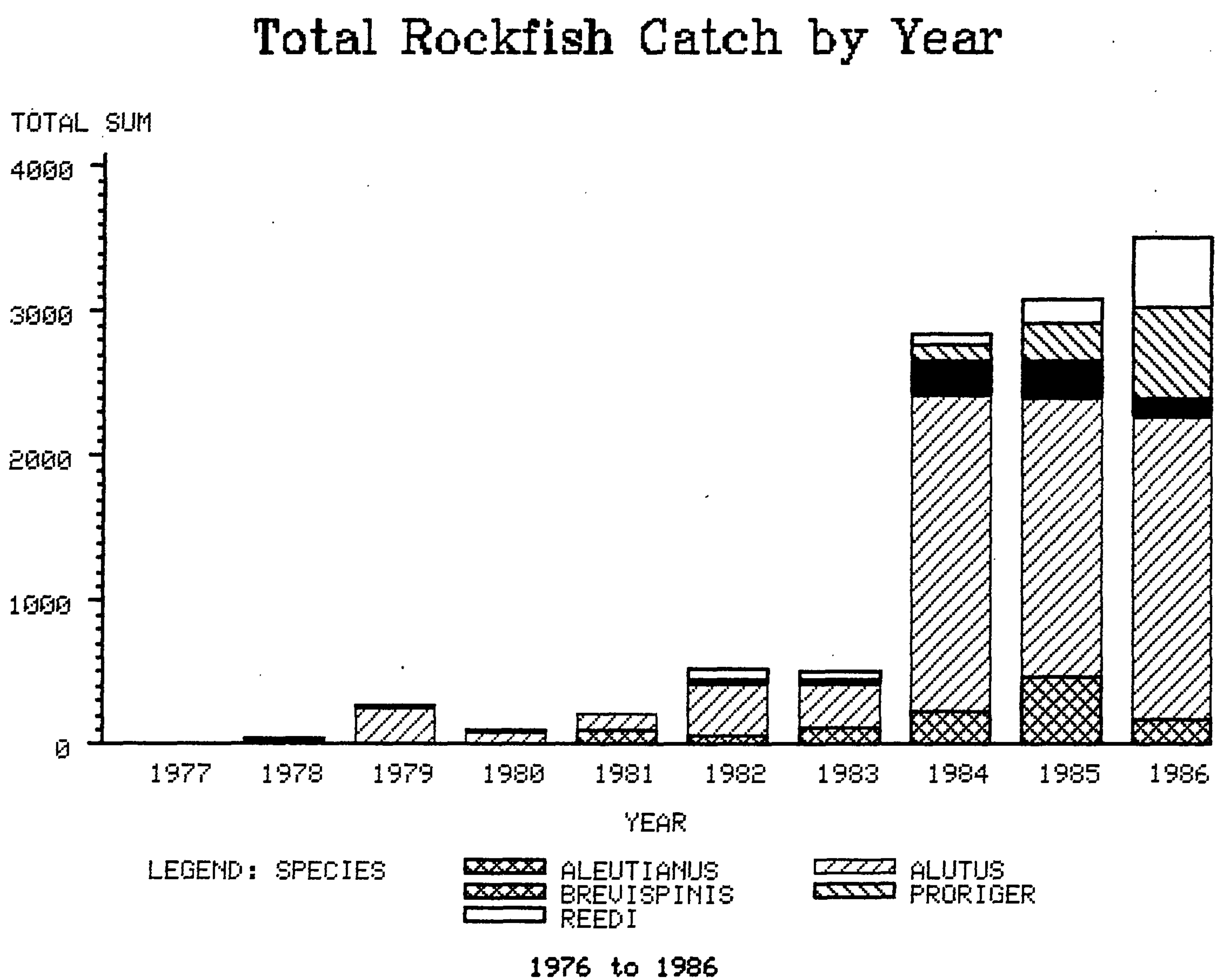

Fig. 9.6. · Total rockfish catch (t), by species, for the experimental fishing area 5E-N, 1977-1986.

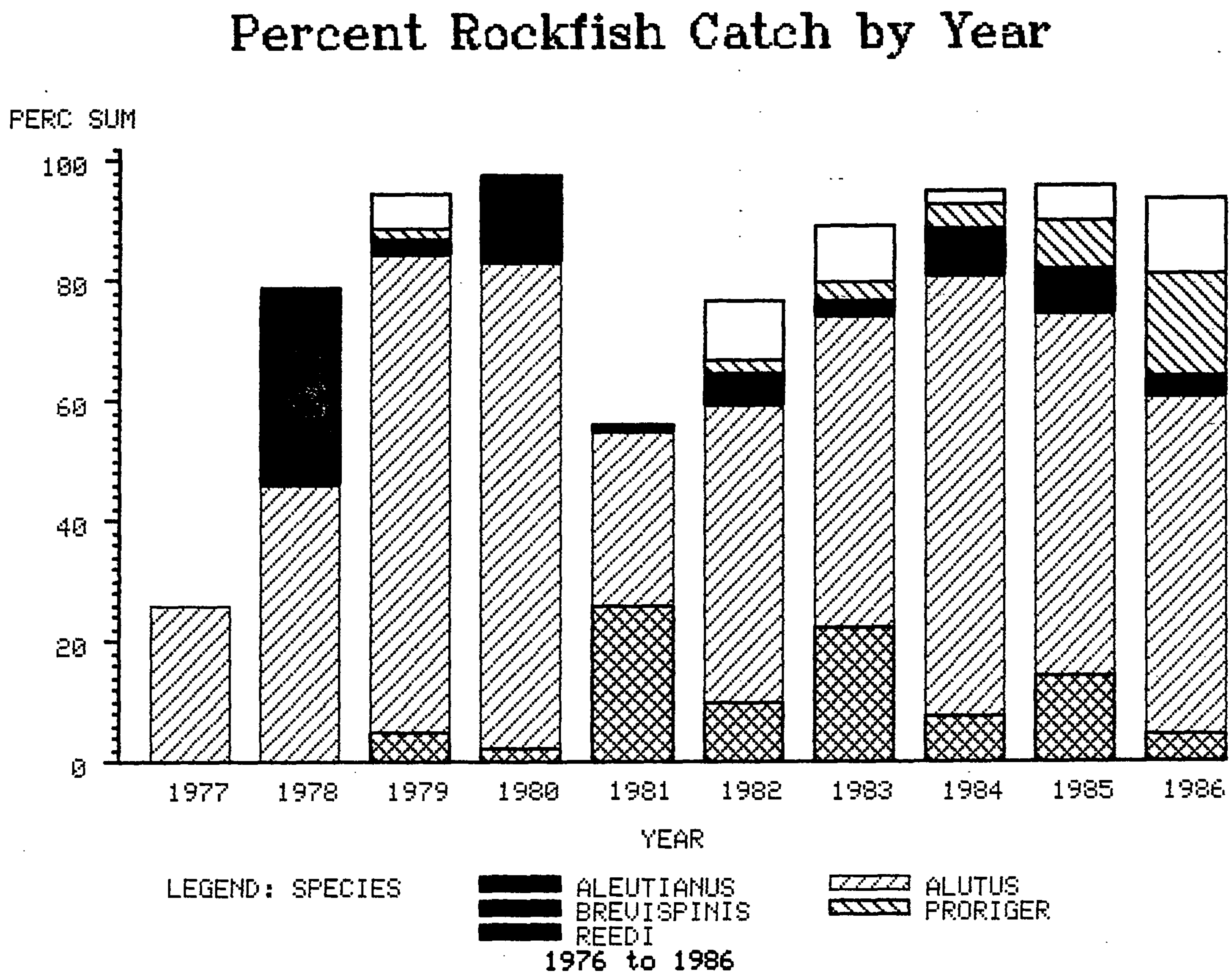

Fig. 9.7. Percent species composition of the rockfish catch in the experimental fishing area 5E-N, 1977-1986.

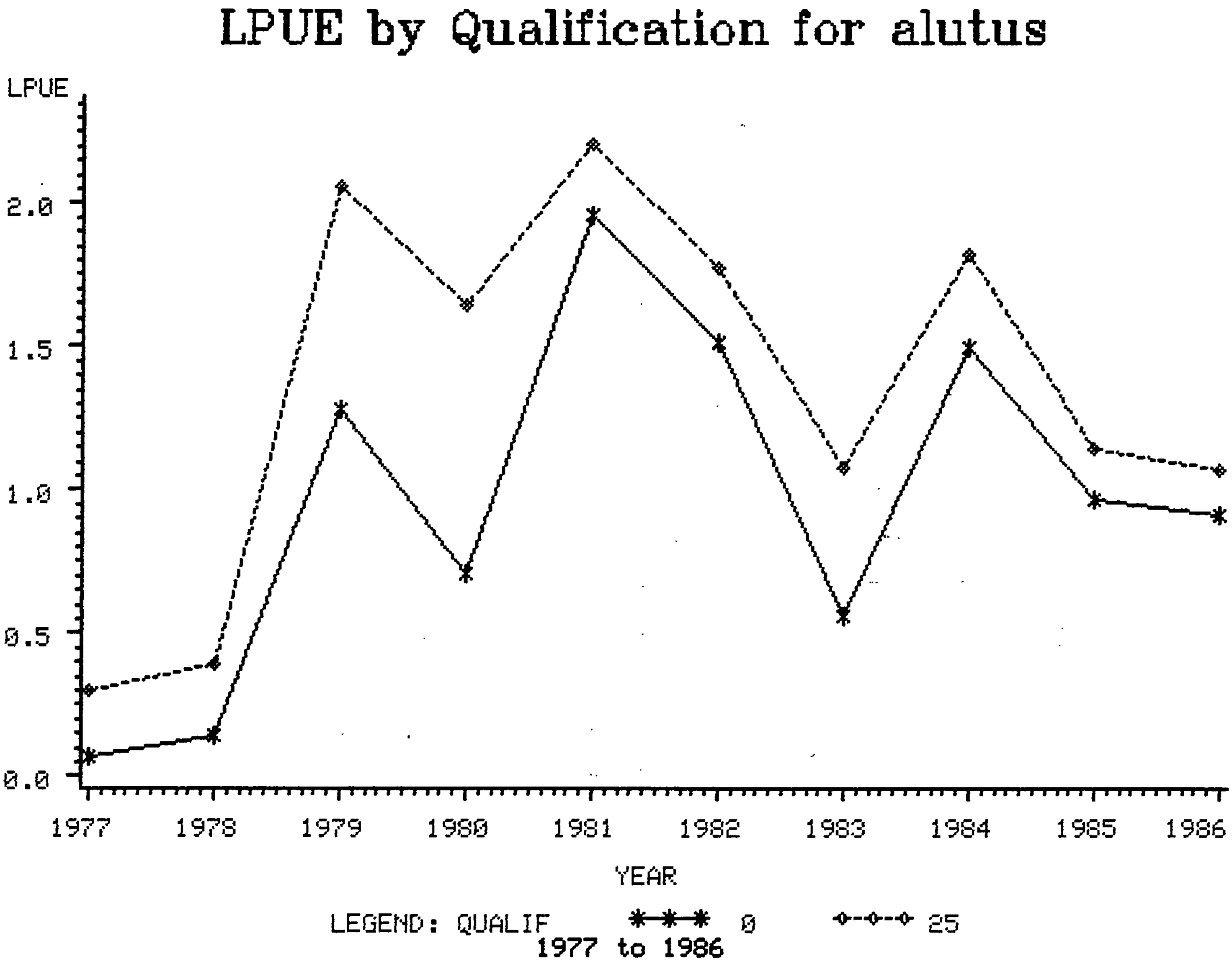

Fig. 9.8. Nominal and qualified (25%) LPUE (t/h) for Pacific ocean perch (Sebastes alutus) in Area 5E-N, 1977-1986.

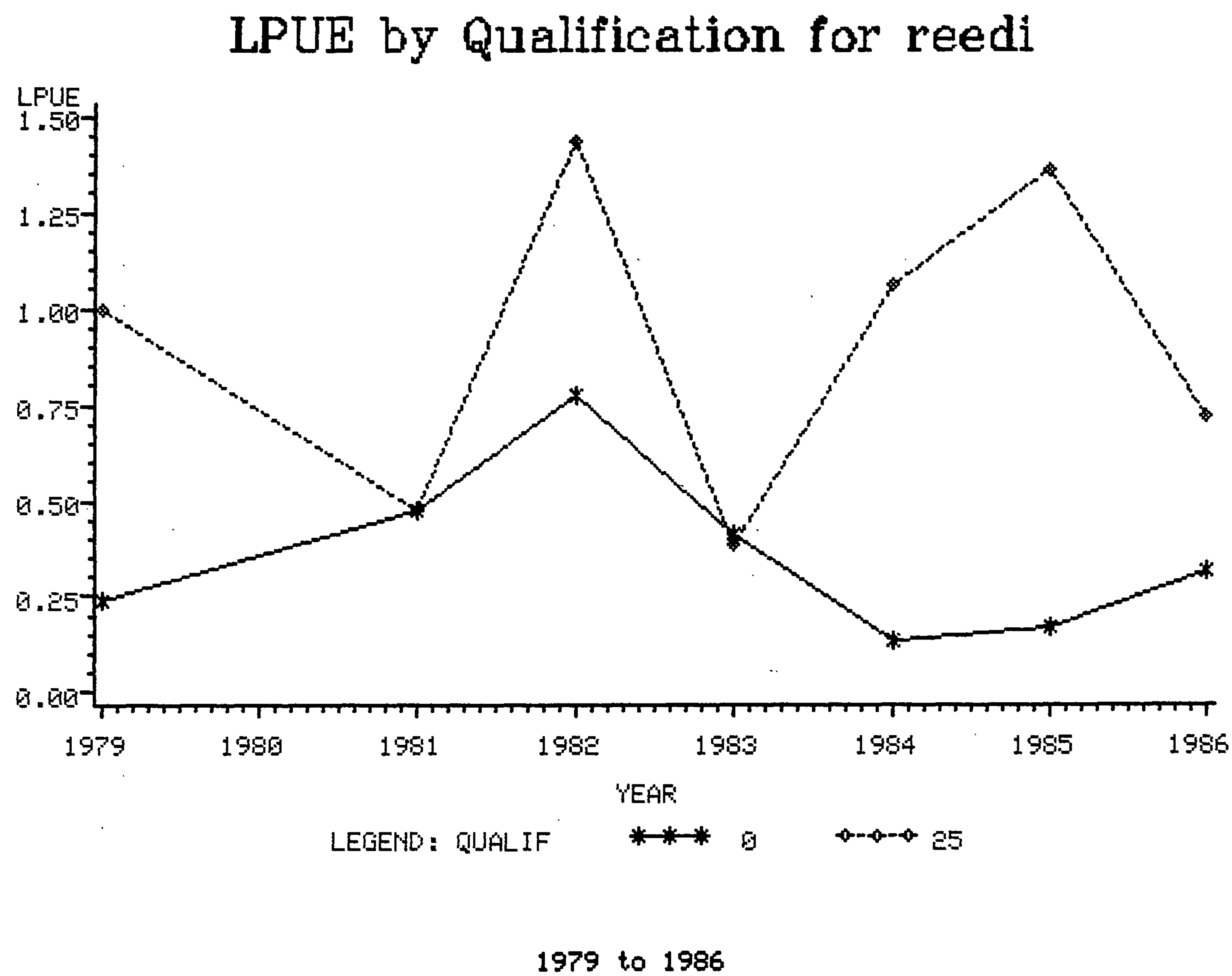

Fig. 9.9. Nominal and qualified (25%) LPUE (t/h) for yellowmouth rockfish (Sebastes reedi) in Area 5E-N, 1977-1986.

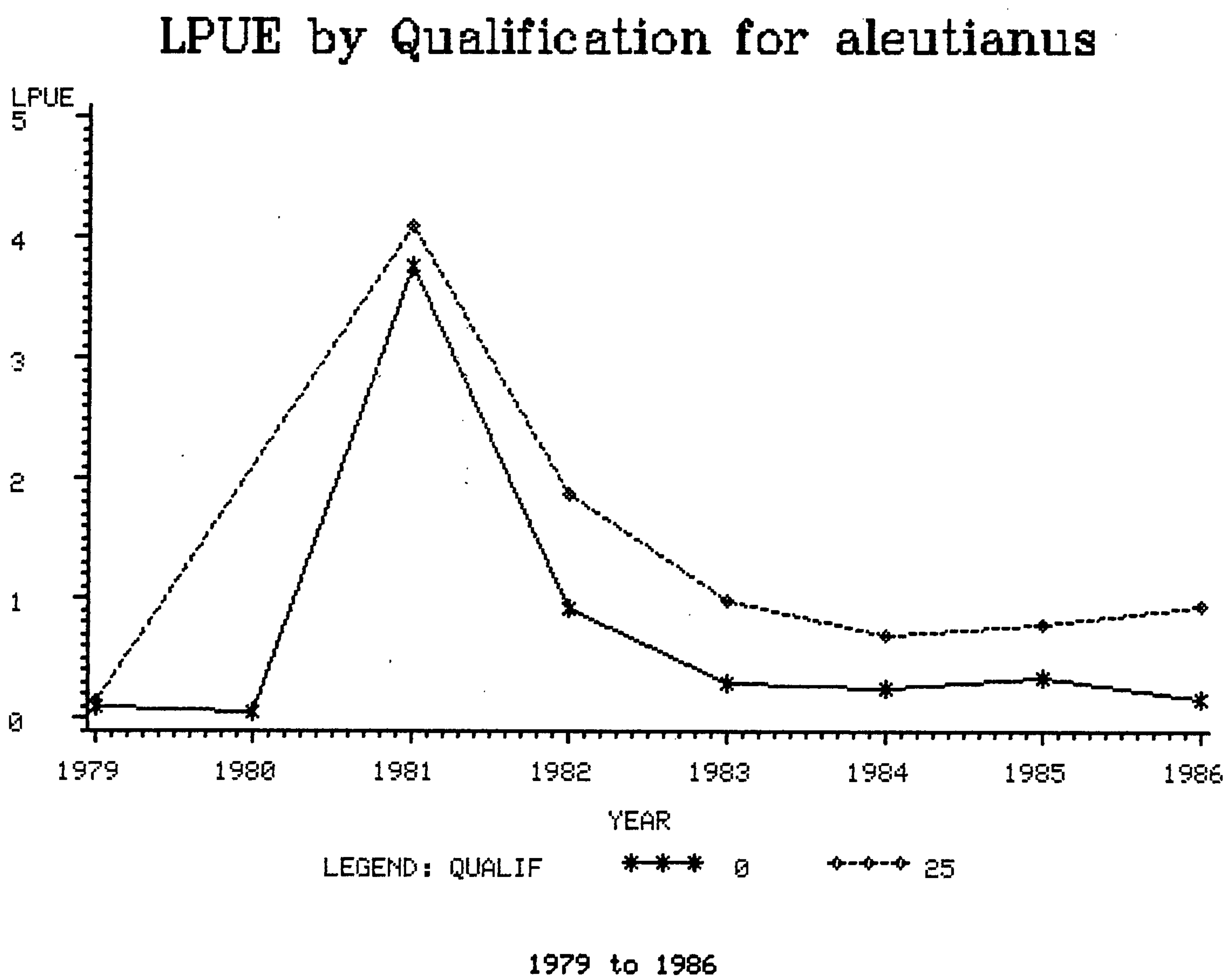

Fig. 9.10. Nominal and qualified (25%) LPUE (t/h) for rougheye rockfish (*Sebastes aleutianus*) in Area 5E-N, 1977-1986.

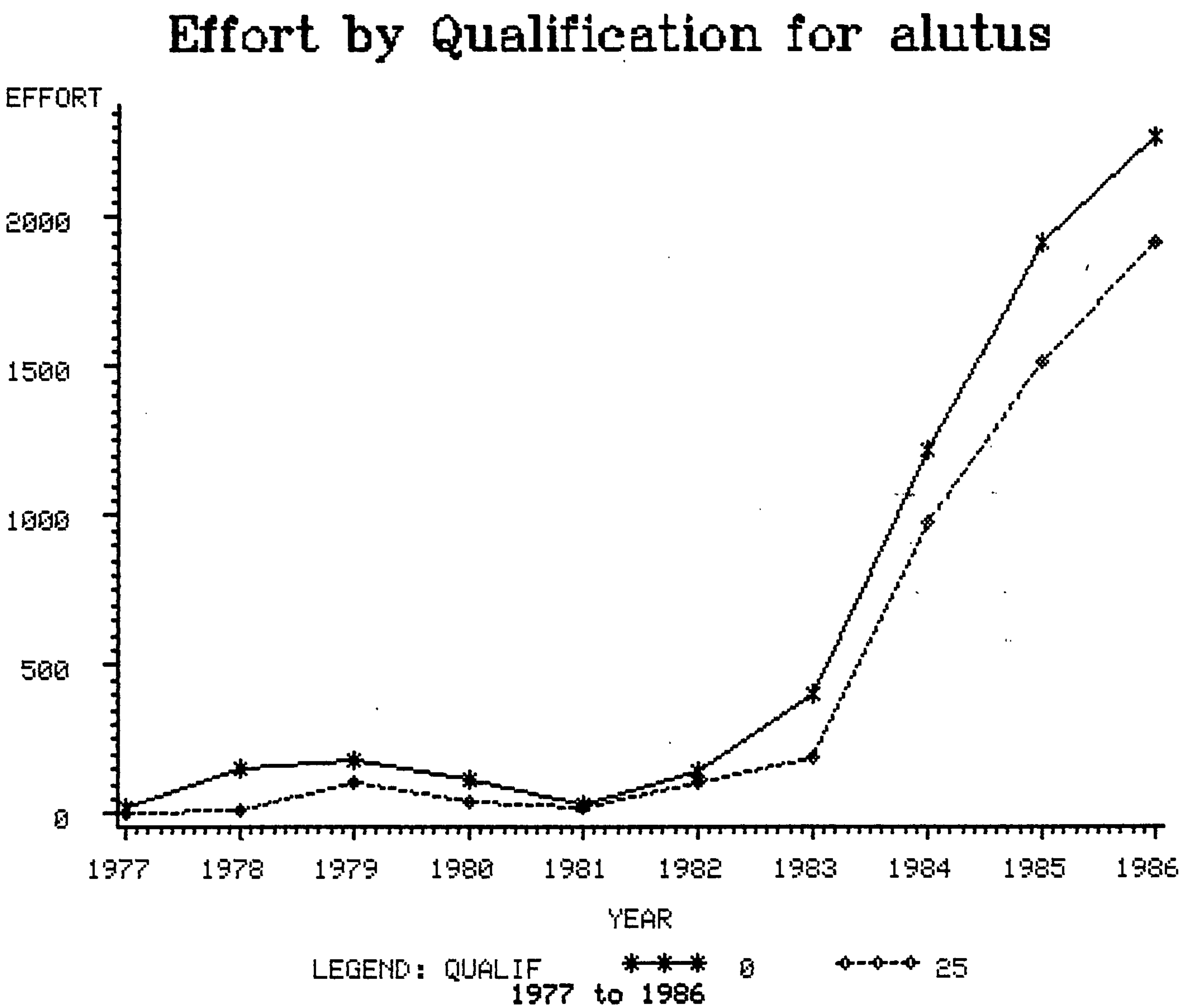

Fig. 9.11. Nominal and qualified (25%) effort (h) for Pacific ocean perch (Sebastes alutus) in Area 5E-N, 1977-1986.

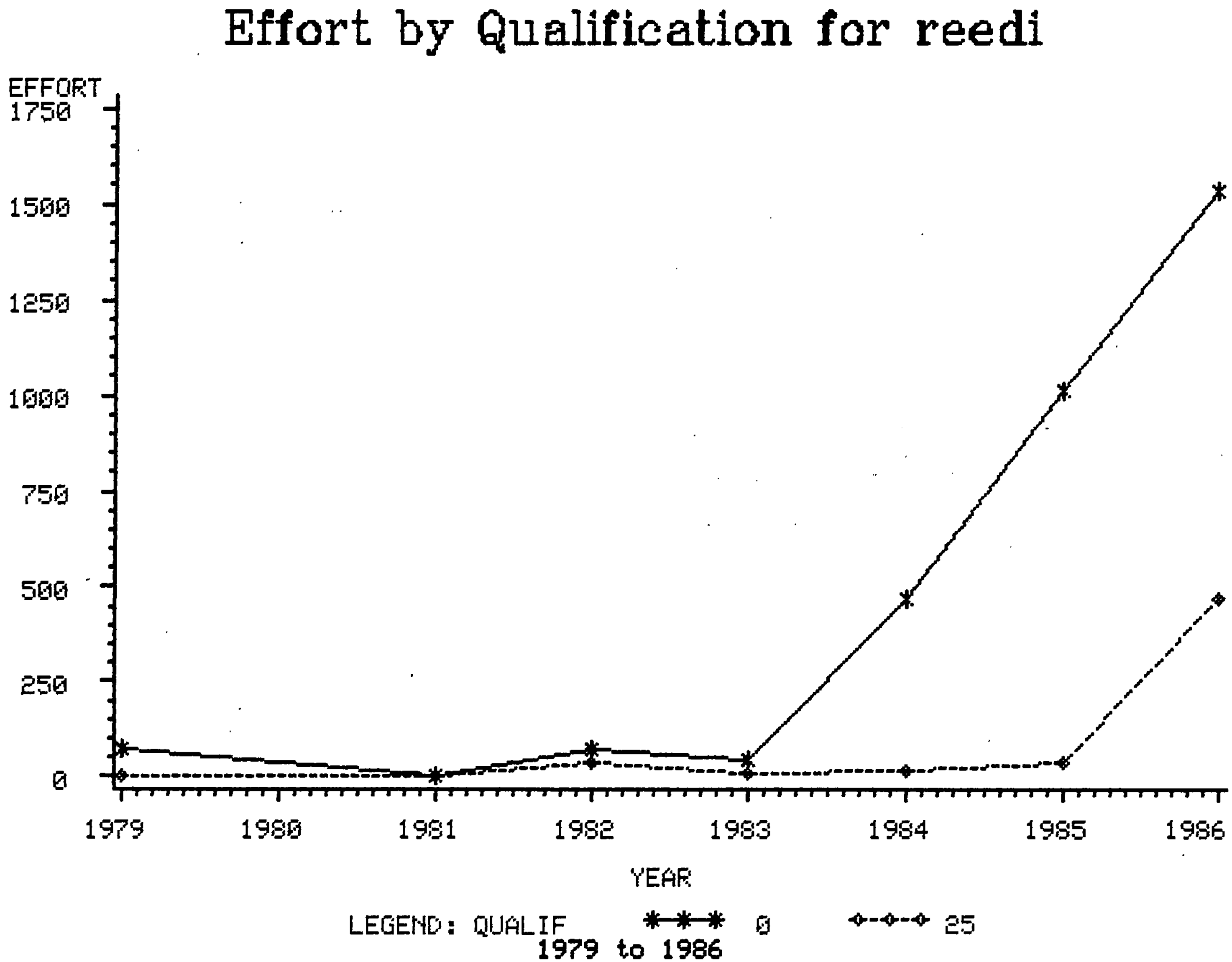

Fig. 9.12. Nominal and qualified (25%) effort (h) for yellowmouth rockfish (<u>Sebastes reedi</u>) in Area 5E-N, 1977-1986.

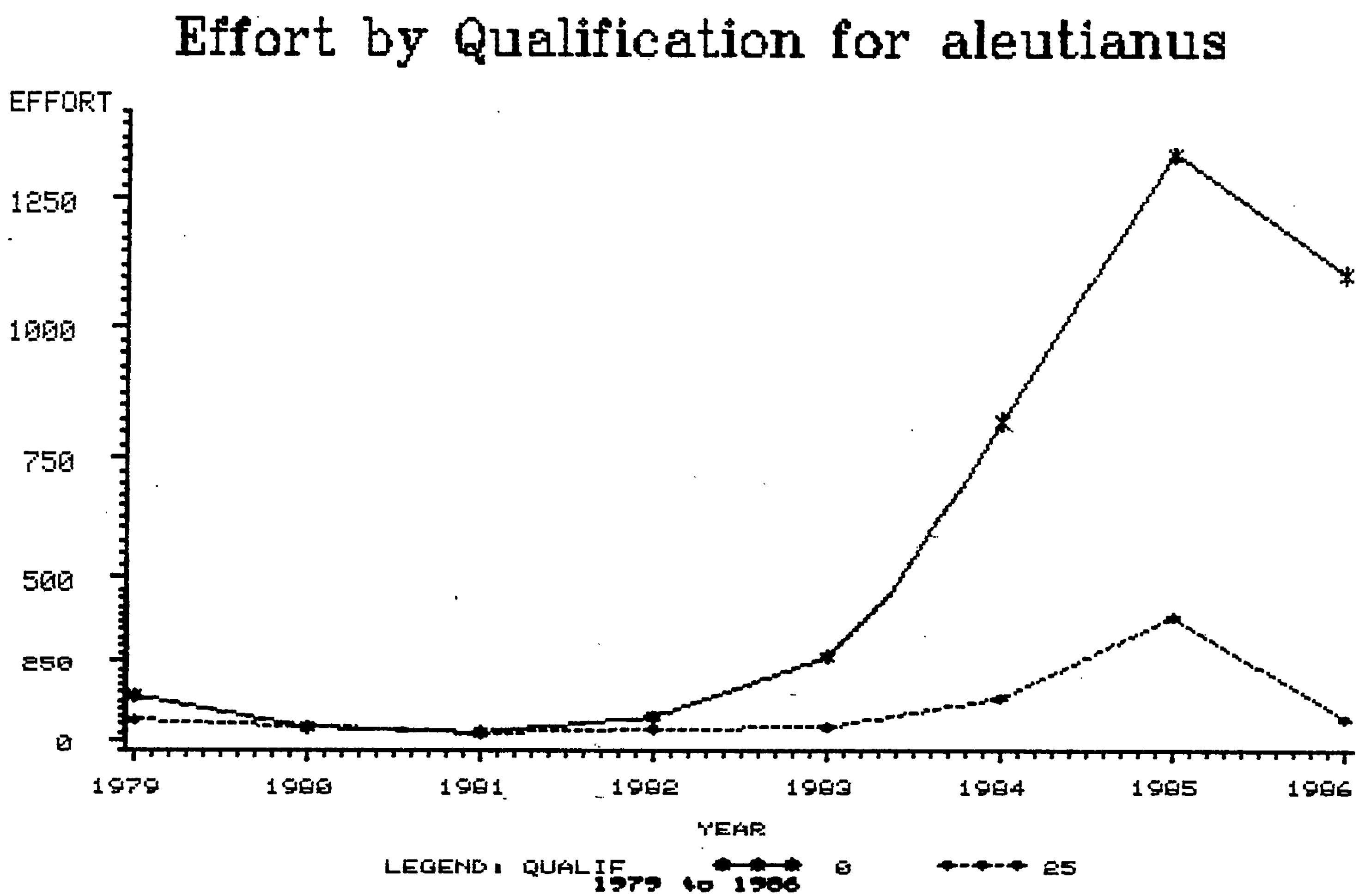

Fig. 9.13. Nominal and qualified (25%) effort (h) for rougheye rockfish (<u>Sebastes aleutianus</u>) in Area 5E-N, 1977-1986.

10.0 SHELF ROCKFISH (silvergray, yellowtail, and canary rockfish)

R. D. Stanley

10.0.1 General introduction and unit area productivity calculations

The yield option recommendations for 1985 (Stanley 1985, 1986) explained the present method for estimating sustainable yields for shelf rockfish. A summary follows. If an examination of recent trends in LPUE and length frequency composition provides no indication of over-exploitation, the mean 20-year yield is assumed to be a minimum estimate of sustainable yield. Guidelines were suggested for deriving a "sustainable yield" option from the minimum estimate based on such factors as the current yield of the fishery, rate of change in LPUE, length frequency composition and the quality of biological information. Mean 20-year yields have not changed significantly with the addition of the 1985 catches, therefore these estimates have not been re-calculated. They will be updated in the next year's document. The purpose of the present report is to examine recent data on LPUE and size composition relative to the yield options proposed for 1986.

10.0.2 Conditions of stock (unit area productivity)

We examined silvergray rockfish productivity relative to the surface area of the continental shelf. A compensating planimeter was used to estimate the shelf surface area (km^2) between 150 and 300 metres. This depth range, which accounts for 95% of all silvergray landings, was assumed to represent the extent of adult silvergray habitat.

Estimates of productivity for silvergray rockfish were based on mean long-term yield for the 3C-Canadian, 3D, and 5A+B stocks (Table 10.1). Estimate (a) of 500 t/year for 3C-U.S. was based on the 8-year mean (1977-84) yield. Catches from this area during this period were as follows: 1977, 983 t; 1978, 958 t; 1979, 1005 t; 1980, 243 t; 1981, 147 t; 1982, 60 t; 1983, 375 t; 1984, 478 t. Estimate (b) of 150-200 t/yr is an estimate of sustainable yield implied by a possible fishing down effect resulting from high yields of 1000 t per year from 1977 to 1979. If the 3000 t harvest from 1977 to 1979 was responsible for the sudden decline in yields to 60-243 t from 1980 to 1982, it suggests that the recruited biomass in 1977 could not have greatly exceeded 3000-4000 tons. In which case, a sustainable harvest rate of 5% for the initial biomass indicates a sustainable yield of 150-200 t. The decline in catches is however also correlated with peak activity in the widow rockfish fishery and may reflect reduced effort, therefore, the mean 8-yr yield of 500 t/year might be more representative. Estimates of productivity were not possible for the 5C+5D or 5E stocks because of their short history of exploitation.

The long-term yields of 3D and 5A+B are probably the best estimates of sustainable yield for this species given their long history of significant exploitation (>26 yr). Both results suggest a productivity of 0.08-0.10 $t/km^2/yr$.

The 3C data are not congruent with the area-productivity relationship observed for 3D and 5A+B. The explanation may lie in mis-allocation of catches. If some of the catches from the later 1970s in 3C-U.S. were actually captured in the 3C Canadian zone, then the two sets of results should be combined. In which case, the results at least for estimate (a') would roughly correspond with the productivity of 3D and 5A+B (Table 10.1).

The 3D and 5A+B results, if representative, imply that significant yields of silvergray rockfish can be expected from the developing fishery in Moresby Gully. This suggestion is supported by the increasing catches and high catch rates there in the last three years. It also implies that large yields are probably not likely from the west coast of the Queen Charlotte Islands. The linear relationship based on minimum estimates of 3D and 5A+B productivity predicts sustainable yields of at least 1000 and 200 t respectively for Moresby Gully and the west coast of the Queen Charlotte Islands.

10.1 Coastwide

10.1.1 Silvergray and Canary Rockfish

10.1.1.1 Introduction

Coastwide yield options for shelf rockfish were adopted for the first time for the 1986 fishing year. Management selected a 4100 t yield option for combined canary and silvergray rockfish and no limiting quota for yellowtail rockfish. FRB biologists listed separate coastwide "sustainable" yields of 1350 t, 1500 t, and 1050 t for silvergray, yellowtail and canary rockfish, respectively. The lower FRB recommendations reflected the concern that coastwide quotas be conservative in the event that the fleet direct a disproportionate share of effort at one stock or species.

10.1.1.2 Landing Statistics

Although the 1986 fishing year was not completed at the time of report preparation, it was possible with the landings to August 1 to examine how the fishing pressure was distributed. Table 10.2 includes the 1986 recommended sustainable yield options and the landings to August 1, 1986. Only the silvergray and yellowtail catches in 3D indicate the likelihood of significant catch overrun. The implications of the yellowtail catches are discussed in 10.1.2.2. The silvergray catch is almost twice the recommended sustainable level and three times the minimum estimate of the long-term yield for this area. This overrun results because 1) the coast-wide combined quota for canary and silvergray is in excess of the recommended sustainable yields for the traditionally fished stocks (4100 t versus 3050 t), 2) canary rockfish landings were low, leaving the balance to silvergray, and 3) effort and catch rates were not distributed in proportion to the estimated sustainable yields. While little can be done to re-distribute effort given the framework of a coast-wide quota, the overrun can be reduced by choosing lower quotas initially and, if practicable, separate quotas for the two species. Although silvergray and canary rockfish are often captured coincidentally, the problem of incidental catches can be minimized through instituting large trip limits (i.e. 50,000 lbs) as soon as a relatively low percentage of the coast-wide quota is captured (i.e. 50%).

10.1.1.3 Recommendations

Coast-wide yield options are not changed from 1986 (Table 10.3). We continue to recommend the approach of using the sum of the sustainable options from only the principal historical centers of production. For silvergray, the sustainable coast-wide option would equal the sum of sustainable options for 5A+B and 5C+D (750 + 600 = 1350 t). Conservative and non-sustainable yield options would be 700 and 2000 t. The coast-wide sustainable option for canary rockfish equals the sum of the sustainable yield options from 3D and 5A+B (550 + 500 = 1050 t). Conservative and non-sustainable yield options are 550 and 1600 t. The combined yield option for these two species could equal the sum of the two values, 2400 t. If the two species were managed separately, the chance of overrun would be reduced.

10.1.2 Yellowtail Rockfish

10.1.2.1 Introduction

Yellowtail rockfish stock dynamics remain poorly understood. Availability is highly unpredictable and variable in time and space. Size composition is also highly dependent on gear type with mid-water catches typically being composed of larger fish. However, while stock dynamics are poorly understood, the species shares the life history parameters of other rockfish and is therefore presumed to be highly vulnerable to overfishing. This is indicated by U.S. stock assessments for the Columbia and Vancouver INPFC areas (Tagart 1984).

10.1.2.2. Landing Statistics

The mobility of yellowtail rockfish, as indicated in tagging studies, implies that there is one coast-wide stock. This in turn suggests that a coast-wide yield option is biologically justifiable. Similarly, the overrun of yellowtail catches for 1986 in Area 3D relative to the sustainable yield option is not viewed as a concern since it is balanced by the low catch in Area 5A+B.

10.1.2.3 Recommendations

We recommend the same coast-wide yield options as 1986 of 750 t (conservative), 1500 t (sustainable), and 2250 t (non-sustainable). This is based on the Queen Charlotte Sound sustainable yield option.

10.2 Strait of Georgia (4B)

Silvergray, yellowtail, and canary rockfish yields are not significant in the Strait of Georgia.

10.3 West Coast Vancouver Island (3C/3D)

10.3.1 Silvergray Rockfish--Southern Stocks (3C)

Biological material collected in the 1985 shelf rockfish charter indicated a stock of relatively small (young) fish. Recommendations for the conservative, sustainable and non-sustainable yield options are unchanged from 1986: a non-directed (incidental) fishery (conservative); 100 t (sustainable); and 200 t (non-sustainable).

10.3.2 Yellowtail Rockfish--Southern and Northern Stock (3C + 3D)

The current stock assessment for west coast Vancouver Island yellowtail rockfish combines Areas 3C and 3D. Assessments for this fishery continue to be hampered by a lack of information on the incidental catches in the offshore hake fishery.

Domestic landings to August 1, 1986 totalled 1017 t, five times the historic mean yield by domestic trawlers. As yearly landings, they have only been exceeded by large estimated Polish catches of 6700 and 2339 t in 1975 and 1976.

If yellowtail stocks are non-mobile, the 1986 harvest may represent significant overfishing. One biological sample was obtained in 1986 with mean length of 44.5 cm for males and 46.7 cm for females. These means were larger than 1985 results and are larger than what is currently found in the U.S. stocks. However, even if 1986 yields are excessive, mean size cannot be expected to decline within the first year of over-harvest.

We recommend that yellowtail be managed on a coast-wide basis. If however area-specific yield options are adopted, we continue to recommend yield options which reflect the long-term catch by U.S. and Canadian fleets for this area. The conservative, sustainable and non-sustainable yield options are unchanged, from the sum of the 3C and 3D options for 1986: a non-directed (incidental) fishery, 250 t and 450 t.

10.3.3 Canary Rockfish--Southern Stock (3C)

Samples collected aboard the 1986 HOWE BAY charter indicated a bi-modal size composition for both sexes. The larger mode of 53-54 cm indicated that older fish continue to persist in the population. The larger mode was not observed in a 1983 sample.

Recommendations are unchanged from 1986: a non-directed (incidental) fishery as the conservative option, a sustainable yield option of 200 t and a non-sustainable yield option of 300 t.

10.3.4 Silvergray and Canary Rockfishes--Grouped Yield Option for Southern Stocks (3C)

Yield options are reduced slightly with the assumption that yellowtail rockfish will be covered by a specific coast-wide quota. The conservative, sustainable and non-sustainable yield options are: a non-directed (incidental) fishery, 250 t and 400 t.

10.3.5 Silvergray Rockfish--Northern Stock (3D)

Catch rates have remained stable for this fishery during the last four years of significant Canadian landings. Biological samples collected in 1985 tend to indicate relatively high estimates of instantaneous total mortality, ranging from 0.20 to 0.25. The derivation of these estimates is described in Stanley 1985. The method involves a graphical comparison of observed length frequency versus a theoretical length frequency derived for a given value for Z. As the instantaneous natural mortality rate for this species is approximately 0.05, these total mortality rate results are a source of concern. A more thorough analysis will be possible with the results of the 1986 charter and will be available for the 1987 assessment. In the interim, the conservative, sustainable and non-sustainable recommendations are unchanged from 1986: 150 t, 350 t, and 700 t.

10.3.7 Canary Rockfish--Northern Stock (3D)

Qualified catch rates declined slightly in 1985 from 1984 (0.80 to 0.74 t/hr) and preliminary data from 1986 indicates an even lower LPUE of 0.50. Samples collected on the 1985 charter showed a bi-modal distribution for both sexes at 48-49 cm and 53-54 cm. The 53-54 cm mode indicates a continued presence of older fish while the 48-49 cm mode possibly indicates one or more incoming year-classes. A commercial sample also indicated the continued presence of older fish. The length frequency distributions for both sexes indicated Z values of 0.10-0.15.

The continued presence of larger (older) fish indicates that the long-term mean yield of approximately 500 t still represents a minimum estimate of the sustainable yield. In light of the relatively poor fishery in 1986 however, we suggest that 1986 conservative, sustainable and non-sustainable yield options be left unchanged at 300,550 and 800 t respectively. The 550 t sustainable option represents only a modest increase over the long-term mean yield of 500 t.

10.3.8 Silvergray and Canary Rockfishes--Grouped Quota for Northern Stocks

For Area 3D, the optimal catch ratio of silvergray to canary based on the ratio of recommended sustainable options is 0.64 (350/550). The ratios for the last four years have been 0.58, 0.79, 0.52, and 1.12 with a mean of 0.75. If area specific quotas are used, silvergray and canary quotas could be combined should managers feel it would be more practical. The recommended conservative, sustainable, and non-sustainable combined options would be

400 t, 800 t, and 1500 t, unchanged from 1986. Owing to the variability in the ratios, options are slightly lower than the sum of the two quotas to avoid significant overruns for one species. The combined catch for 1985 was 1538 t. The total catch to August 1, 1986 was 917 t.

10.4 Queen Charlotte Sound (5A/5B)

10.4.1 Silvergray Rockfish

Catches continue to exceed the 19-year mean yield of 700 t. Total landings in 1984 and 1985 were 922 and 905 t. Qualified catch rates appear stable over the last eight years during a significant directed fishery by Canadian vessels. No recent biological samples are available from this area. A rockfish sampling trip aboard the FRV W.E. RICKER is proposed for 1987 to collect baseline biological data on this stock.

While catch rates do not indicate any sign of overfishing, the lack of biological data with which to monitor suggests that the sustainable yield options be only 10% greater than the long-term mean yield. Yield options are unchanged from 1986 at 400,750 and 1100 t for the conservative, sustainable, and non-sustainable levels, respectively. The sustainable level represents a modest increase over the long-term yield.

10.4.2 Yellowtail Rockfish

Landings remained low in 1985 (330 t) but increased in 1986. The total to August 1 equalled 626 t. Qualified catch rates indicate a moderate increase from 0.45 to 0.55 t/hr. All three biological samples from commercial landings collected in 1985 and 1986 indicate relatively small fish with males averaging 43.5 cm (n=500) and females averaging 43.4 cm (n=399), but all three samples were from bottom trawl catches which tend to produce smaller fish.

We recommend a coast-wide option for this species (Section 10.3). If area-specific quotas are adopted, the recommended conservative, sustainable and non-sustainable options for yellowtail in 5A+B are 750, 1500 t and 2500 t.

10.4.3 Canary Rockfish

Canary rockfish landings declined to 369 t in 1985, partially because the silvergray-canary combined quota was taken predominantly in silvergray rockfish. The qualified catch rate was approximately equal to the three previous years (1982: 0.3; 1983: 0.35; 1984: 0.33; 1985: 0.29 t/hr). No biological samples have been collected in recent years. Recommendations are unchanged from 1986. The sustainable option is set at 500 t, 30% above the mean yield. The conservative and non-sustainable options are 250 and 750 t.

10.4.4 Silvergray and Canary Rockfishes--Grouped Quota for Queen Charlotte Sound

The optimal ratio of silvergray to canary catches should equal the ratio of sustainable yield options, or 1.5 (750/500). The ratio in 1985 was 2.4 and to July 1 for 1986 was 2.5. We suggest that separate species quotas be adopted for these two species either on an area or coastwide basis. If a combined option is chosen for Queen Charlotte Sound, we again recommend a combined sustainable yield which prevents overfishing of silvergray at the cost of not fully harvesting the canary rockfish allotment. The recommendations for conservative, sustainable and non-sustainable are unchanged from 1986 at 500 t, 1100 t, and 1700 t respectively.

10.5 Hecate Strait (5C/5D)

10.5.1 Silvergray Rockfish

Landings reached an all-time high of 1023 t in 1985 and were limited by quota restrictions. The qualified catch rate of 1.35 t/hr was the highest on record. Four samples were obtained from commercial landings in 1985. There was considerable variation in length frequency compositions among the samples but in general they continued to show a strong presence of larger (older) fish. Two samples have been aged. They both indicated that a large proportion of the older fish are in the 30- 40-year-old range.

Recommendations are unchanged from 1986. We continue to recommend a 600 t sustainable yield option through 1985. This represents a 168% increase over what appears to be a minimum estimate of the sustainable yield. Conservative and non-sustainable options are 300 and 900 t. As discussed in the introduction, the area may sustain a long-term yield of 1000 t/hr but a more conservative development by stages is recommended for this fishery.

10.5.2 Yellowtail Rockfish

Landings of yellowtail rockfish in Hecate Strait continue to be low with 189 t landed in 1985 and 26 t to August 1 in 1986. No recent biological samples have been collected. A coast-wide quota for yellowtail is recommended. Should area-specific quotas be required, we suggest combining north and south Hecate Strait with yield options of 200 t (conservative), 500 t (sustainable), and 800 t (non-sustainable).

10.5.3 Canary Rockfish

Landings of canary rockfish from Hecate Strait continue to be low with 190 t landed in 1985 and 27 t landed in August 1, 1986. One biological sample was collected in 1985 which indicated very large (old) males and small females. We recommend that canary rockfish quotas for north and south Hecate Strait be combined. The conservative, sustainable, and non-sustainable options are 150 t, 300 t, and 600 t respectively.

10.6 West Coast of the Queen Charlotte Islands

10.6.1 Silvergray Rockfish

Landings of silvergray rockfish from 5E-N (248 t, 1984; 245 t, 1985) may represent overfishing, but no restrictions are recommended until the experimental period of open fishing for Pacific ocean perch is terminated. Conservative, sustainable and non-sustainable yield options are a non-directed (incidental) fishery, 100 t and 200 t.

10.6.2 Yellowtail and Canary Rockfish

Landings of these species continued to be negligible in 1985 (yellowtail, 5 t; canary, 9 t). Guideline sustainable yields are unchanged from 1986. For canary rockfish, we recommend 200 t and 400 t for 5E(N) and 5E(S) respectively. The suggested yield options for yellowtail rockfish are 200 t for both 5E(N) and 5E(S). we recommend however, that these yellowtail fisheries be part of a coast-wide yield option.

Table 10.1 Comparison of Continental shelf surface area with estimates of sustainable yield for silvergray rockfish.

Stock	Shelf surface area (km^2)	Mean yield (t/yr)	Productivity ($t/km^2/yr$)
3C - U.S.	1,600	(a) 500 (b) 150-200	0.31 0.09-0.125
3C - Canadian	3,700	20	0.01
3C - US and Canadian combined	5,300	(a') 520 (b')170-220	0.10 0.03-0.04
3D	2,600	200	0.08*
5A + B	7,200	700	0.10*
5C + D	10,300	(1000?)	-
5E	2,600	(200?)	-

*Assumed to be better estimates as they are derived from longer time series.

Table 10.2. The recommended 1986 sustainable yield options compared with catches to August 1, 1986.

Area	Rockfish species	Sustainable yield option	1986 catch (to August 1)
3C	Silvergray	100	142
	Canary	200	102
3C+D	Yellowtail	250	1017
3D	Silvergray	350	656
	Canary	550	261
5A+B	Silvergray	750	258
	Yellowtail	1500	626
	Canary	500	136
5C+D	Silvergray	600	730

Table 10.3. Yield options (t) for shelf rockfish (silvergray, yellowtail, and canary).

Area	Rockfish species	Conservative	Sustainable	Non-sustainable
Coast	Silvergray	750	1500	2250
	Yellowtail	750	1500	2250
	Canary	650	1275	1900
	Canary and silvergray	1200	2400	3600
3C	Silvergray	non-directed	100	200
	Canary	n.d.	200	300[a]
	Canary and silvergray	n.d.	250	400[b]
3C+D	Yellowtail	n.d.	250	450
3D	Silvergray	150	350	700
	Yellowtail	n.d.	150	250
	Canary	300	550	800
	Canary and silvergray	400	800	1500
5A+B	Silvergray	400	750	1100
	Yellowtail	500	1500	2500
	Canary	250	500	750
	Canary and silvergray	500	1100	1700
5C+D	Silvergray	300	600	900
	Yellowtail	200	500	750
	Canary	150	300	600
5E(N)	Silvergray	----------	100[b]	----------
	Yellowtail	----------	200[b]	----------
	Canary	----------	200[b]	----------
5E(S)	Silvergray	----------	350[b]	----------
	Yellowtail	----------	200[b]	----------
	Canary	----------	200[b]	----------

[a]Joint international quotas recommended if catches exceed suggested non-sustainable levels.

[b]Little knowledge of resource status.

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