Reconstruction of Pacific Ocean Perch *(Sebastes alutus)* Stock History in Queen Charlotte Sound. Part II. Catch per Unit of Effort as a Measure of Abundance, 1959-79

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RECONSTRUCTION OF PACIFIC OCEAN PERCH (SEBASTES ALUTUS) STOCK HISTORY IN QUEEN CHARLOTTE SOUND. PART II. CATCH PER UNIT OF EFFORT AS A MEASURE OF ABUNDANCE, 1959-79

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ABSTRACT

Ketchen, K. S. 1981. Reconstruction of Pacific ocean perch (Sebastes alutus) stock history in Queen Charlotte Sound. Part II. Catch per unit of effort as a measure of abundance. Can. MS Rep. Fish. Aquat. Sci. 1599: 72 p.

Statistics of the Canadian fishery for Pacific ocean perch (Sebastes alutus) in Queen Charlotte Sound have been used to develop a new CPUE measure of relative abundance. This index is positively correlated with an earlier one based on the performance of a U.S. fishing fleet and is compatible with independent, provisional estimates of available biomass. A rapid decline in abundance occurred between 1965 and the early 1970s, a period of relatively heavy removals. By the late 1970s catch as well as total effort had reached its lowest point since the inception of fishing in the early 1950s. It is too soon to conclude that a modest reversal of the CPUE trend is a reflection of stock recovery.

The new index of abundance has been applied to a range of estimates of total removals (required because of uncertainty about the reliability of reported foreign catch) to obtain a range of estimates of total fishing effort. These data are to be used in further stock assessment studies and reported in this publication series.

Key words: Pacific ocean perch, CPUE, relative abundance, standardized effort.

RÉSUMÉ

Ketchen, K. S. 1981. Reconstruction of Pacific ocean perch (*Sebastes alutus*) stock history in Queen Charlotte Sound. Part II. Catch per unit of effort as a measure of abundance. Can. MS Rep. Fish. Aquat. Sci. 1599: 72 p.

Les statistiques sur l'industrie canadienne de la pêche du sébaste du Pacifique (*Sebastex alutus*) dans le détroit Reine-Charlotte ont servi à élaborer une nouvelle mesure de l'abondance relative basée sur les prises par unité d'effort (PUE). Cet indice est directement lié à un indice précédent basé sur le rendement d'une flottille de pêche américaine et est compatible avec les données distinctes, provisoires de la biomasse disponible. Une baisse rapide de l'abondance s'est produite entre 1965 et le début des années soixante-dix, période d'exploitation relativement forte. Vers la fin des années soixante-dix, les prises ainsi que l'effort total avaient atteint leur point le plus bas depuis le commencement de la pêche au début des années cinquante. Il est encore trop tôt pour conclure qu'un modeste renversement de la tendance des PUE constitue une indication du rétablissement des stocks.

Le nouvel indice d'abondance a été appliqué à un éventail de prévisions de l'exploitation totale (nécessaire à cause de l'incertitude face à l'exactitude des prises rapportées par les étrangers) en vue d'obtenir un éventail de prévisions pour l'effort de pêche total. Ces données seront utilisées pour des évaluations des stocks et rapportées dans la présente série de publications.

Mots clés: Sébaste du Pacifique, PUE, abondance relative, effort normalisé.

LIST OF FIGURES

Fig. 15. Estimated total catch, standardized catch per unit of effort and calculated total fishing effort in the fishery for Pacific ocean perch on grounds associated with Mitchell's Gully.

Fig. 16. Evidence of an increase in the efficiency of the Canadian fleet fishing for Pacific ocean perch in Queen Charlotte Sound. (Numbers adjacent to dots refer to vessel class).

INTRODUCTION

The trawl fishery for Pacific ocean perch (Sebastes alutus), in Queen Charlotte Sound, began in the early 1950s largely as a United States operation based in the State of Washington. Until 1970 the Canadian share of the catch by the two nations rarely exceeded 20%, but more recently (1975-77), because of improved markets in Canada and declining U.S. fishing effort, the share has ranged from 51-77%. In 1978, there was negligible fishing for ocean perch by U.S. vessels, as a result of the failure of the two countries to reach accord on an interim reciprocal fishing privileges agreement. This situation continued through 1979.

Cooperative stock assessment studies (Gunderson et al. 1976) based on catch per unit of effort (CPUE) as an index of abundance have depended heavily on data from the predominant U.S. fishery. However, now that the Canadian fishery has achieved equal or greater prominence, along with the prospect that Canada may soon become the sole participant in the fishery, there is need to develop an independent Canadian CPUE index, in order to continue the monitoring of ocean perch stock size.

Thus the purpose of this report: (1) to conduct a detailed examination of historical catch and effort data on the Canadian trawl fishery for Pacific ocean perch in Queen Charlotte Sound; (2) to determine as far as possible whether Canadian CPUE provides a valid measure of relative abundance by comparing results with U.S. estimates and independent measures of stock size (e.g. biomass estimates), (3) to reconstruct a Canadian CPUE index for the years prior to significant Canadian involvement in the fishery, and (4) to assemble estimates of total catch and calculated total fishing effort in a form which may be used in future stock assessments.

BACKGROUND

Because of the many pitfalls which attend calculation and interpretation of CPUE it is important to review what is known of the distribution and movements of ocean perch, definition of stocks/populations and general features of the fishery. This information provides a useful background to the problems of analysis and to the development of appropriate methodology.

FISHING GROUNDS

Queen Charlotte Sound is defined as that part of Canadian coastal waters lying between the northern end of Vancouver Island (ca 50°30'N) and the southern extremity of the Queen Charlotte Islands (ca 52°00'N). Within the Sound are three banks (Cook, Goose Island, and Middle) separated by three gullies (Goose Island, Mitchell's, and Moresby) (Fig. 1). It is in or around the perimeter of the first two of these gullies that the main domestic (Canada-U.S.A.) fishery takes place. With the arrival of fishing fleets of the USSR (1965) and Japan (1966) extensive fishing for rockfish including Pacific ocean perch occurred in the outer (westerly) portions of Goose Island and Mitchell's gullies and also on the slopes to seaward of the three banks mentioned above (see Ketchen 1980b). In 1971 Canada imposed a fishery closing line running from Cape St. James on the southern tip of the Queen Charlotte Island group to Triangle Island off the northern tip of Vancouver Island (Fig. 1). This discouraged, but did not entirely prevent, further foreign fishing within Goose Island and Mitchell's gullies.

Goose Island Gully Grounds

As shown in Figure 2, Goose Island Gully is comprised of six more or less confluent fishing grounds. Historically, those lying along the southern margin of Goose Island Bank (NE corner to the SE edge and corner) have been the most important ones to the North American fleet. Those lying in the easterly horns of the gully ("Virgin Rocks", "Stump Ranch", and "Cape Scott") and the "Triangle Ground" near the seaward entrance to the gully have been irregular and relatively minor producers as far as the Canadian fleet is concerned (Fig. 3).

Farther to the westward on the southwest slope of Goose Island Bank (Fig. 1), the bottom is rough and although never fished to any great extent by North American trawlers, appears to be largely untrawlable with conventional domestic gear. Large foreign trawlers have been observed on the southwest slope fishing for rockfishes which characteristically occur on or over rough bottom (*Sebastes reedi*, *S. proriger* and others). However, it is apparent from reports of observers aboard Japanese trawlers (Leaman et al. 1978) that *S. alutus* is present during summer months in moderate quantities on a ground here defined as "slope ground" (see Fig. 2).

On the southerly side of the seaward entrance to Goose Island Gully, about 18 miles true west of Triangle Island, is another area which has attracted a great deal of attention by foreign trawlers. Here the bottom is rough from a depth of about 100 fathoms (183 m) to the sharp drop off beyond 150 fathoms (275 m) and research vessel catches as well as those observed on Japanese vessels contain little if any *S. alutus* during summer months (Westrheim 1967; Leamam et al. 1978), but the area may be an important producer in wintertime. For present purposes this area will be identified as the "West Triangle" ground (Fig. 2) to distinguish it from the Triangle ground farther eastward in the gully. The intervening ground apparently is untrawlable with conventional bottom gear.

Mitchell's Gully Grounds

Mitchell's Gully is narrower and shorter than Goose Island Gully and appears to possess less trawlable bottom. Its inner reaches, extending from the NW corner to the SW corner of Goose Island Bank (SW edge is shown in Fig. 2), have been fished extensively by U.S. trawlers at least since 1965. Canadian activity was comparatively light and sporadic until the fall of 1972 when discovery of trawlable bottom towards the westward and deeper parts of the gully (Westrheim 1972, 1974b) led to a significant shift in Canadian fishing effort in subsequent years.

SEASONAL MOVEMENTS OF OCEAN PERCH

It is well known that in the vicinity of British Columbia S. alutus engages in substantial seasonal bathymetric movements (Alverson 1960; Gunderson 1971). In the southwestern Vancouver Island area and off the Washington-Oregon coast, where the species can be tracked over its entire depth range, Gunderson (1971) noted mean depth of commercial catch to be 120 fm (220 m) or less during summer months and 160-180 fm (290-220 m) during winter months. However, Westrheim's 1973 study of age and growth revealed a significant complication, viz. ocean perch encountered in deep water in winter are not necessarily of the same stock encountered in shallow water in summer. He postulated the existence of mutually exclusive sub-stocks of shallow-water, fast growing ocean perch which disperse or otherwise become relatively unavailable during winter, and deep-water, slow growing fish which are relatively unavailable in summer. Further tests of this hypothesis are required.

In any event, the annual bathymetric range of ocean perch in Queen Charlotte Sound has not yet been fully described. One of the difficulties, as identified by Gunderson (1971) is that there is little ground below a depth of 150 fm (275 m) available to conventional North American trawling gear. Thus, unlike areas off Vancouver Island and Washington, the commercial fleet loses contact with schools of fish as they move to deep water in winter and re-establishes contact only when the spring migration to shallow water is well underway. The same cannot be said for certain with regard to Soviet and Japanese vessels which, during their periods of most active winter fishing (1966-68 and 1972-76, respectively), were equipped with both rough-bottom and mid-water trawling gear. The possibility that ocean perch were vulnerable to these types of gear during winter has been taken into consideration in estimating foreign catches (Ketchen 1980b).

Information collected from trip reports and logbook records of Canadian commercial fishermen provides an interesting comparison between the apparent behavior of ocean perch in the Goose Island Gully and Mitchell's Gully. In the former area, the migration to relatively shallow water appears to be completed by the month of May (Fig. 4). However, it may well be that at the beginning of the Canadian fishing season, vessels do not operate over the entire depth range where the species is available. Indeed observations by Gunderson (1971:421) on the U.S. fishing operations for an earlier period of years (1961-65) show a weighted mean depth of catch at about 120 fm (220 m) in April, 110 fm (201 m) in May with shallowest depths of about 100 fm (183 m) being achieved in June-July.

Canadian data suggest that depth distribution in Goose Island Gully remains fairly stable (ca 110 fm or 200 m) through August after which there is a progressive movement to deep water. The descent is more rapid than that observed by Gunderson (1971)[1]. For neither the Canadian nor U.S. fishery is there adequate information on the ultimate depth reached in winter, because of the abrupt drop in bottom depths beyond 150 fm (275 m), roughness of the terrain, lack of mid-water trawl effort, and onset of winter storms.

Gunderson (1971), again referring to Queen Charlotte Sound as a whole and to the 1966-69 period, noted that male ocean perch predominated (80-87%) in the February-April period, suggesting that they do not accompany females on their spawning migration to deep water. As the inshore season progresses the proportion of females increases, reaching parity by October-November. However, in Canadian market samples for this period, as well as for later years, it is apparent that in Goose Island Gully parity is reached usually in June-July. This is supported by research vessel observations during the month of June (Harling et al. 1970; Westrheim et al. 1974a).

Data on the bathymetric movements of ocean perch in Mitchell's Gully (Fig. 5), as indicated by Canadian commercial fishing operations, cover a broader span of months than those for Goose Island Gully. Schools are intercepted in deep water (ca 150-160 fm or 275-295 m) well before they reach their minimum depth range in the June-August period (ca 120-125 fm or 220-230 m). This is nearly 15 fm (27 m) deeper than the mean depth of occurrence for the corresponding period in Goose Island Gully--a depth differential which is more or less maintained throughout the succeeding fall months as the schools of fish retreat once again to deep water. This difference possibly indicates a difference in temperature structure in the two gullies, or may merely reflect the difference in bathymetry and distribution of habitable bottom.

As in Goose Island Gully, male fish predominate in the spring but the sex ratio reaches parity in June-July.

DEFINITION OF STOCKS

For present purposes it is assumed that ocean perch inhabiting Goose Island and Mitchell's gullies belong to two separate stocks or groups of stocks.[2] Grounds for such an assumption are: (i) the gullies are separated by a 15- to 40-mile wide area where depths and/or bottom type are those not normally associated with the spring-autumn occurrence of adult ocean perch, (ii) North American fisheries in the two gullies are more or less contemporaneous and at somewhat different depths, (iii) otoliths

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[1]Disparities between the U.S. and Canadian observations may arise from the fact that the former made no distinction between the fisheries in Goose Island and Mitchell's gullies.

[2]"Groups of stocks" acknowledges the possible existence of shallow-water and deep-water components in each area, in keeping with the Westrheim hypothesis.

collected for age-determination from ocean perch caught in Mitchell's Gully are distinctively more difficult to read, because of accessory checks, than those from Goose Island Gully (Westrheim, pers. comm.), and (iv) although no quantitative comparisons have been made, it is believed that there is a significantly lower incidence of the trematode parasite Prosorhynchus in the ocean perch inhabiting Goose Island Gully (Harling, pers. comm.).

There remains the question of the whereabouts of these stocks during the winter months. Westrheim (personal communication) is of the opinion that, following the autumn migration out of the gullies to deeper water, they disperse in midwater at some depth below 150 fm. Wintering of the Goose Island Gully stock probably takes place in the general vicinity of the West Triangle ground and on the SW slope of Goose Island Bank (Fig. 2). The Mitchell's Gully stock presumably occupies either the SW slope of Middle Bank, the northern part of the SW slope of Goose Island Bank, or both.

MATERIALS AND METHODS

STATISTICS OF CATCH

North American fishery

Monthly statistics of Canadian and United States landings of Pacific ocean perch are combined and published annually by the staff of the Pacific Marine Fisheries Commission (PMFC). Landings originating in Queen Charlotte Sound are represented in records of PMFC Statistical Areas 5A and 5B (Fig. 6). For present purposes the two areas have been combined and landings by country have been obtained by subtracting Canadian landings from the totals published by PMFC. Records of the North American annual and monthly landings since 1956 are summarized in Tables 1 and 2, respectively. Table 3 shows annual North American removals by the two major sections of Queen Charlotte Sound: Goose Island and Mitchell's gullies, and is an extension of information contained in Gunderson et al. (1976: Table 2).

Foreign fishery

Statistics on production by vessels from distant-water nations shown in Table 1 are approximations derived by Ketchen (1980b) from information provided by the USSR and Japan on catches of all rockfish combined[3].

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[3]These estimates supersede figures used by Gunderson et al. (1976) in their assessment of the state of ocean perch stocks in Queen Charlotte Sound.

Estimates of foreign removals from the stocks associated with Goose Island and Mitchell's gullies, as shown in Table 3, are likewise based on Ketchen's (1980b) derivation. The figures used are those classed as "intermediate" by Ketchen. "Minimum" and "maximum" estimates will be dealt with in another section of the text.

STATISTICS OF CATCH PER UNIT OF EFFORT (CPUE)

As mentioned at the outset, statistics of the United States fishery hereto have constituted the base for calculation of annual considered more reliable than Canadian data for earlier years because of the predominance of the U.S. fishery and the stability of the fleet's composition, the data may have been weakened by an obvious reduction in U.S. fishing interest in years subsequent to 1974. Thus, development of a Canadian CPUE index has become imperative.

Method of calculating Canadian CPUE

Qualifying fishing effort

The first step in the analysis was to make certain that fishing effort used in the calculation of ocean perch CPUE was indeed directed at that species and not diluted by effort on other target species. Throughout the history of the Canadian fishery in Queen Charlotte Sound it has always been relatively easy to identify fishing effort on ocean perch by the depth of fishing, because, at least until 1977-78, there was usually a sharp distinction in terms of depth between the fisheries for ocean perch and for other species (mainly Pacific cod, lingcod and several species of flatfish)--85-180 fm for the former and usually less than 60 fm for the latter. With the belated development of Canadian interest in species of rockfish other than ocean perch the separateness of the shallow-water and deep-water fisheries is becoming less obvious. In any event, establishment of a minimum depth for selection or rejection of fishing effort is one method of qualification.

Another is to set a minimum limit on the percentage that ocean perch constitutes of the total catch reported by a vessel from a given locality and depth range (i.e. establishment of a catch qualification).

As yet no statistical technique has been developed to enable one to determine which depth and catch qualification levels are likely to provide the most reliable estimate of directed (effective) effort. However, from examination of Canadian statistics on the fishery in Queen Charlotte Sound, it was decided that only those landing data would be considered in which the catch of ocean perch (a) was made at an average depth of 85 fm or greater and (b) constituted 60%[4] or more of the catch in the locality for which such depths were specified.

For purposes of consistency a further constraint has been placed on the data by limiting the analysis to fishing conducted during the months of May through December. Canadian catches in the first four months of the year have been negligible and at best erratic (Table 2).

Standard vessel class

While the size and gross tonnage composition of the United States fleet has remained relatively constant over several decades, the Canadian fleet has undergone a spectacular shift to larger vessels (Fig. 7). On the assumption that CPUE is positively correlated with vessel gross tonnage and/or horsepower (verified for numerous trawl fisheries around the world, and even locally--cf Ketchen 1979), there is an obvious need to standardize the unit of Canadian fishing effort. For analytical purposes Canadian trawlers involved in the fishery for ocean perch in Queen Charlotte Sound are separated into the following categories:

Class	Gross tons
3	25-49
4	50-74
5	75-99
6	100-149
7	150-199
8	200-299
9	300-399
10	400+

Table 4 shows that Class 6 vessels have the longest unbroken record of participation in the fishery, yet that class ceased to be well represented after 1970, being relegated to a minor role by successively larger classes of vessels in more recent years. Since the past decade is the most critical period for evaluating changes in abundance, Class 7 will be used as the standard vessel class, and the effort expended by Class 6, 8, and 9 will be expressed in terms of the standard class (performances of Classes 3, 4, 5, and 10 will be ignored because of their low and erratic involvement in the fishery).

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[4]This qualification level (threshold) was deemed necessary to eliminate "extraneous" and irregular deep-water fisheries for turbot in earlier years, and, particularly in 1977-79 the growing fisheries for certain species of rockfish whose bathymetric ranges during summer months may overlap those of ocean perch.

Fishing power factor

Beverton and Holt (1957:29) defined fishing power as the catching power of an individual vessel as measured by the ratio of the quantity of fish caught per unit time to that of a vessel selected as a standard. Each vessel of a fleet can then be allocated a power factor (P.F.). In the present study, no one vessel (and skipper) fished throughout the period under consideration. Thus as a less desirable alternative, a class of vessels becomes the standard, and other classes are assigned a P.F., which is some value greater or less than 1.00. When the fishing effort of a class is multiplied by the P.F., the effort, in theory at least, is thereby expressed in terms of the standard class.

To arrive at the power factor for a particular class of vessel (say Class 8), an average ratio of the CPUE of Class 8 to Class 7 vessels, weighted to effort expended by the two classes, was obtained from monthly pairs of observations over the number of years where such pairs existed. The weighting formula, as recommended by D. Fournier, is a refinement of the one used by Ketchen (1979) in that it involves a logarithmic transformation namely,

$$\text{Log (P.F.)}_{ij} = \frac{\sum\limits_{km} \frac{E_{ikm} \quad E_{jkm}}{E_{ikm} + E_{jkm}} \cdot \text{Log} \frac{C_{ikm}\, E_{ikm}}{C_{jkm}\, E_{jkm}}}{\sum\limits_{km} \frac{E_{ikm} \cdot E_{jkm}}{E_{ikm} + E_{jkm}}}$$

where P.F. is the power factor for the ith vessel class in terms of the jth (standard) class, E is fishing effort in hours and C is catch in metric tons in the kth month and mth year for each of the vessel classes i and j. An example of the calculation procedure is given in Appendix 1.

Table 5 contains the basic information for calculation of power factors, which in turn are provided in Table 6. Using the weighted average power factors of 0.89 for Class 6, 1.16 for Class 8, and 1.36 for Class 9 vessels, total May-December fishing effort can now be expressed in terms of the Class 7 standard[5].

These power factors have been applied to Goose Island and Mitchell's gullies alike, even though it would be more correct to compute

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[5]It is of interest to note in Table 6, that there is virtually no difference between weighted and unweighted estimates of power factors. A similar situation was observed in the standardization of Strait of Georgia fishing effort (Ketchen 1979), which raises the possibility that an elaborate weighting process is not necessary in analyses of Canadian west coast trawl fishery data. However, because of the uniqueness of the ocean perch fishery and the special features of the general trawl fishery in the Strait of Georgia, it would perhaps be wise to defer such a conclusion until the standardizing exercise has been applied to one of the other open coast fisheries.

them separately. The problem arises from a paucity of data, e.g. for the period of significant Canadian participation in the Mitchell's Gully fishery (1972-78) there were only 3 pairs of monthly average CPUEs comparing Class 7 with Class 6, 17 with Class 8 and 18 with Class 9. Fragmentary though the data are the latter two sets of comparisons yielded power factors of 1.14 and 1.28, respectively, which suggest that errors are not likely to be large in using the estimates provided in Table 6.

RESULTS

ESTIMATION OF STANDARDIZED CPUE

Table 7, col. 5 shows the total standardized fishing effort of the Canadian fleet of Class 6-9 vessels operating in Goose Island Gully, standardized to Class 7 by multiplying nominal effort recorded for each class by the corresponding power factor in Table 6. The total catch of Classes 6-9 (col. 6) was then divided by the standard effort to obtain a standardized CPUE (col. 7) for the 1962-79 period. Calculations for years prior to 1962 are included in the table, but these are provisionally dismissed because of the low level of the Canadian fishery in those earlier years.

A similar treatment has been applied to the brief run of data on the Canadian fishery in Mitchell's Gully during the period 1972-78 (Table 8).

RELIABILITY OF STANDARDIZED CPUE ESTIMATES

Before trying to relate standardized CPUE estimates for the two gullies to those calculated from catch-effort data on the U.S. fishery, it is desirable to determine whether the estimates are a reasonably reliable reflection of changes in relative abundance--not necessarily on a year-to-year basis, but over a span of several years, to accommodate short-term changes in availability. To do this requires some independent measure of abundance and fortunately such may exist in estimates of the available biomass of marketable sized ocean perch in Goose Island Gully as determined by surveys carried out aboard the R/V. G.B. REED. The methodology, involving a swept-area technique, has been described by Westrheim (1972).

Biomass estimates for the period 1965-77 (Ketchen, Ed. 1980a) are compared in Table 9 with estimates of standardized CPUE derived from the Canadian commercial fishery. The correlation coefficient, r=0.665, is marginally significant at the 5% level and therefore provides only borderline support for the reliability of the CPUE values. In any event, caution must be exercised at this time because the biomass estimates are subject to further examination and possible revision[6].

An alternative method of estimating available biomass is to be found in sequential computation of stock size (cohort analysis) as described by Pope (1972). Details of the application to Pacific ocean perch will be reported elsewhere (Ketchen MS). For present purposes it is sufficient to say that, using (a) total catch in numbers of fish by age, (b) an assumed instantaneous natural mortality rate (M) of 0.13, and (c) a trial, terminal instantaneous fishing mortality rate (F) of 0.3, the resulting estimates of available biomass for the years 1963-1971, inclusive[7], are strongly correlated with corresponding estimates of CPUE (Fig. 8).

Thus we can say that available independent evidence supports the view that standardized CPUE is a reasonably reliable indicator of changes in relative abundance of the ocean perch stock available to the fishery in Goose Island Gully.

Intuitively one would expect CPUE to underestimate relative abundance at high stock levels. Conceivably the numbers of fish entering a trawl net could be so great as to reduce the opening gape of the net and/or, by their sheer weight, reduce the distance covered by the net in a given period of time. Whether or not such actually occurred during years of relatively high abundance cannot be ascertained. Data in Figure 8 are too sparse to suggest anything other than a straight line relationship.

At the other extreme, CPUE might be over-estimated because it fails to take into account the amount of time spent by fishermen searching for schools before they set their nets. Increasing length of searching time theoretically should manifest itself in information on catch per fishing day and a plot of CPUE against such data would tend to be convex upward. The relationship shown in Figure 9 is only marginally curvilinear, and thus we may conclude that over the range of abundances occurring during the middle to later years of the fishery, distortion of CPUE by changing length of searching time was negligible. Such a conclusion, of course, assumes that the length of the fishing day did not increase. While there is no way of checking this possibility, it is likely that the length of a fishing day is determined by the amount of daylight which in turn determines the diel

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[6]Westrheim (pers. comm.) is concerned that in the early years of the biomass surveys, and even as late as 1973, numerous schools of Pacific ocean perch were observed in mid-water. As biomass estimates were based on results of on-bottom trawling, he is of the view that absolute abundance was under-estimated. This being true, it clearly invalidates any conclusion about the relationship of CPUE to absolute abundance. However, it invalidates the relationship to relative abundance only if mid-water schools remained at all time beyond the range of the commercial fishery. If, on the other hand, it were assumed that mid-water schooling was merely a reflection of a general on-bottom-off-bottom behaviour pattern that varied from week to week if not from day to day (i.e. mid-water schools seasonally are as available to the fishery as on-bottom schools), then it would not be unreasonable to conclude that the comparison is valid.

bathymetric movement of schools and hence the length of time each day that bottom trawling remains worthwhile.

Another factor which may affect the reliability of a so-called standardized estimate of CPUE lies in the number of hauls comprising a given number of hours of fishing. When abundance is high, the skipper could be expected to make relatively short hauls to avoid overloading his gear or exceeding the rate at which the deck crew could handle a catch before the next haul came aboard. Theoretically, as abundance declines, the length of haul would be expected to increase and this appears to have been the case in the Queen Charlotte Sound ocean perch fishery. When abundance was high in 1965-66 the length of haul was about 2 3/4 h, but during the 1970s it rose to an average of more than 3 1/2 h (Fig. 10). These two questions arise: For a given level of abundance and given number of hours of fishing, would CPUE based on hauls of relatively long duration remain the same as that based on hauls of short duration? If abundance were declining, would CPUE based on hauls of relatively long duration remain the same as that based on hauls of short duration? If abundance were declining, would CPUE continue to be proportional to abundance given constant total number of hours of fishing and increasing duration of hauls? Doubtless there are many opinions on these matters. Certainly, under conditions of high abundance long hauls would be less efficient than short hauls if nets tended to become overloaded. Thus for a given number of hours of fishing long hauls would result in a lower CPUE than would short hauls. Whether or not the observed change in duration of haul has been sufficient to influence the present analysis is unknown. To quantify the error would require well designed experimental fishing at differing levels of abundance.

MONTHLY TRENDS IN CPUE

As an offshoot from the CPUE analysis, data on the performance of the several classes of Canadian trawlers was examined on a monthly basis to determine whether there are seasonal changes in CPUE. A generally upward trend from May through November is noted (Fig. 11) with a drop occurring in December. The rising trend could be attributed to the delayed immigration of females (as claimed by Gunderson (1971), but only partially supported by the present analysis) and/or to the progressive concentration of schools as breeding season approaches. The decline in December, although based on fragmentary data, is probably the result of a combination of declining availability as the schools move into deep water and increasing severity and frequency of winter gales which presumably reduce vessel efficiency.

This seasonal pattern of CPUE is in conflict with that described by Gunderson (1971) who noted for the 1955-65 period a peak in CPUE in May, followed by a slump during the summer months and then a rising trend through

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[7]Reliable estimates could not be extended beyond 1971, because cohort analysis was limited to year-classes in which the oldest age was no less than 13 yr (a tentative estimate of the age of entry into the fishery).

November. To this sequence of events, also reflected in catch, Gunderson attributed biological significance. However, it is possible that the summer slump resulted from withdrawal of more efficient vessels in the U.S. fleet to engage in other fisheries. In the Goose Island Gully fishery by Canadian vessels there usually is a drop in catch for this reason (Fig. 4a) but there is little indication of a decline in CPUE.

Strictly speaking, if there are substantial annual variations in the months of peak production (and this is evident in Table 2), the annual average CPUE should be weighted to allow for within year (monthly) changes in catch rate. However, such has not been attempted because of the labor involved and the questionable benefit of such a refinement when the data on seasonal trends year-by-year are of varying quality.

COMPARISON OF CANADIAN AND U.S. CPUE ESTIMATES

The primary intention of this study, as mentioned earlier, is to develop a Canadian index of the relative abundance of ocean perch in Queen Charlotte Sound. We have already demonstrated that it is in reasonable accord with estimates of available biomass. Its reliability would be further strengthened if exhibited trends in the Canadian standard are in reasonable accord with those derived from data on the U.S. fishery. If this can be established then there is a basis for projecting the Canadian index backward in time to years when the Canadian fishery was of insufficient magnitude to provide a usable measure of abundance.

Canadian and U.S. CPUE values for 1962-77 in Goose Island Gully and 1972-77 in Mitchell's Gully are provided in Table 10, together with data on their correlation. Each set of data has a significant correlation coefficient. Thus, with due recognition of the hazards of extrapolation, we may now estimate U.S. CPUE (in terms of the Canadian standard) for earlier years of the fishery. Estimates for Goose Island Gully (1959-61) and Mitchell's Gully (1965-71) are obtained by substituting values given in the last two columns of Table 3 in equations 1 and 2, respectively, in Table 10. The results are given in Table 11 and illustrated in Figures 12 and 13 along with the historical record of the North American catch from Table 3.

COMPUTATION OF TOTAL FISHING EFFORT

The final step in the analysis is to introduce the estimated catches of Pacific ocean perch by foreign fleets to provide a more complete picture of the relationship between total catch and CPUE, and, from these statistics, to calculate total fishing effort in terms of the Canadian standard.

For Goose Island Gully total catch from Table 1 is plotted in Figure 14 along with previously presented estimates of standard CPUE

(Tables 6 and 9). Also shown is the calculated total effort derived from Table 12. Mitchell's Gully is similarly treated in Fig. 15.

In his estimation of foreign catches, Ketchen (1980b) considered it necessary to provide minimum, intermediate and maximum estimates of the catch by Soviet and Japanese trawlers during the years 1965-1976 when they were engaged in the fishery, because of the questionable accuracy of reported information. Intermediate estimates have been incorporated in the totals shown in Tables 1 and 12. For convenience of future analyses of the response of stocks to changing fishing effort, the minimum and maximum estimates of total removals in the 1965-76 period from Goose Island Gully are provided in Table 13 along with re-computed estimates of total effort. Similar data for Mitchell's Gully are given in Table 14.

CANADIAN FLEET EFFICIENCY

A by-product of the exercise to estimate power factors for the several classes of Canadian trawlers (p. 8) is information on the possible magnitude of change in fishing efficiency of the fleet over the long term. It cannot be determined with high precision because many changes in the over-all efficiency of trawlers are difficult to quantify (changes in design of nets and auxiliary gear, improved charts, navigational aids, etc.). In the present analysis we have observed that the average gross tonnage of vessels has increased markedly since 1960 (Fig. 7). Having at hand the power factor for each of the four main classes of vessels participating in the fishery (Table 6)[8] and the average gross tonnage of vessels occupying each class, we can determine the relationship between relative fishing power (relative efficiency) and gross tonnage, as in Fig. 16. This in turn provides us with a clue to the change in efficiency which has occurred (in association with increase in average gross tonnage alone) since the early years of the fishery. As shown in the figure the increase appears to have been about 30%. To say more about this relationship, especially to explore the possibly more direct relationship to engine horse-power, strays too far from the main purpose of this report. Suffice it to say that the apparent increase in efficiency of 30%, probably is an under-estimate, in view of the fact that no allowance has been made for various unquantifiable improvements which have been made over the past two decades.

DISCUSSION

In the development of a Canadian index of changes in the relative abundance of Pacific ocean perch, the technique of standardizing fishing

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[8]Plus the power factors of classes 4 and 5 which historically have been only marginally involved in the ocean perch fishery.

effort is but one of several that could have been used. It contains the implied reservation that fishing power of a particular vessel class relative to that of other classes remains constant with time (or at least varies without obvious trend over the long term). While this assumption appears to have been reasonably satisfied during the 1959-79 study period, it may not continue to be so. Furthermore, with the inevitable changing composition of a particular vessel class, due to withdrawals from or new entries into the fishery, its relative power factor may change and it might even be necessary to establish a new standard vessel class if fleet composition continues its recent trend. Thus it would be misleading to claim that standards and power factors used in this report are in any way final. They should be continuously monitored and, where necessary, revised to assure that the abundance index retains some semblance of reality.

The trend in relative abundance, especially during the peak years of the fishery (1965-72), as reflected by the new Canadian index, is positively correlated with results obtained by two independent yet still provisional estimates of biomass. The index is also correlated with that derived from CPUE in the U.S. fishery, though the latter could have been afflicted with the same unknown biases contained in the Canadian index. In general, however, there is some basis for confidence that the Canadian index for Goose Island Gully provides a reasonably reliable measure of the impact of the fishery during the years of heaviest removals.

Less confidence can be attached to the index for years prior to 1962, because it involved an extrapolation from U.S. data and conversion to the Canadian standard. Such a procedure may have embodied bias or sources of error of which the writer was unaware. However, it is to be noted in Figure 13 that CPUE estimates for the years 1959 to 1965 showed an irregular upward trend (more obviously so from the U.S. index given in Table 3). If the trend is a true reflection of relative abundance, the inference is that the biomass of commercial-sized fish was increasing during this period. This is supported at least in part by evidence from age composition that during most of this period a group of relatively strong year-classes (1952, 1951, and 1950) was being recruited to the stock (Gunderson et al. 1976). On the other hand, this rising CPUE was accompanied by increasing fishing effort which could mean that fishermen were becoming increasingly adept at fishing ocean perch. Thus, it is perhaps unwise to assume that all of the rise in CPUE between the early years and 1965 can be explained by increased

From 1966 to 1971, Goose Island Gully CPUE dropped very rapidly and this seems to be attributable to relatively high combined domestic and foreign catches during 1966-68 (Fig. 14). Because of the uncertainty which attends the estimates of foreign removals, future analysts should not overlook the fact that North American catches were relatively high from 1965 to 1970 (cf. Fig. 12, 14) and the possibility that the foreign fishery had less impact on the stock of ocean perch available to the North American fleet than is here supposed.

A final note of caution about interpreting changes in Goose Island Gully CPUE concerns events subsequent to 1975. In those years U.S. participation declined appreciably and became negligible in 1978 as the result of a Canada-U.S. dispute over an interim fisheries agreement. During

1976-79, fishing effort was down to the level which prevailed in the early 1950s. While a recovery of stock size is to be expected under such circumstances, the modest (and irregular) improvement in CPUE in this period (Fig. 13) may have been due in part to increased catchability, in the sense that schools of ocean perch are more likely to remain intact in the presence of low fishing pressure than under the dispersing effects of high fishing pressure.

Regarding the Mitchell's Gully fishery (Fig. 15), we are faced with a much more complicated situation than that in Goose Island Gully, even if attention is restricted to the North American fishery alone. There were two periods of relatively high catch and high CPUE, 1967-69 and 1973-74. The first may be identified with the then newly developed U.S. fishery associated with the SW edge of Goose Island Bank (Fig. 2) and possibly the foreign fishery to the west of the SW edge in Mitchell's Gully proper. The second reflects the sudden development of a Canadian fishery (followed by the U.S. fishery as news spread) resulting from discovery of trawlable bottom in the outer reaches of Mitchell's Gully during the course of exploratory fishing by the R/V G.B. REED in 1972.

The two-phase history of the Mitchell's Gully fishery, together with the lack of a complete series of data on age composition, makes interpretation of CPUE rather difficult. During and after each of the two periods of relatively heavy removals, CPUE trended downwards, as would be expected (Fig. 15). Perhaps it is only since 1973 that we have a picture representative of changes in the Mitchell's Gully stock as a whole, for by that time both the inner and outer reaches of the gully were being fished by the North American fleet. However, one cannot ignore the possibility that the bimodal CPUE pattern was in part a reflection of variations in recruitment.

The sharp upward turn in CPUE in 1978 deserves the same cautious treatment recommended in regard to recent data for Goose Island Gully. Indeed, it can be stated as a generality that, because of the large number of age groups in the catch and slow rate of recruitment, any sharp upturns in CPUE observed between one year and the next must be attributed to changes in availability. On the other hand, a sharp downward turn could reflect reduced availability, and/or a sudden change in abundance if it were preceded by an abrupt increase in catch. Since availability variations alone do not explain short-term variations in CPUE, it follows that added complications would arise if one were to attempt to minimize the effects of variations in availability by using running averages of CPUEs.

In any event, several more years of data may be required to confirm that, as a result of greatly reduced effort since 1975, the ocean perch stocks in both gullies are undergoing a recovery in abundance.

In regard to uncertainties concerning catches made by foreign trawlers, it is beyond the scope of this report to determine which of the several estimates (minimum, intermediate or maximum) most accurately reflects the actual removals from the two gullies. This is reserved for a later study.

Finally, and once again for the guidance of future analysts, the possibility should not be overlooked that ocean perch inhabiting Goose Island and Mitchell's gullies are in fact inseparable parts of a single stock, despite the available evidence supporting a two-stock concept. More direct and quantitative studies may be required before this question can be fully resolved.

CONCLUSIONS

The new CPUE index of abundance of Pacific ocean perch appears to be reliable in broad terms (not necessarily always year by year) on grounds that it is (1) positively correlated with an earlier U.S. index and (2) compatible with independent but provisional estimates of available biomass. Conclusions on the state of stocks are beyond the scope of the present analysis. Yet it has already been indicated elsewhere (Gunderson et al. 1976) that heavy removals in the mid to late 1960s resulted in a sharp reduction in CPUE. Such is confirmed by the present analysis at least with respect to the Goose Island Gully stock, but interpretation of events before and after that time requires further study in company with an analysis of changes in age structure of the stocks--the subject of a subsequent report.

SUMMARY

The objective of this report was to develop a Canadian standard from which to measure changes in relative abundance (from CPUE data) of Pacific ocean perch (Sebastes alutus) in Queen Charlotte Sound. Because of suspected changes in fishing power of the Canadian fleet during the past decade it was necessary to develop a standard unit of fishing effort. This was done by using Class 7 trawlers (150-199 gross tons) as the standard and equating the effort of all other significantly participating classes to this particular class.

Standardized CPUE estimates for the ocean perch stock in Goose Island Gully for 1965-77 were found to be correlated with provisional estimates of available biomass. They were also correlated with CPUE estimates derived from the U.S. fishery during the same period and the resulting equation was used to obtain CPUE estimates expressed in terms of the Canadian standard for the years 1959-61, a period when the Canadian production was but a small fraction of that of the U.S. fishery. A similar procedure was used to determine a standardized CPUE for the early years of the fishery on the Mitchell's Gully stock.

Using the Canadian index and estimates of total catch by domestic and foreign fleets, total fishing effort (expressed in terms of the Canadian

Class 7 trawler standard) was then computed for each of the two major fisheries in Queen Charlotte Sound.

Pitfalls in the use of these statistics in future stock assessment models are discussed.

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REFERENCES

Alverson, D. L. 1960. A study of annual and seasonal bathymetric catch patterns for commercially important groundfishes of the Pacific Northwest coast of North America. Pac. Mar. Fish. Comm. Bull. 4: 66 p.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. U. K. Min. Agric. Fish., Fish. Invest. (Ser. 2). 19: 533 p.

Gunderson, D. R. 1971. Reproduction patterns of Pacific ocean perch (Sebastodes alutus) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Board Can. 28(3): 417-425.

Gunderson, D. R., S. J. Westrheim, R. L. Demory, and M. E. Fraidenberg. 1976. The status of Pacific ocean perch (Sebastes alutus) stocks off British Columbia, Washington, and Oregon in 1974. Rep. of the Technical Sub-committee of the International Groundfish Committee 17th Annual Meeting, Appendix b: 49 p.

Harling, W. R., D. Davenport, M. S. Smith, U. Kristiansen, and S. J. Westrheim. 1970. G.B. REED Groundfish cruise 70-1, March 5-June 18, 1970. Fish. Res. Board Can. Tech. Rep. 205: 82 p.

Ketchen, K. S. 1979. An overview of the Strait of Georgia winter trawl fishery, 1951-52 to 1977-78. Fish. Mar. Serv. MS Rep. 1511: 63 p.

Ketchen, K.S. 1980a. (Editor) Assessment of groundfish stocks off the west coast of Canada (1979). Can. Data Rep. Fish. Aquat. Sci. No. 185: 213 p.

Ketchen, K. S. 1980b. Reconstruction of Pacific ocean perch (Sebastes alutus) stock history in Queen Charlotte Sound. Part I. Estimation of foreign catches, 1965-76. Can. MS Rep. Fish. Aquat. Sci. 1570: 46 p.

Leaman, B. M., D. Davenport, W. R. Harling, D. A. Nagtegaal, W. A. Ostermann, J. R. Selsby, and G. A. Thomas. 1978. Biological observer coverage of foreign fisheries off Canada's Pacific coast, 1977. Part 2 (Rept. no. 6). Fish. Mar. Serv. Data Rep. 99.

Pope, J. G. 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. Internat. Comm. for the Northwest Atlantic Fisheries. Res. Bull. 9: 65-74.

Westrheim, S. J. 1967. G.B. REED Groundfish cruise reports, 1963-66. (Groundfish cruise no. 66-2). Fish. Res. Board Can. Tech. Rep. 30.

Westrheim, S. J., W. R. Harling, D. Davenport, and M. S. Smith. 1968. Preliminary report on maturity, spawning season, and larval identification of rockfishes (Sebastodes) collected off British Columbia in 1968. Fish. Res. Board Can. MS Rep. 1005: 28 p.

Westrheim, S. J. 1972. Explorations of rockfish grounds off British Columbia in 1971. Fish Res. Board Can. MS. Rep. 1200: 29 p.

Westrheim, S. J., W. R. Harling, D. Davenport, and M. S. Smith. 1974a. G.B. REED cruise no. 74-3, June 4-26, 1974 (Data Record). Fish. Mar. Serv. Tech. Rep. 478: 26 p.

Westrheim, S. J., W. R. Harling, D. Davenport, and M. S. Smith. 1974b. Echo-sounder and trawl survey of Queen Charlotte Sound and southern Hecate Strait, 1972-73. Fish. Res. Board Can. MS Rep. 1307: 43 p.

Westrheim, S. J. 1973. Age determination and growth of Pacific ocean perch (Sebastes alutus) in the Northeast Pacific Ocean. J. Fish. Res. Board Can. 30(2): 235-247.

Table 1. Pacific ocean perch (Sebastes alutus) landings (t) by nation and CPUE (t/h) by U.S. trawlers operating in Queen Charlotte Sound.

Year	North America			Foreign[b]			All-nation total	USA CPUE[c]
	Canada	USA	Subtotal[a]	USSR	Japan	Subtotal		
1956	141	1,093	1,234	-	-	-	1,234	-
1957	96	661	757	-	-	-	757	-
1958	315	616	931	-	-	-	931	-
1959	232	1,658	1,890	-	-	-	1,890	0.672
1960	356	1,323	1,679	-	-	-	1,679	0.577
1961	118	1,081	1,199	-	-	-	1,199	0.645
1962	531	1,307	1,838	-	-	-	1,838	0.661
1963	451	3,261	3,712	-	-	-	3,712	0.841
1964	419	3,088	3,507	-	-	-	3,507	0.731
1965	1,387	3,502	4,889	3,096	-	3,096	7,985	1.040
1966	2,361	5,893	8,254	12,992	888	13,880	22,134	1.132
1967	384	5,361	5,734	9,688	2,165	11,853	17,587	0.800
1968	876	5,175	6,051	3,931	2,872	6,803	12,854	0.722
1969	1,500	5,128	6,628	56	3,162	3,218	9,846	0.656
1970	1,762	4,315	6,077	-	1,863	1,863	7,940	0.710
1971	1,098	3,066	4,164	80	168	248	4,412	0.670
1972	2,196	3,366	5,562	-	1,126	1,126	6,688	0.710
1973	1,360	2,266	3,626	-	2,422	2,422	6,048	0.812
1974	1,496	2,157	3,653	-	5,632	5,632	9,285	0.610
1975	1,831	961	2,792	-	2,722	2,722	5,514	0.487
1976	1,518	448	1,966	-	1,220	1,220	3,186	0.361
1977	1,074	1,030	2,106	-	-	-	2,106	0.420
1978	1,299	37	1,336	-	-	-	1,336	0.705
1979	1,358	191	1,549	-	-	-	1,549	-

[a]Revised totals for PMFC Areas 5A and 5B combined.

[b]"Intermediate" estimates as given by Ketchen (1980b); for "minimum" and "maximum" estimates see his Table 17.

[c]From Gunderson et al. (1976) for 1959-74; from correspondence with Wash. State Dept. Fisheries for 1975-78.

Table 2. North American landings of Pacific ocean perch (Sebastes alutus) by month from Queen Charlotte Sound (figures in metric tons).

	J	F	M	A	M	J	J	A	S	O	N	D
1959 Total	-	12	-	-	103	433	406	136	175	502	105	18
CAN	-	-	-	-	12	93	46	-	23	58	-	-
USA	-	12	-	-	91	340	360	136	152	444	105	18
1960 Total	-	-	-	4	381	234	141	114	286	314	192	13
CAN	-	-	-	-	159	15	25	12	49	96	-	-
USA	-	-	-	4	222	219	116	102	237	218	192	13
1961 Total	-	-	-	28	283	176	113	157	151	169	89	33
CAN	-	-	-	17	61	40	-	-	-	-	-	-
USA	-	-	-	11	222	136	113	157	151	169	89	33
1962 Total	-	-	-	tr	611	637	220	100	85	116	69	-
CAN	-	-	-	tr	238	255	29	-	5	4	-	-
USA	-	-	-	-	373	382	191	100	80	112	69	-
1963 Total	-	-	-	77	1182	661	389	211	473	457	213	49
CAN	-	-	-	-	135	124	104	5	37	44	2	-
USA	-	-	-	77	1047	537	285	206	436	413	211	49
1964 Total	-	-	2	147	616	435	218	356	427	517	560	229
CAN	-	-	-	2	1	45	15	170	93	93	-	-
USA	-	-	2	145	615	390	203	186	334	424	560	229
1965 Total	1	tr	-	116	810	662	381	405	767	913	790	44
CAN	-	-	-	7	101	147	96	109	199	442	279	7
USA	1	tr	-	109	709	515	285	296	568	471	511	37
1966 Total	-	-	-	82	724	1569	428	1215	1166	1740	1006	324
CAN	-	-	-	-	-	463	121	351	400	645	348	33
USA	-	-	-	82	724	1106	307	8645	766	1095	658	291

Table 2 (cont'd)

		J	F	M	A	M	J	J	A	S	O	N	D
1967	Total	-	-	-	2	891	980	938	1018	663	376	757	120
	CAN	-	-	-	-	25	-	44	55	17	27	196	20
	USA	-	-	-	2	866	980	894	963	646	349	561	100
1968	Total	41	144	5	31	1032	1051	789	725	1067	628	423	125
	CAN	-	1	-	1	171	257	106	26	121	146	47	-
	USA	41	143	5	30	861	784	683	699	946	482	376	125
1969	Total	2	-	-	tr	859	1553	1060	648	558	1110	655	183
	CAN	-	-	-	-	144	524	425	2	-	221	151	33
	USA	2	-	-	tr	715	1029	635	646	558	889	504	150
1970	Total	8	4	tr	12	756	1231	547	578	748	1043	861	289
	CAN	-	-	-	-	235	464	135	1	49	528	274	76
	USA	8	4	tr	12	521	767	412	577	699	515	587	213
1971	Total	-	tr	tr	3	280	1025	800	453	859	400	305	39
	CAN	-	tr	tr	1	85	386	458	61	-	56	51	-
	USA	-	-	-	2	195	639	342	392	859	344	254	39
1972	Total	-	-	-	1	472	914	687	847	958	1036	532	115
	CAN	-	-	-	-	94	379	241	259	368	388	358	109
	USA	-	-	-	1	378	535	446	588	590	648	174	6
1973	Total	-	-	38	930	297	248	566	601	439	186	237	84
	CAN	-	-	38	400	53	89	179	127	73	94	225	82
	USA	-	-	-	530	244	159	387	474	366	92	12	2
1974	Total	-	-	181	164	166	796	857	515	459	298	211	6
	CAN	-	-	120	54	56	356	425	20	58	243	164	-
	USA	-	-	61	110	110	440	432	495	401	55	47	6

Table 2 (cont'd)

	J	F	M	A	M	J	J	A	S	O	N	D
1975 Total	-	-	19	10	337	715	527	75	394	464	203	48
CAN	-	-	-	5	202	424	362	-	266	340	184	48
USA	-	-	19	5	135	291	165	75	128	124	19	-
1976 Total	-	-	-	tr	43	216	115	283	530	335	204	240
CAN	-	-	-	-	36	211	104	133	447	299	136	152
USA	-	-	-	tr	7	5	11	150	83	36	68	88
1977 Total	-	-	2	-	45	559	596	441	196	234	32	1
CAN	-	-	-	-	26	289	315	199	85	155	5	-
USA	-	-	2	-	19	270	281	242	111	79	27	1
1978 Total	-	-	1	-	130	157	198	132	329	255	88	36
CAN	-	-	-	-	105	156	198	132	329	255	88	36
USA	-	-	1	-	25	1	-	-	-	-	-	-
1979 Total	19	26	-	-	50	141	758	150	142	236	27	-
CAN	19	26	-	-	14	138	609	147	141	236	27	-
USA	-	-	-	-	36	3	149	3	1	-	-	-

Table 3. Estimated removals from the Goose Island and Mitchell's Gully stocks of Pacific ocean perch (*S. alutus*) in Queen Charlotte Sound (t); CPUE of U.S. trawlers (t/h).

	Goose Island Gully					Mitchell's Gully					U.S. CPUE[c]	
Year	Canada[d]	USA[d]	USSR[b]	Japan[b]	Total	Canada[a,d]	USA[a,d]	USSR[b]	Japan[b]	Total	Goose	Mitchell
1959	232	1,658	-	-	1,890	-	-	-	-	-	0.672	-
1960	356	1,323	-	-	1,679	-	-	-	-	-	0.577	-
1961	118	1,081	-	-	1,199	-	-	-	-	-	0.645	-
1962	531	1,307	-	-	1,838	-	-	-	-	-	0.661	-
1963	451	3,261	-	-	3,712	-	-	-	-	-	0.841	-
1964	362	3,088	-	-	3,450	57	-	-	-	57	0.731	-
1965	1,387	3,463	2,628	-	7,478	-	20	468	-	488	1.079	0.514
1966	2,361	5,869	11,728	794	20,752	-	11	1,264	94	1,369	1.181	0.552
1967	313	3,493	6,482	1,831	12,119	71	1,708	3,206	334	5,319	0.789	0.925
1968	770	3,947	3,356	2,140	10,213	106	1,143	575	732	2,556	0.718	0.903
1969	1,416	3,367	40	2,049	6,872	85	1,731	16	1,113	2,945	0.635	0.748
1970	1,743	3,453	-	1,293	6,489	19	707	-	570	1,296	0.702	0.765
1971	1,093	2,197	-	165	3,455	6	804	-	3	813	0.689	0.704
1972	1,951	2,698	-	996	5,645	245	580	-	130	955	0.794	0.714
1973	487	1,117	-	2,151	3,755	873	1,120	-	271	2,264	0.716	1.112
1974	461	1,362	-	5,446	7,269	1,035	684	-	186	1,917	0.666	0.672
1975	1,032	653	-	2,524	4,209	799	154	-	198	1,151	0.501	0.466
1976	1,015	266	-	1,161	2,442	503	14	-	59	576	0.507	0.522
1977	884	809	-	-	1,693	190	66	-	-	256	0.505	0.377
1978	831	34[e]	-	-	865	372	3[e]	-	-	375	-	-
1979	801	150	-	-	951	467	13	-	-	480	-	-

[a]There may have been occasions between 1959 and 1964 when some fishing occurred, but significant catches were not made before 1967 (Gunderson et al. 1976). Records for the Canadian fishery prior to 1964 were not coded to distinguish one gully from the other.

[b]Figures estimated by Ketchen (1980b) are "intermediate" values. For "minimum" and "maximum" estimates see Ketchen's Table 17.

[c]For 1959-74 figures are from Gunderson et al. (1976), based on performance of the Washington trawl fleet; 1975-79 data provided by Wash. State Dept. Fisheries.

[d]North American totals for the two gullies differ slightly from those in Gunderson et al. (1976) as a result of re-analysis of Canadian data.

[e]Estimated from 1977 ratio in this table.

Table 4. Numbers of trawlers making more than one interviewed landing of Pacific ocean perch per year from Queen Charlotte Sound.

	Vessel class							
Year	3	4	5	6	7	8	9	10
1960	1	-	-	4	-	-	-	-
61	-	-	-	2	-	-	-	-
62	1	1	1	3	-	-	-	-
63	2	1	-	3	-	-	-	-
64	4	3	-	4	1	-	-	-
1965	-	4	1	4	2	-	-	-
66	-	1	4	7	3	-	-	-
67	-	2	5	4	2	-	-	-
68	2	4	1	4	1	-	-	-
69	-	4	1	4	3	1	-	-
1970	-	5	-	4	4	1	-	-
71	-	3	1	3	3	1	-	-
72	-	1	-	1	2	1	1	-
73	-	1	-	2	3	1	1	-
74	-	-	1	1	4	3	1	-
1975	-	-	3	2	3	2	1	-
76	-	-	3	3	3	3	2	-
77	-	-	3	2	4	1	1	-
78	-	-	2	2	5	2	1	1
79	-	-	1	2	3	2	1	2

Table 5. Statistics of the Canadian catch of Pacific ocean perch and fishing effort by class of trawler, by month and year in Queen Charlotte Sound.

		Catch by class (t)				Effort by class (h)			
Year	Mo.	6	7	8	9	6	7	8	9
1964	Aug	101	62	-	-	153	42	-	-
	Sep	62	13	-	-	54	7	-	-
1965	Jun	74	19	-	-	48	11	-	-
	Jul	44	52	-	-	25	34	-	-
	Sep	107	72	-	-	117	66	-	-
	Oct	310	58	-	-	179	36	-	-
	Nov	188	58	-	-	139	71	-	-
	Dec	4	1	-	-	9	3	-	-
1966	Jun	186	162	-	-	108	91	-	-
	Jul	9	75	-	-	10	54	-	-
	Sep	288	33	-	-	251	30	-	-
	Oct	472	35	-	-	357	32	-	-
1967	Jul	2	52	-	-	3	27	-	-
	Aug	9	37	-	-	12	34	-	-
1968	May	83	79	-	-	115	43	-	-
	Jun	201	30	-	-	241	48	-	-
	Jul	55	51	-	-	41	52	-	-
	Sep	90	24	-	-	77	25	-	-
1969	May	94	31	14	-	91	44	12	-
	Jun	193	199	86	-	295	225	68	-
	Jul	149	107	179	-	198	230	223	-
	Oct	98	19	30	-	139	33	56	-
	Nov	48	55	17	-	77	64	22	-
	Dec	13	19	-	-	16	16	-	-

Table 5 (cont'd)

Year	Mo.	Catch by class (t)				Effort by class (h)			
		6	7	8	9	6	7	8	9
1970	May	82	82	66	-	137	132	70	-
	Jun	64	245	139	-	128	510	182	-
	Jul	14	8	47	-	45	27	129	-
	Sep	20	27	-	-	36	66	-	-
	Oct	164	201	115	-	197	188	128	-
	Nov	42	114	68	-	51	126	70	-
	Dec	7	31	-	-	12	24	-	-
1971	Jun	38	121	136	-	106	226	254	-
	Jul	86	118	193	-	247	241	286	-
	Aug	9	22	22	-	21	37	33	-
1972	May	7	70	15	-	33	75	32	-
	Jun	12	127	169	-	17	183	172	-
	Jul	60	44	94	5	145	46	155	10
	Aug	39	34	171	-	48	28	181	-
	Sep	68	40	40	109	24	24	46	66
	Oct	9	71	51	88	13	70	54	80
	Nov	-	127	61	171	-	153	76	144
1973	May	-	8	20	4	-	17	14	4
	Jun	12	53	18	-	26	68	31	-
	Jul	8	58	58	55	19	125	98	46
	Aug	-	75	-	50	-	55	-	39
	Oct	-	36	-	22	-	37	-	19
	Nov	-	65	152	83	-	50	30	46
1974	May	-	29	8	17	-	52	20	17
	Jun	36	102	150	88	80	144	193	75
	Jul	55	113	176	65	48	125	138	70
	Oct	-	52	107	64	-	48	154	52

Table 5 (cont'd)

Year	Mo.	Catch by class (t) 6	7	8	9	Effort by class (h) 6	7	8	9
1975	May	12	37	68	16	16	52	65	30
	Jun	23	46	101	133	38	52	159	126
	Jul	25	43	114	78	26	61	135	102
	Sep	-	50	111	49	-	102	136	67
	Oct	-	127	86	144	-	119	66	116
	Nov	-	49	64	53	-	68	74	53
1976	May	-	14	7	15	-	22	13	19
	Jun	-	46	13	146	-	56	17	117
	Jul	3	6	33	62	5	29	35	67
	Aug	2	1	50	30	4	2	98	26
	Sep	50	149	103	34	53	178	161	44
	Oct	1	78	75	82	2	113	90	86
	Nov	8	24	15	51	12	23	21	40
	Dec	-	32	48	72	-	35	85	63
1977	May	-	2	1	4	-	7	3	11
	Jun	44	103	55	42	61	187	75	50
	Jul	18	34	94	111	39	63	136	114
	Aug	-	33	44	74	-	51	97	60
	Sep	-	7	30	-	-	13	44	-
	Oct	-	28	36	29	-	31	37	20
1978	May	7	4	12	38	10	9	30	66
	Jun	8	36	49	18	27	78	65	23
	Jul	11	33	53	36	16	29	92	28
	Aug	5	25	23	59	14	39	19	45
	Sep	-	54	99	30	-	68	42	21
	Oct	-	119	36	91	-	93	14	35
	Nov	-	42	44	-	-	38	28	-

Table 5 (cont'd)

		Catch by class (t)				Effort by class (h)			
Year	Mo.	6	7	8	9	6	7	8	9
1979	Jun	35	32	31	79	47	65	65	31
	Jul	27	73	171	87	48	108	174	105
	Aug	-	26	40	16	-	22	36	21
	Sep	-	4	78	20	-	7	64	32
	Oct	-	-	73	85	-	-	95	73
	Nov	-	-	19	18	-	-	10	6

Table 6. Estimation of annual and over-all power factors for the several classes of Canadian trawlers that participated in the Queen Charlotte Sound fishery for Pacific ocean perch.

Year	Class 6	Class 7	Class 8	Class 9
1964	0.32	1.00	-	-
65	1.17	1.00	-	-
66	1.01	1.00	-	-
67	0.63	1.00	-	-
68	0.95	1.00	-	-
69	1.04	1.00	1.47	-
1970	0.94	1.00	1.26	-
71	0.70	1.00	1.18	-
72	0.92	1.00	0.92	1.19
73	0.75	1.00	1.25	1.56
74	0.84	1.00	1.05	1.32
1975	0.96	1.00	1.22	1.19
76	1.06	1.00	0.97	1.48
77	1.05	1.00	1.12	1.48
78	0.65	1.00	1.53	1.47
Wt'd Av'ge	0.89	1.00	1.16	1.36
Unwt'd Av'ge*				
Type 1	0.87	1.00	1.20	1.38
Type 2	0.88	1.00	1.16	1.39

*The Type 1 average is merely the unweighted mean of the annual (weighted) estimates shown in the table.

The Type 2 average is the unweighted mean of all the monthly values, regardless of the amount of fishing effort involved.

Table 7. Calculation of a standardized (Canadian) CPUE in the fishery for Pacific ocean perch in Goose Island Gully.

	1	2	3	4	5	6	7
	Standardized fishing effort (h)						
Year	Class 6	Class 7	Class 8	Class 9	Total	Can. catch (t)	Stand. CPUE (t/h)
1959	107	-	-	-	107	88	(0.822)[a]
1960	258	-	-	-	258	291	(1.128)
61	43	-	-	-	43	67	(1.558)
62	322	-	-	-	322	374	1.161
63	300	-	-	-	300	437	1.457
64	281	39	-	-	320	311	1.134
1965	584	221	-	-	805	1,200	1.491
66	1,097	207	-	-	1,304	1,879	1.441
67	150	69	-	-	219	234	1.068
68	589	168	-	-	757	791	1.045
69	677	549	442	-	1,668	1,272	0.763
1970	539	1,073	672	-	2,284	1,535	0.672
71	333	743	665	-	1,741	916	0.526
72	249	542	831	292	1,914	1,586	0.829
73	22	289	138	75	524	405	0.773
74	103	180	238	82	603	442	0.773
1975	71	236	456	272	1,035	525	0.507
76	65	331	390	248	1,034	758	0.733
77	89	250	356	248	943	622	0.660
78	33	227	133	273	666	547	0.821
79	93	141	389	194	796	636	0.799

[a]Figures in parentheses to be adjusted. See text and Table 11.

Table 8. Calculation of a standardized (Canadian) CPUE in the fishery for Pacific ocean perch in Mitchell's Gully.

	Standardized effort (h)					
Year	Class 7	Class 8	Class 9	Total	Can. catch (t)	Stand. CPUE (t/h)
1972	37	-	203	240	205	0.854
73	203	63	366	632	854	1.351
74	245	392	416	1,053	1,026	0.974
1975	218	281	471	970	959	0.989
76	127	213	381	721	485	0.673
77	110	102	101	313	160	0.511
78	108	109	116	333	272	0.817
79	48	106	234	388	260	0.670

Table 9. Available biomass estimates of marketable ($\geq$31 cm) Pacific ocean perch and annual average estimates of standardized (Canadian) CPUE for Goose Island Gully.

Year	Month	Biomass (t)	CPUE (t/h)
1965	August	63,600	1.491
1966	August	45,500	1.441
1967	September	54,200	1.068
1968		-	-
1969	September	51,800	0.763
1970	June	36,800	0.672
1971	October	39,100	0.526
1972		-	-
1973	September	22,300	0.773
1974		-	-
1975		-	-
1976	September	33,100	0.733
1977	August	23,000	0.661

Y = CPUE; X = biomass

$Y = 0.222367 + .00001659X$

n = 9; r = 0.665, marginally significant at the 5% level.

Table 10. Comparison of U.S. and Canadian (standard) CPUE estimates for Pacific ocean perch on the major fishing grounds in Queen Charlotte Sound (figures in t per h).

	Goose Island Gully		Mitchell's Gully	
Year	U.S. CPUE[a] (X)	Canada CPUE[b] (Y)	U.S. CPUE[a] (X)	Canada CPUE[c] (Y)
1962	0.838	1.161		
1963	0.841	1.457		
1964	0.731	1.134		
1965	1.079	1.491		
1966	1.181	1.441		
1967	0.789	1.068		
1968	0.718	1.045		
1969	0.635	0.763		
1970	0.702	0.672		
1971	0.689	0.526		
1972	0.794	0.829	0.714	0.854
1973	0.716	0.773	1.112	1.351
1974	0.666	0.773	0.672	0.974
1975	0.501	0.507	0.466	0.989
1976	0.507	0.733	0.522	0.673
1977	0.505	0.661	0.377	0.553
	1. $Y = 1.457X - 0.143$ $n = 16$ $r = 0.836$ .01 level signif.		2. $Y = 0.918 + 0.308$ $n = 6$ $r = 0.859$ .05 level signif.	

[a]From Table 3.
[b]From Table 7.
[c]From Table 8.

Table 11. Conversion of U.S. CPUE of Pacific ocean perch to the Canadian standard for Goose Island and Mitchell's Gullies (figures in t/h).[a]

	Goose Is. Gully	Mitchell's Gully
1959	0.836	-
1960	0.698	-
61	0.797	-
62	-	-
63	-	-
64	-	-
1965		0.780
66		0.815
67		1.157
68		1.137
69		0.995
1970		1.010
71		0.954

[a]CPUE data in Table 2 converted to Canadian standard with equations 1 and 2 in Table 10.

Table 12. Total catch (foreign and domestic) of Pacific ocean perch, standardized CPUE and calculated total effort on the principal fishing grounds of Queen Charlotte Sound.

	Goose Island Gully			Mitchell's Gully		
Year	Total catch (t)	Standard CPUE (t/h)	Calculated effort (h)	Total catch (t)	Standard CPUE (t/h)	Calculated effort (h)
1959	1,890	0.836	2,261	-	-	-
1960	1,679	0.698	2,405	-	-	-
61	1,199	0.797	1,504	-	-	-
62	1,838	1.161	1,583	-	-	-
63	3,712	1.457	2,548	-	-	-
64	3,450	1.134	3,042	57	-	-
1965	7,478	1.491	5,015	488	0.780	626
66	20,752	1.441	14,401	1,369	0.815	1,680
67	12,119	1.068	11,347	5,319	1.157	4,597
68	10,213	1.045	9,773	2,556	1.137	2,248
69	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
71	3,455	0.526	6,568	813	0.954	852
72	5,645	0.829	6,809	995	0.854	1,165
73	3,755	0.773	4,858	2,264	1.351	1,676
74	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
76	2,442	0.733	3,332	576	0.673	856
77	1,693	0.660	2,565	256	0.551	465
78	865	0.821	1,054	375	0.817	459
79	951	0.799	1,190	480	0.670	716

Table 13. Alternative estimates of calculated total fishing effort in Goose Island Gully based on possible minimum and maximum estimates of removals by the foreign fishery (catches in metric tons).

Year	Domestic catch[a]	Foreign catch[b]		Total catch		Stand. CPUE t/h[c]	Calculated total effort	
		Min.	Max.	Min.	Max.		Min.	Max.
1959	1,890	-	-	1,890	1,890	0.836	2,261	2,261
1960	1,679	-	-	1,679	1,679	0.698	2,431	2,431
1961	1,199	-	-	1,199	1,199	0.797	1,504	1,504
1962	1,838	-	-	1,838	1,838	1.161	2,193	2,193
1963	3,712	-	-	3,712	3,712	1.457	2,548	2,548
1964	3,450	-	-	3,450	3,450	1.134	3,042	3,042
1965	4,850	1,627	4,485	6,477	9,335	1.491	4,344	6,261
1966	8,230	7,751	19,254	15,981	35,714	1.441	11,090	24,784
1967	3,806	4,740	12,785	8,546	16,591	1.068	8,002	15,535
1968	4,717	3,368	7,976	8,085	12,693	1.045	7,737	12,146
1969	4,783	1,359	2,780	6,142	7,563	0.763	8,050	9,912
1970	5,196	1,144	1,442	6,340	6,638	0.672	9,435	9,878
1971	3,290	80	422	3,370	3,712	0.526	6,407	7,057
1972	4,649	603	1,367	5,252	6,016	0.829	6,335	7,257
1973	1,604	1,181	3,101	2,785	4,705	0.773	3,603	6,087
1974	1,823	2,533	8,294	4,356	10,117	0.773	5,635	13,088
1975	1,685	1,309	3,650	2,994	5,335	0.507	5,905	10,523
1976	1,281	584	1,730	1,865	3,011	0.733	2,544	4,108
1977	1,693	-	-	1,693	1,693	0.660	2,565	2,565
1978	847	-	-	847	847	0.821	1,032	1,032
1979	951	-	-	951	951	0.799	1,190	1,190

[a]Canada and U.S.A., from Table 3.
[b]Japan and U.S.S.R., from Ketchen (1980b; Table 17).
[c]From Tables 7 and 11.

Table 14. Alternative estimates of calculated total fishing effort in Mitchell's Gully based on possible minimum and maximum estimates of removals by the foreign fishery (catches in metric tons).

Year	Domestic catch[a]	Foreign catch[b]		Total catch		Stand. CPUE t/h[c]	Calculated total effort	
		Min.	Max.	Min.	Max.		Min.	Max.
1964	57	-	-	57	57	-	-	-
1965	20	290	797	310	817	0.780	397	1,047
1966	11	696	2,205	707	2,216	0.815	867	2,719
1967	1,779	1,707	5,734	3,486	7,513	1.157	3,013	6,494
1968	1,249	944	1,728	2,193	2,977	1.137	1,929	2,618
1969	1,816	980	1,264	2,796	3,080	0.995	2,810	3,095
1970	726	505	636	1,231	1,362	1.010	1,219	1,349
1971	810	2	3	812	813	0.954	851	852
1972	825	114	143	939	968	0.854	1,100	1,133
1973	1,993	122	299	2,115	2,292	1.351	1,566	1,697
1974	1,719	187	206	1,906	1,925	0.974	1,957	1,976
1975	953	52	211	1,005	1,164	0.989	1,016	1,177
1976	517	35	66	552	583	0.673	820	866
1977	256	-	-	256	256	0.551	465	465
1978	375	-	-	375	375	0.817	459	459
1979	480	-	-	480	480	0.670	716	716

[a]Canada and U.S.A. from Table 3.
[b]Japan and U.S.S.R. from Ketchen (1980b: Table 17)
[c]From Tables 8 and 11.

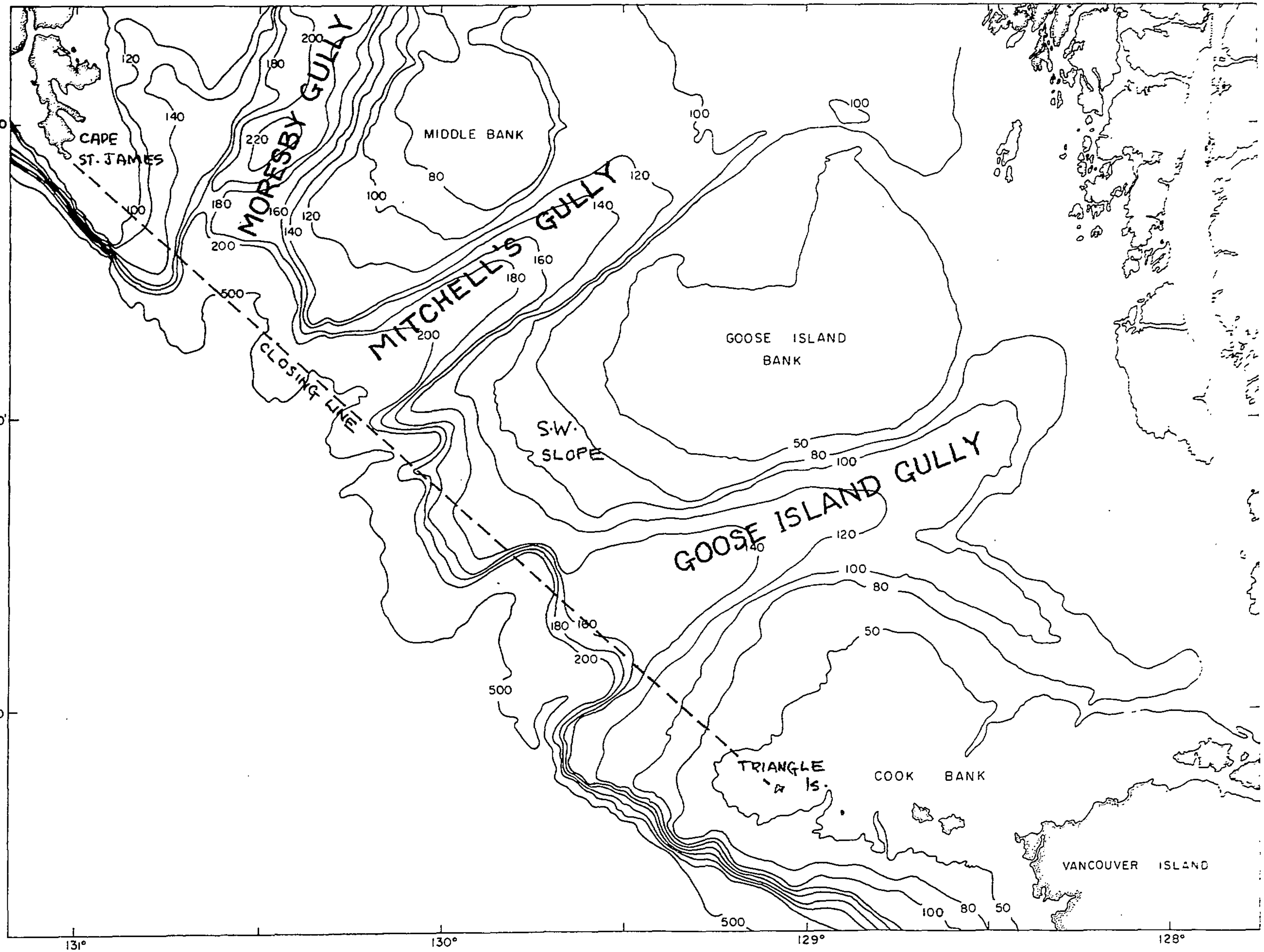

Figure 1. Bathymetry of Queen Charlotte Sound showing position of Goose Island Gully and Mitchell's Gully, the principal fishing grounds for Pacific ocean perch. (Depths in fathoms.)

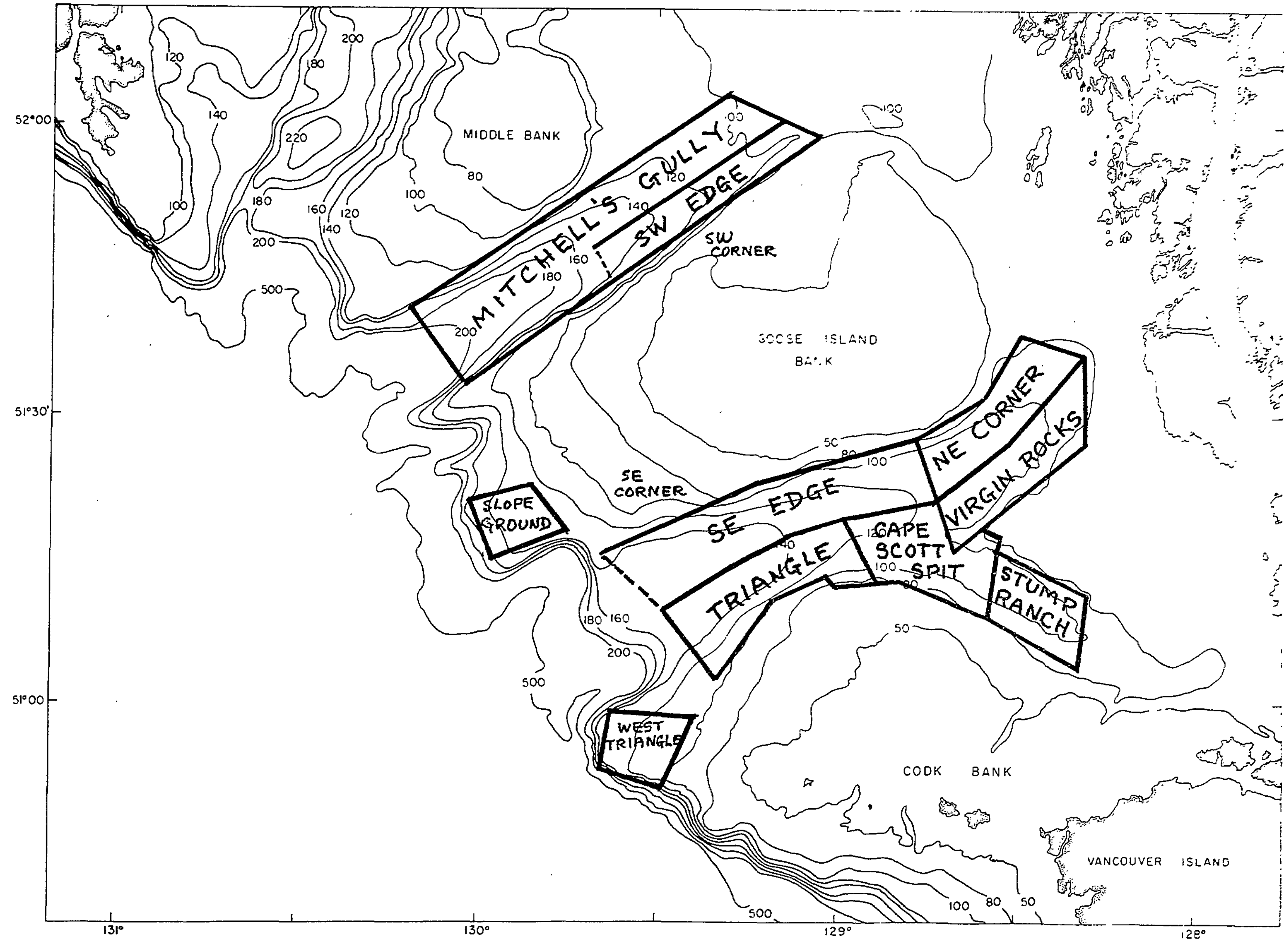

Fig. 2. Names and approximate locations of fishing grounds associated with Goose Island Gully and Mitchell's Gully in Queen Charlotte Sound.

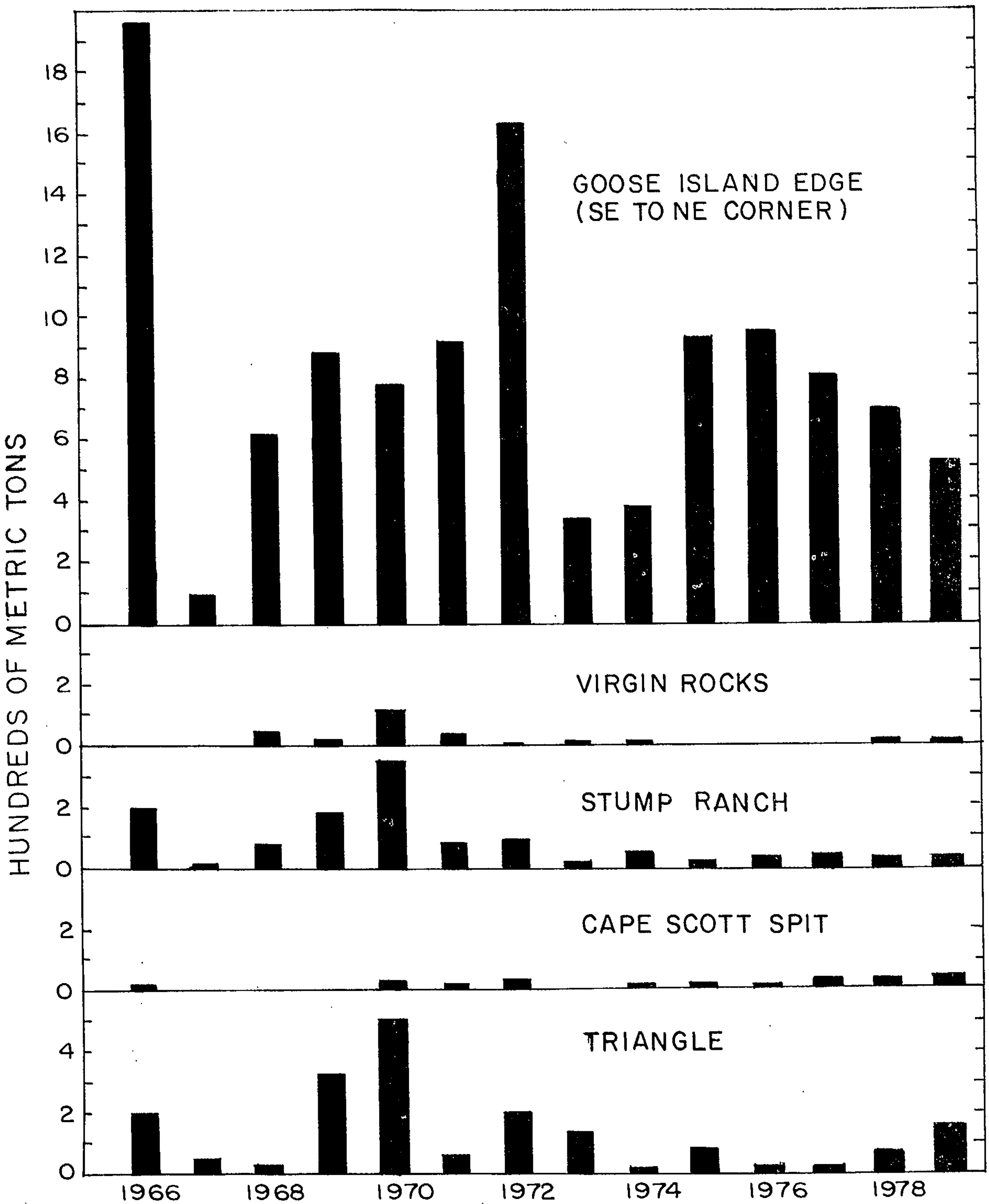

Fig. 3. Canadian catch of Pacific ocean perch by grounds within Goose Island Gully.

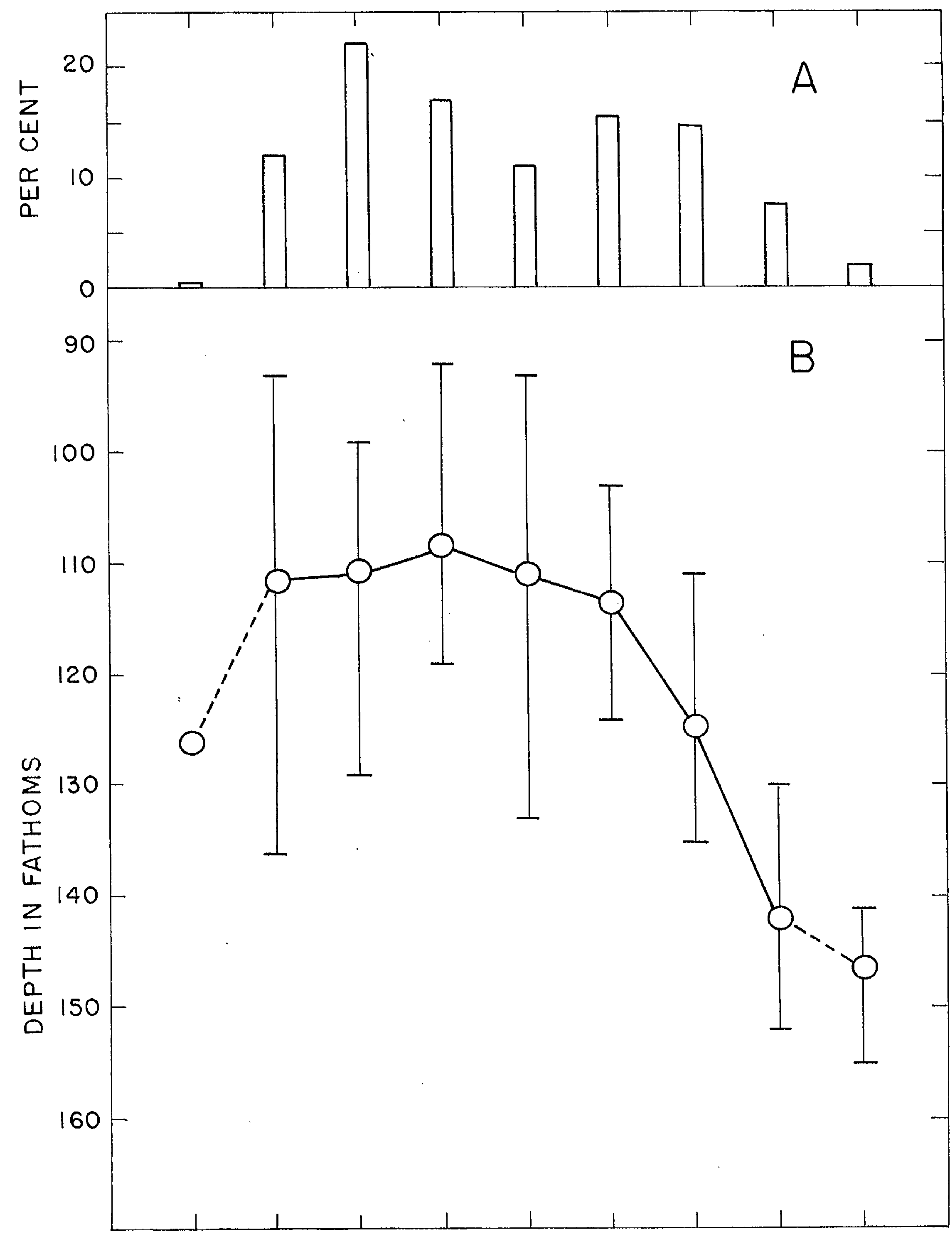

Fig. 4. (A) Average monthly landings of Pacific ocean perch by Canadian trawlers operating on grounds associated with Goose Island Gully (1968-78), and (B) mean and range of average depths of fishing (weighted to catch) during the same period.

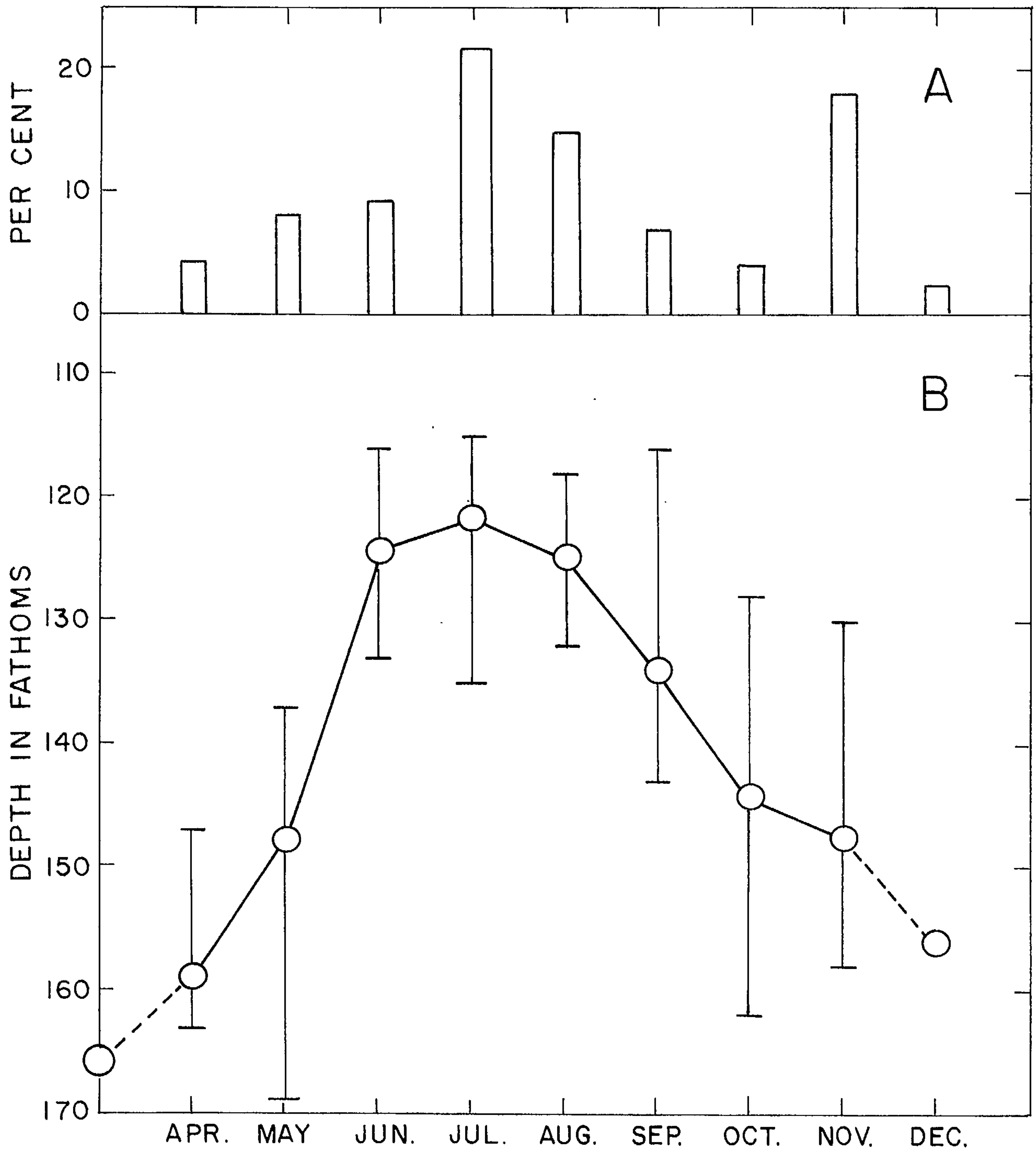

Fig. 5. (A) Average monthly landings of Pacific ocean perch by Canadian trawlers operating on grounds associated with Mitchell's Gully (1972-78), and (B) mean and range of average depths of fishing (weighted to catch) during the same period.

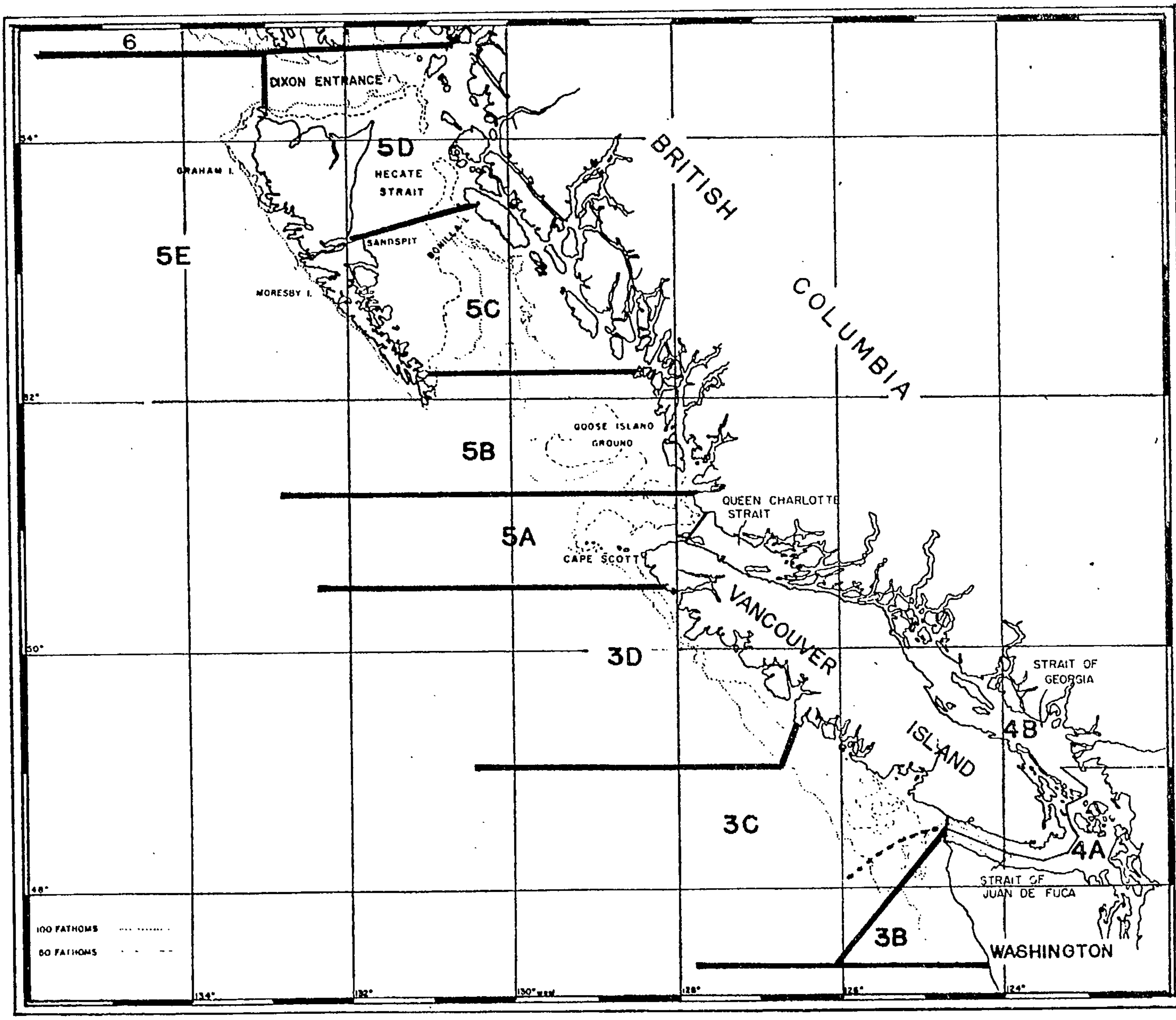

Fig. 6. PMFC statistical areas of the Canada-U.S. trawl fishery for groundfish in waters adjacent to Canada.

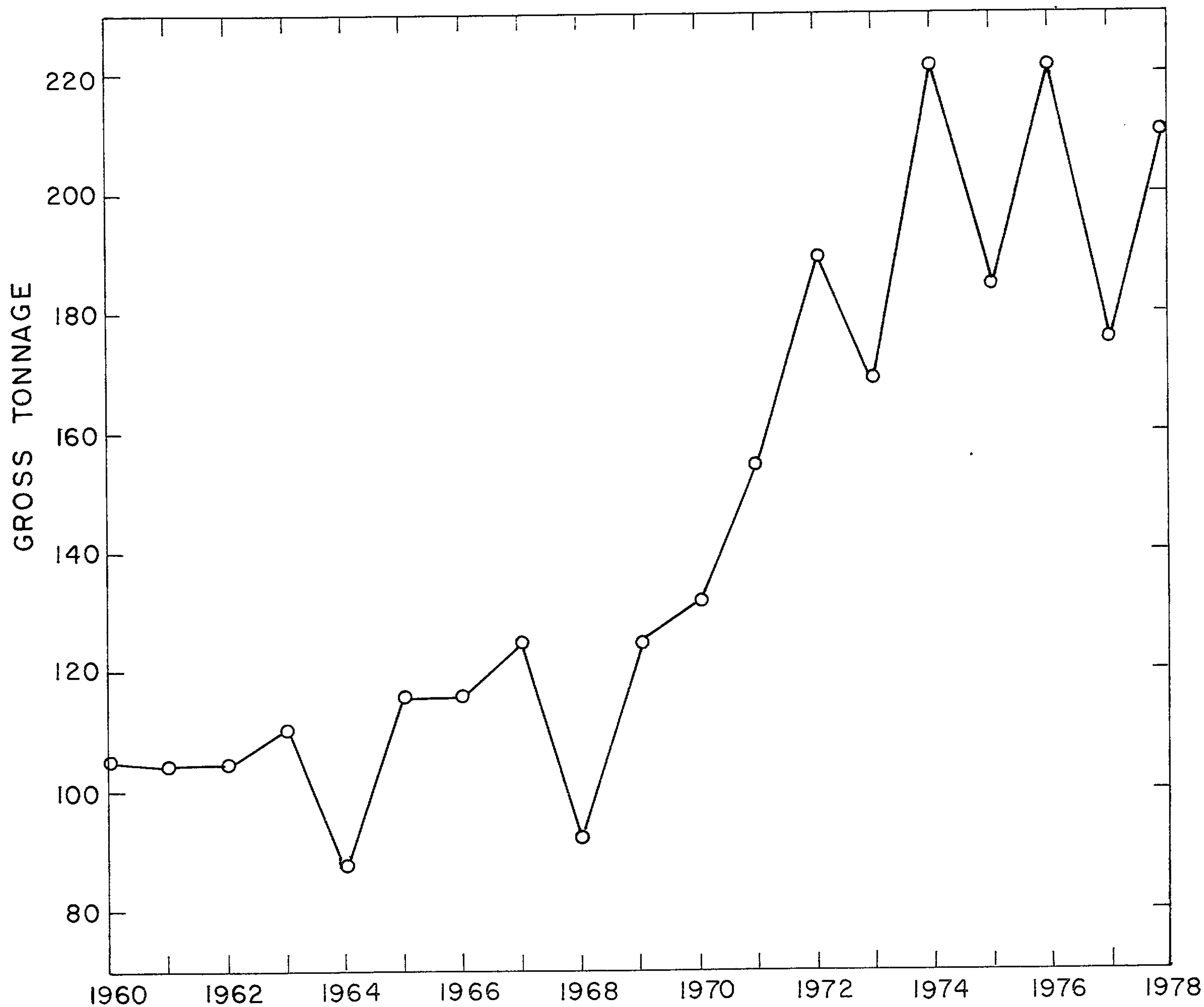

Fig. 7. Average annual gross tonnage of Canadian trawlers participating in the fishery for Pacific ocean perch in Queen Charlotte Sound.

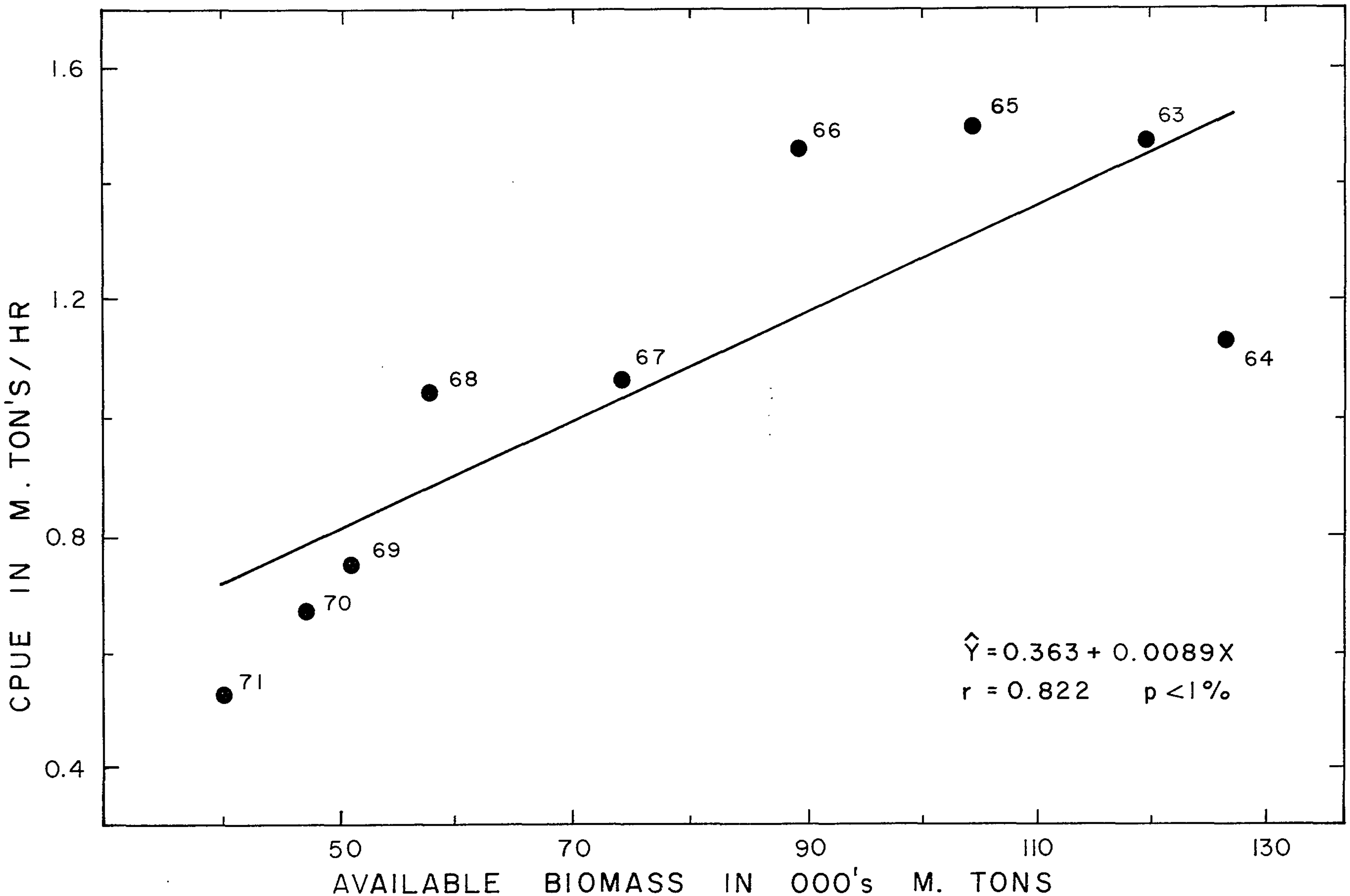

Fig. 8. Relationship between average catch per unit of effort and available biomass as determined by sequential (cohort) analysis.

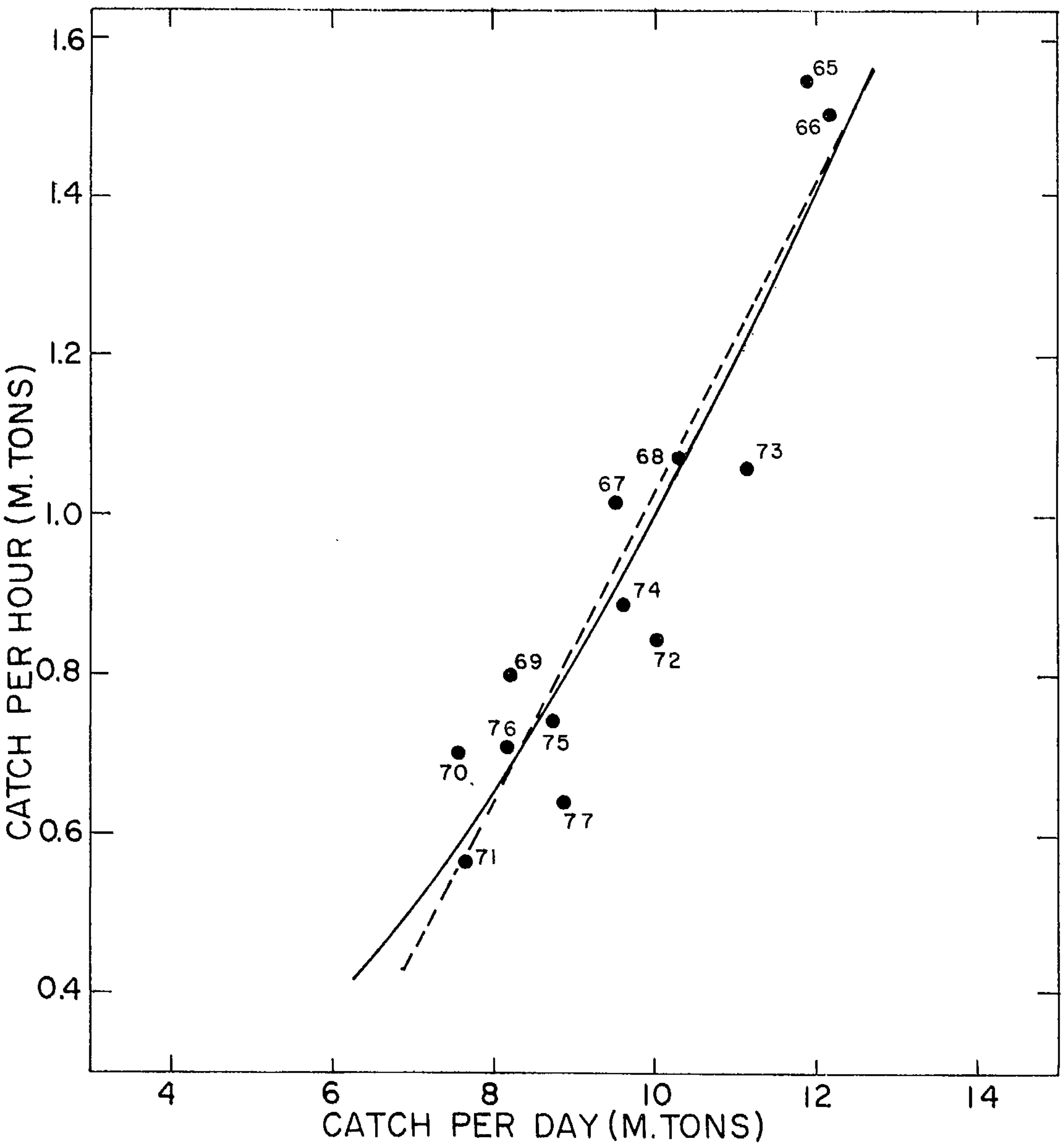

Fig. 9. Relationship between average catch per hour and average catch per day of trawling in the Canadian fishery for Pacific ocean perch in Goose Island Gully (broken line--linear; solid line--curvilinear, log/log).

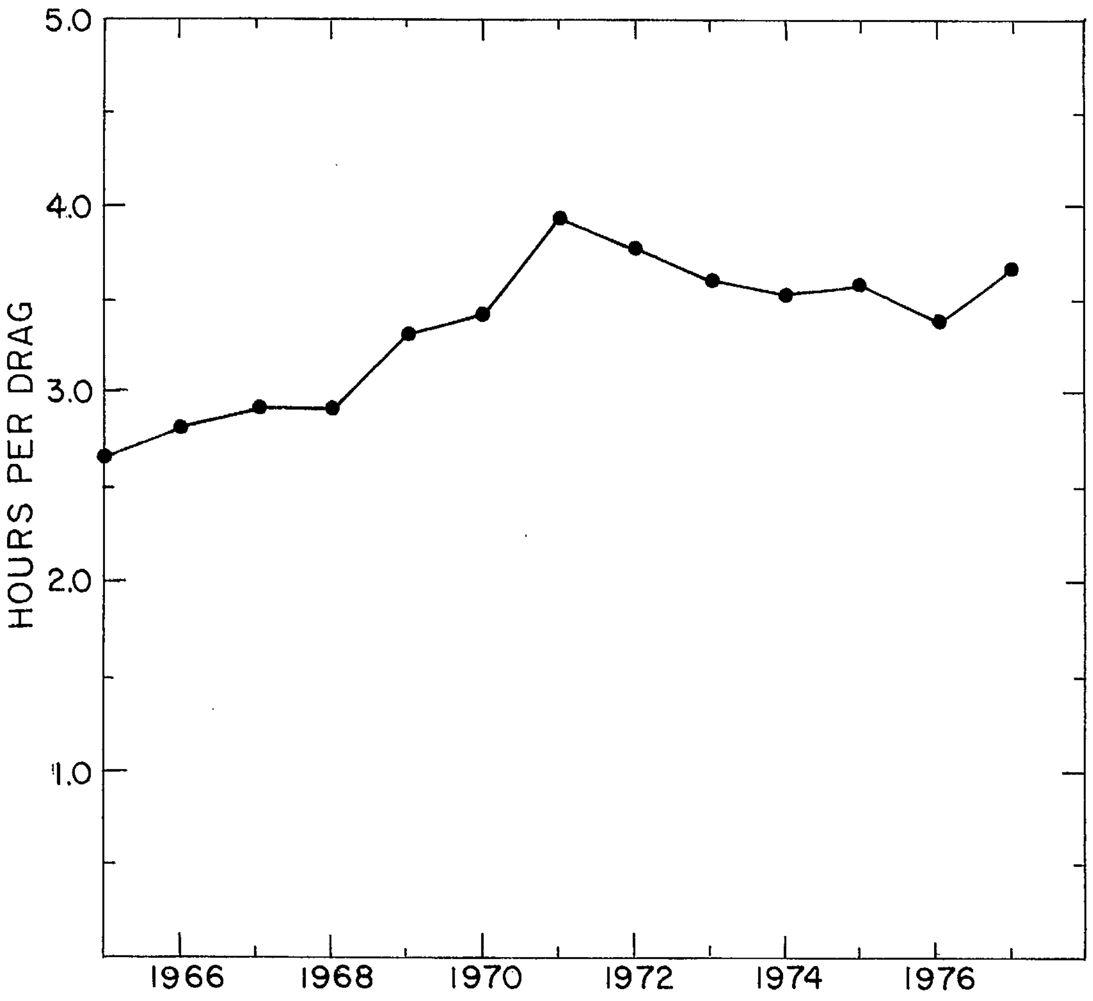

Fig. 10. Changes in average duration of hauls in the Canadian fishery for Pacific ocean perch in Queen Charlotte Sound.

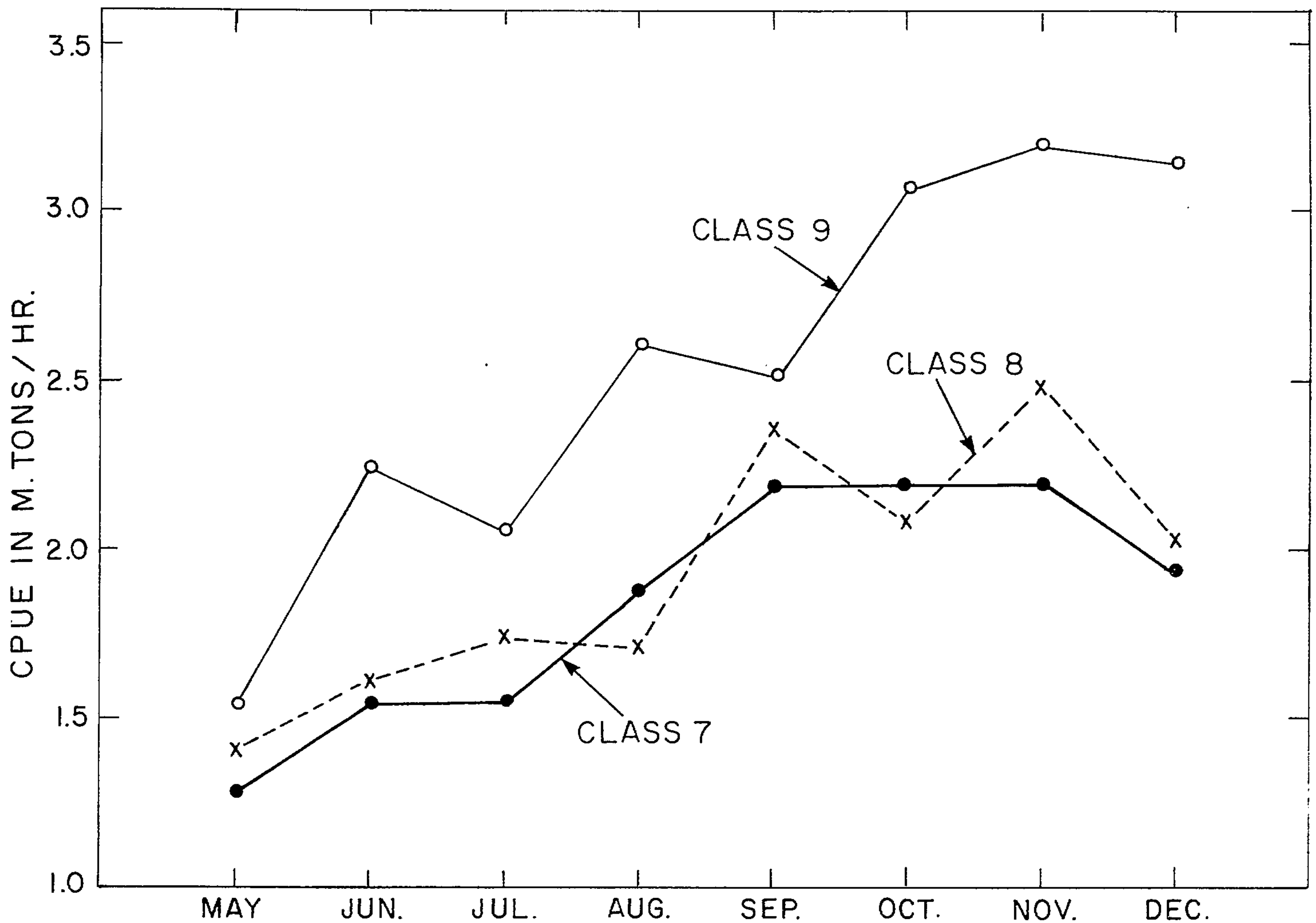

Fig. 11. Monthly average catch per unit of effort by vessel class in the Canadian trawl fishery for Pacific ocean perch in Queen Charlotte Sound (1972-78).

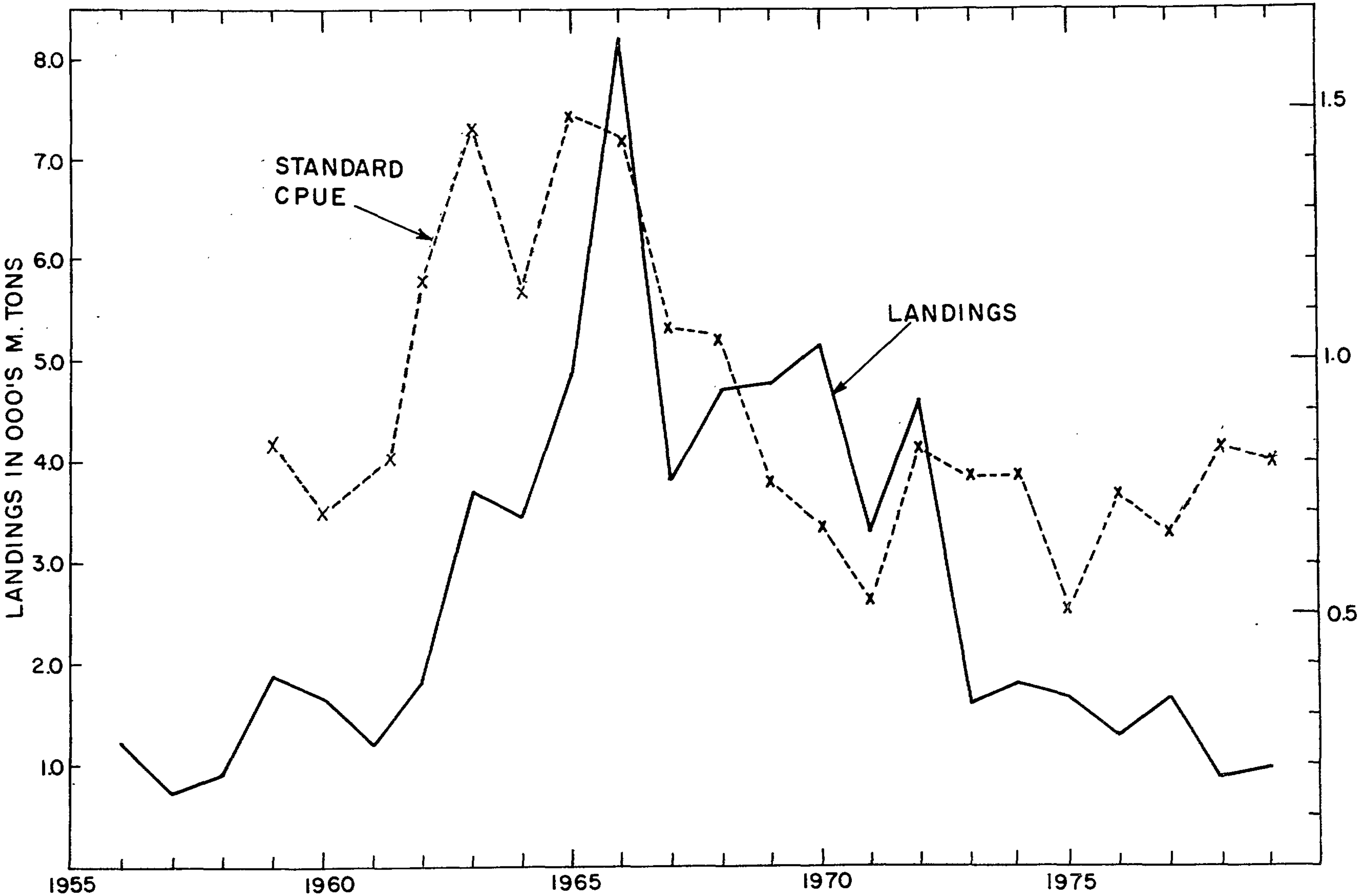

Fig. 12. North American landings of Pacific ocean perch from Goose Island Gully and standardized annual average catch per unit of effort.

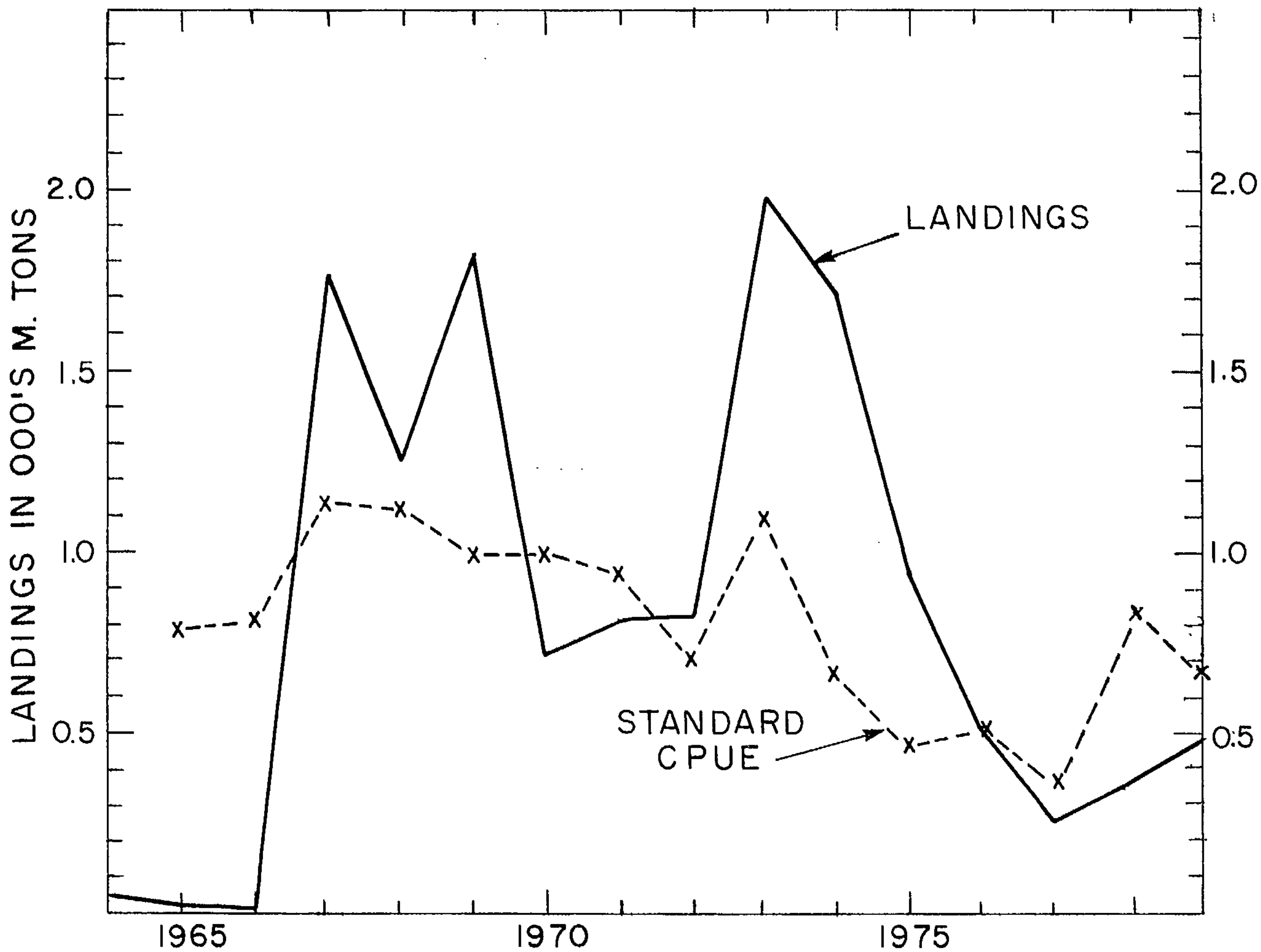

Fig. 13. North American landings of Pacific ocean perch from Mitchell's Gully and standardized annual average catch per unit of effort.

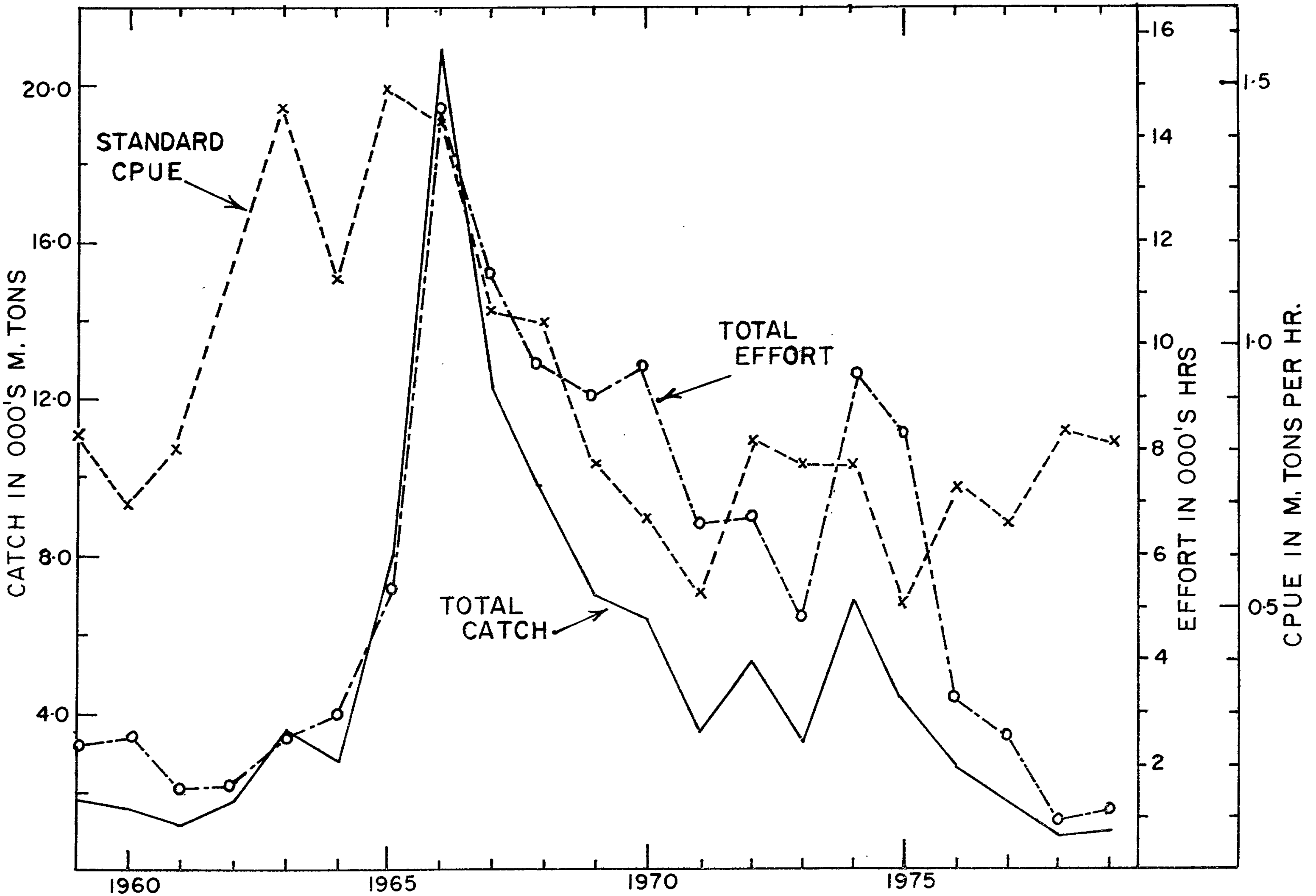

Fig. 14. Estimated total catch, standardized catch per unit of effort and calculated total fishing effort in the fishery for Pacific ocean perch on grounds associated with Goose Island Gully.

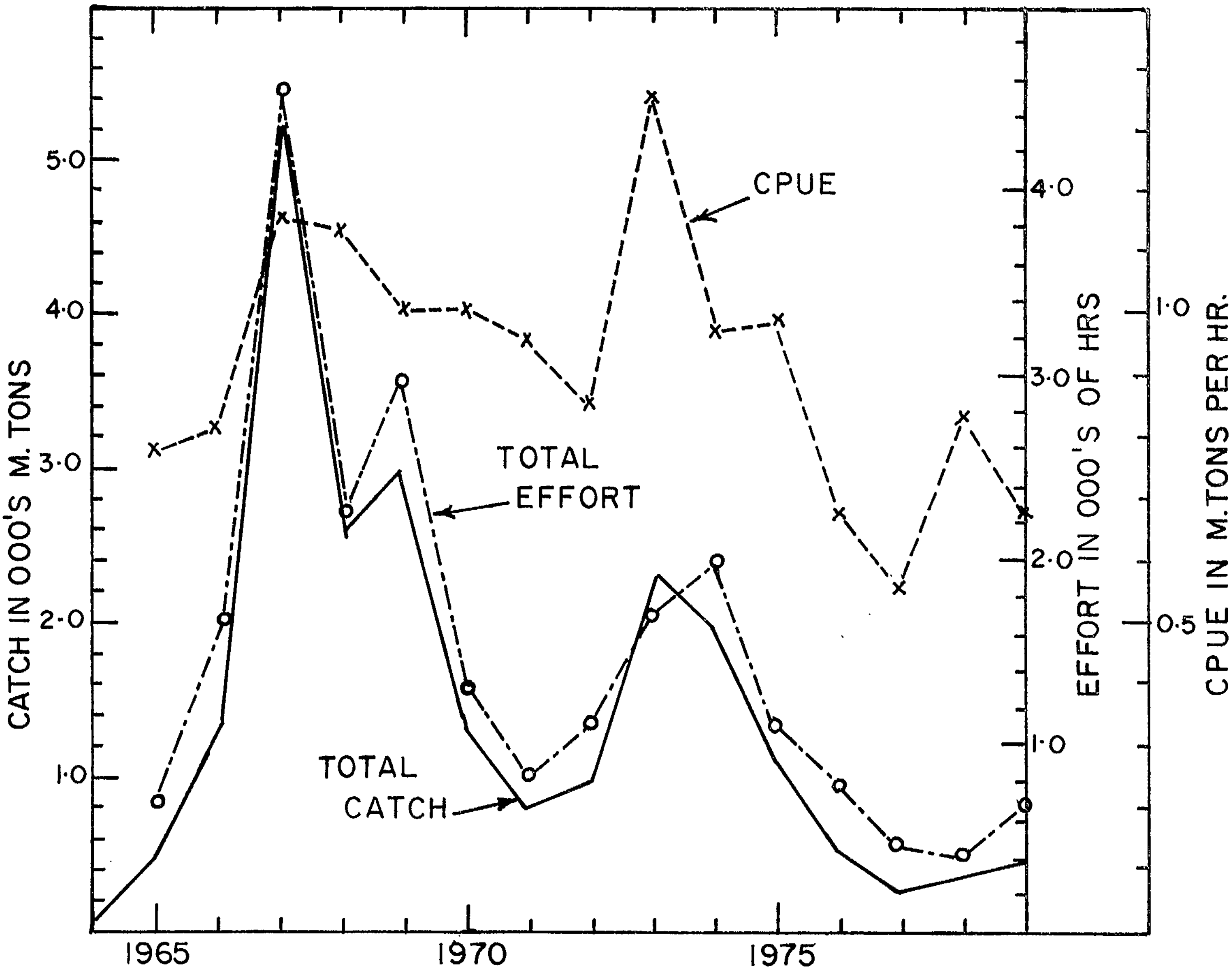

Fig. 15. Estimated total catch, standardized catch per unit of effort and calculated total fishing effort in the fishery for Pacific ocean perch on grounds associated with Mitchell's Gully.

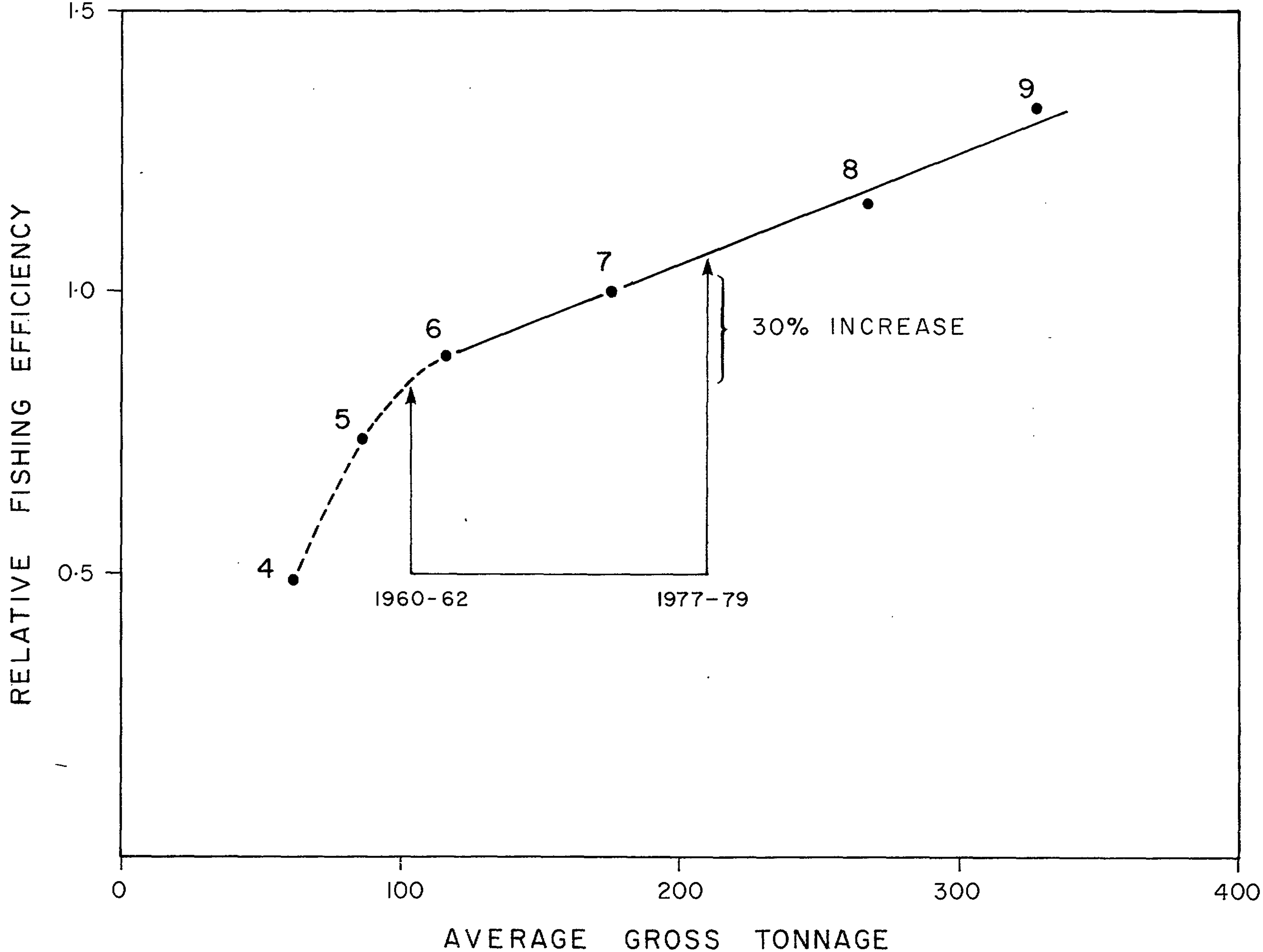

Fig. 16. Evidence of an increase in the efficiency of the Canadian fleet fishing for Pacific Ocean perch in Queen Charlotte Sound (numbers next to dots refer to vessel classes).

Appendix I. An example of the procedure for determining the fishing power (PF) factor of Class 8 trawlers relative to those of Class 7 (CPUE in tons and effort in h).

Year and month	CPUE Class 8 U8	CPUE Class 7 U7	Effort Class 8 E8	Effort Class 7 E7	Sum of efforts E8 + E7	Product of efforts E8 · E7	$\frac{E8 \cdot E7}{E8+E7}$ (=A)	Axlog $\left[\frac{U8}{U7}\right]$ (=B)	Antilog $\frac{A}{B}$ (=PF)
1969									
May	1.138	0.712	12	44	56	528	9.43	1.92	
June	1.261	0.885	68	225	293	15,300	52.22	8.04	
July	0.803	0.463	223	230	453	51,290	113.22	27.10	
Oct.	0.535	0.572	56	33	89	1,848	20.76	−0.59	
Nov.	0.762	0.862	22	64	86	1,408	16.37	−0.88	
Total							211.99	+35.59	1.47
1970									
May	0.943	0.621	70	132	202	9,240	45.74	8.30	
June	0.762	0.481	182	510	692	92,820	134.13	26.83	
July	0.363	0.295	129	27	156	3,483	22.33	2.01	
Oct.	0.898	1.070	128	188	316	24,064	76.15	−5.81	
Nov.	0.971	0.903	70	126	196	8,820	45.00	1.42	
Total							323.35	+32.75	1.26
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	

Appendix I (cont'd)

Year and month	CPUE Class 8 U8	CPUE Class 7 U7	Effort Class 8 E8	Effort Class 7 E7	Sum of efforts E8 + E7	Product of efforts E8 · E7	$\frac{E8 \cdot E7}{E8+E7}$ (=A)	Axlog $\left[\frac{U8}{U7}\right]$ (=B)	Antilog $\frac{A}{B}$ (=PF)
1978									
May	0.399	0.494	30	9	39	270	6.92	0.02	
June	0.758	0.463	65	78	151	5,594	37.71	6.21	
July	0.572	1.152	92	29	121	2,668	22.05	-6.71	
Aug.	1.188	0.644	19	39	58	741	12.78	3.40	
Sept.	2.363	0.794	42	68	183	5,922	32.36	16.86	
Oct.	2.549	1.275	14	93	107	1,302	12.17	3.66	
Nov.	1.583	1.102	28	38	66	1,064	16.12	2.53	
Total							140.11	+25.97	1.53
1969-78 Total							2,125.03	+138.08	1.16