A Comparison of Stratified Systematic and Stratified Random Methods of Estimating Catch Rates, by Depth Interval, for Biomass Estimation of Pacific Ocean Perch (*Sebastes alutus*) in Goose Island Gully, Queen Charlotte Sound, British Columbia

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ABSTRACT

Westrheim, J. S., and Yamanaka K. L. 2007. A comparison of stratified systematic and stratified random methods of estimating catch rates, by depth interval, for biomass estimation of Pacific ocean perch (*Sebastes alutus*) in Goose Island Gully, Queen Charlotte Sound, British Columbia. Can. Tech. Rep. Fish. Aquatic. Sci. 2707: vii + 34p.

On-bottom trawl surveys have been conducted since 1967 for stock assessment of Pacific ocean perch (*Sebastes alutus*) in Goose Island Gully (Queen Charlotte Sound, British Columbia). Prior to 1995, all surveys involved a single vessel, and employed the stratified systematic method, along six pre-determined LORAN lines. In 1995, the stratified random method was introduced, using two vessels, and involving a more extensive coverage of the Gully. The purpose of this report was to compare sampling intensity (hauls/100 sq nm), catch rates (kg/h), and mean catches (kg) for the two methods, within the Study Area, defined by the trawl locations in the 1976 survey. Additional comparisons dealt with north-south orientation of hauls (1976 & 1995) and order of trawling (1995). In 1976, sampling intensity (stratified systematic) was 3.6 hauls/100 sq nm. In 1995, sampling intensity was 2.6 hauls/100 sq nm by each vessel along the six GBR LORAN lines, and 4.4 hauls/100 sq nm for all trawl hauls (ALL) in the Study Area. For each vessel, catch-rate differences were minor at 110 (4 - 19%), 130 (6 - 8%), and 150 (0%) fms, but substantial at 90 fms (63 - 86%). However, at 90 fms, catch rates were mostly small. Neither method adequately covered the 90-fm interval, based on single-vessel catches. Although catch rates differed substantially between the paired vessels (37 - 87%), mean catches rarely differed significantly. Orientation of hauls favoured the north side of the Gully for the stratified systematic method, and the south side for the stratified random method. The report concluded that the two survey methods were equivalent, in this case, and that the 1995 survey could have achieved the same results with a single vessel, and fewer hauls. On-bottom trawl surveys, of any kind, for Pacific ocean perch may no longer be relevant, because off-bottom concentrations of Pacific ocean perch have recently been demonstrated in Goose Island Gully, and elsewhere off British Columbia.

RÉSUMÉ

Westrheim, J. S., et Yamanaka K. L. 2007. Comparaison des méthodes d'échantillonnage stratifié systématique et aléatoire utilisées pour l'estimation des taux de capture, par intervalle de profondeur, dans le but d'évaluer la biomasse de sébaste à longue mâchoire (*Sebastes alutus*) dans le goulet de l'île Goose, détroit de la Reine-Charlotte (Colombie-Britannique). Can. Tech. Rep. Fish. Aquatic. Sci. 2707: vii + 34 p.

Depuis 1967, on effectue des relevés au chalut de fond afin d'évaluer les stocks de sébaste à longue mâchoire (*Sebastus alutus*) dans le goulet de l'île Goose in Goose Island Gully (détroit de la reine-Charlotte, Colombie-Britannique). Avant 1995, tous les relevés étaient faits à l'aide d'un seul navire, suivant une méthode d'échantillonnage stratifié systématique, le long de six lignes LORAN prédéfinies. La méthode d'échantillonnage stratifié aléatoire, faisant appel à deux navires et permettant une meilleure couverture du goulet, a été introduite en 1995. Le présent rapport visait à comparer l'intensité de l'échantillonnage (prises/nm^2), le taux de capture (kg/h) ainsi que la prise moyenne (kg) obtenus respectivement avec ces deux méthodes dans la zone d'étude, définie d'après la position des chaluts lors de l'enquête de 1976. D'autres comparaisons ont été établies, notamment en ce qui concerne l'orientation nord-sud des prises (1976 et 1995), et la séquence de chalutage (1995). En 1976, l'intensité de l'échantillonnage (stratifié systématique) a atteint 3,6 prises/100 nm^2. En 1995, elle était de 2,6 prises/nm^2 pour chacun des navires le long de 6 lignes LORAN RAS, et de 4,4 prises/100 nm^2 pour toutes les prises des chaluts (TOUS) dans la zone d'étude. On a enregistré des différences mineures dans les taux de capture par bateau à 110 (4 – 19 %), 130 (6 – 8 %) et 150 (0 %) fms, mais des différences substantielles à 90 fms (63 – 86 %). Cependant, à 90 fms, les taux de capture étaient faibles dans la plupart des cas. Ni l'une ni l'autre des méthodes ne convenait pour l'échantillonnage dans l'intervalle 90 fm, d'après les taux de capture enregistrés par vaisseau. Les taux de capture différaient de manière substantielle selon le navire dans le cas du chalutage jumelé (37 – 87 %), mais les prises moyennes ne variaient pas significativement. L'orientation des prises privilégiait le côté nord du goulet dans le cas de la méthode d'échantillonnage stratifié systématique, et le côté sud dans le cas de la méthode d'échantillonnage stratifié aléatoire. Les conclusions du rapport sont les suivantes : les deux méthodes de relevés s'équivalent, dans le cas concerné; en outre, un seul navire et un moins grand nombre de prises auraient suffi pour obtenir les mêmes résultats, dans le cas du relevé de 1995. Il se pourrait que les relevés au chalut de fond, de quelque type que ce soit, ne soient plus pertinents pour évaluer les stocks de sébaste à longue mâchoire compte tenu que les concentrations de fond cette espèce dans le goulet de l'île Goose et ailleurs au large de la Colombie-Britannique ont été récemment établies.

INTRODUCTION

Biomass surveys, using on-bottom trawl gear, for Pacific ocean perch (*Sebastes alutus*) in Goose Island Gully began in 1967 (Westrheim *et al*. 1968), and 11 have been completed through 1995 (Yamanaka *et al*. 1996). The stratified systematic method was utilized for all cruises until 1995, when a stratified random method was introduced. The question arises as to the advantage, if any, of either method for estimating catch rates by depth interval.

The purpose of this report was to compare sampling intensity (hauls/100 sq nm), catch rates (kg/h), and mean catches (kg) for the two methods, within the Study Area, defined by the trawl locations in the 1976 survey. Additional comparisons dealt with north-south orientation of hauls (1976 & 1995) and order of trawling (1995).

METHODS AND MATERIALS

MATERIALS

Goose Island Gully is located in southern Queen Charlotte Sound (Areas 5A and 5B; Figure 1.), between Goose Island Bank and the north coast of Vancouver Island. Its area was originally reported to be 1,147 sq nm, at 80 - 159 fms, based on trawl explorations in 1971 (Westrheim 1972). Subsequent trawl and echo-sounder explorations in 1973 delineated an adjacent ground (Southwest Slope, Goose Island Bank), which reduced the area of Goose Island Gully to 993 sq nm, at 80 - 159 fms (Westrheim 1974). The estimated areas by 20-fm depth interval were reported, as a text table, in Gunderson *et al.* (1977, p. 7). Goose Island Bank Slope was differentiated from Goose Island Gully by the type of bottom (generally “untrawlable”), and principal rockfish species (S. *proriger and S. reedi*).

Two cruise reports provided the data for analysis. Details of each trawl haul included: number, date, area, start time, duration, start and end (latitude and longitude), direction, distance traveled (1976 only), depth (fms; start-end), total catch (lbs in 1976; kg in 1995), catch of each species, and remarks (usable, unusable).

The first cruise report, dealt with the R/V G.B. REED on-bottom trawl survey in the Goose Island Gully Study Area during September 1976 (Westrheim *et al*. 1976).

The second cruise report dealt with the on-bottom trawl survey of Goose Island Gully and vicinity, in September 1995, by two chartered, commercial trawlers, the F/Vs OCEAN SELECTOR and FROSTI (Yamanaka *et al*. 1996).

METHODS

Surveys

1976. The survey employed a stratified systematic design. That is, along six predetermined tracklines (LORAN lines 4080, 4090, 4100, 4120, 4140, and 4160), trawl hauls were undertaken, from north to south, at the mid-points of four 20-fm depth intervals (90, 110, 130, and 150) (Figure 2.). Haul duration was 30 min.

1995. The survey employed a depth stratified random design. The area was divided into a grid of two-kilometer-square units, and each unit was assigned to one of the four depth strata used in previous surveys (80 - 99, 100 - 119, 120 - 139, and 140 - 159 fms). Trawl hauls were allocated in proportion to average stratum catch rate variance (determined from previous surveys) and weighted by the number of stratum grid units. Trawl locations were randomly selected for the first vessel, and virtually all were replicated by the second vessel. The choice of "lead" vessel was alternated. Haul duration was 20 min. Figure 3 shows the haul locations for the OCEAN SELECTOR and Figure 4 shows the haul locations for the FROSTI.

Catch Processing

G.B. REED catches of Pacific ocean perch were estimated using the 6-tub method of Westrheim (1967). The entire catch was sorted by species into numbered tubs. For Pacific ocean perch, the weights were recorded for the first two, middle two, and last two full tubs in each haul, plus the last, partially full tub. Total weight was determined by extrapolation. Biological data were collected from specimens in the six full tubs. For other species, the first six full tubs, and the last partially filled tub, were weighed, and the total weight determined by extrapolation.

Aboard the F/V OCEAN SELECTOR and F/V FROSTI, all catches less than 500 kg were processed completely. For larger catches, total weight was estimated as the catch was dropped on deck, then a sub-sample was collected from the conveyor belt; 3 baskets each from the beginning, middle, and end of the catch. The contents of the nine baskets provided the basis for estimating species composition, by weight, and other biological information.

Assignment to LORAN Lines

G.B. REED trawl hauls were assigned to LORAN lines by inspection, based on their array in Figure 2 of Westrheim *et al.* (1976).

For the F/V OCEAN SELECTOR and F/V FROSTI, conversion of haul locations to LORAN lines was more complex. Haul locations for each vessel were plotted on a chart containing latitude and longitude markings on the border. Then appropriate LORAN lines were superimposed, and conversions were undertaken by inspection.

Definition of the Study Area

The Study Area is that portion of Goose Island Gully which was selected for the series of biomass surveys, exemplified by the 1976 G.B. REED survey (Westrheim *et al.* 1976*)*. Bathymetrically it is limited to the depth range of 80 - 159 fms (146 - 291 m). Within the Study Area, two sets of data were created. One involved those usable hauls completed on the six G.B. REED LORAN (GBR LORAN) lines. The other involved all usable hauls (ALL) in the Study Area.

Sector Assignment

The North and South sectors were delineated by the boundary created by connecting the mid-points of each relevant "north-south" LORAN line. Results are included in Appendix tables 1 - 3. A few hauls were located close to this line. The assignment of sector was determined by the position of the first of the paired hauls.

Order of Trawling

Order of trawling, for all hauls, was reported in Table 10 of Yamanaka *et al.* (1996), and is included in Appendix tables 2 and 3.

Analysis

Six steps are involved in the analysis.

Step one converts trawl-haul locations to relevant depth cells, with sub-sectors North and South. All the 1976 trawl hauls were used in this analysis, but the 1995 trawl hauls were limited to those: (1) deemed usable by the authors; (2) paired; and (3) lying within the Study Area.

Step two creates two sets of 1995 data for each vessel. One involves all usable hauls completed along the six GBR LORAN lines, and the other, ALL usable hauls within the Study Area.

Step three compares the sampling intensity of the two methods, as hauls per 100 square nautical miles (sq nm).

Step four compares the catch rates and mean catches, by 20-fm depth interval, of Pacific ocean perch from the two sets of data in Step Two. Conventional statistics are not applicable to rates, such as kg/h (Snedecor 1947, p. 100). Ratio estimators have been developed, but have proved "annoyingly intractable, because both y and x vary from sample to sample" (Cochran 1977, p. 153). However, in the present case, effort (the x variable) is virtually constant, and thus conventional statistics should be applicable to catch (the y variable). Thus, the "t" test of differences between means (variances unknown) was utilized (Dixon and Massey 1969, p. 116).

Step five compares the north-south distribution of hauls, with respect to catch rates and mean catches on GBR LORAN lines and ALL hauls.

Step six compares the order of trawling, with respect to catch rates and mean catches, of the two chartered, commercial vessels in the 1995 survey.

RESULTS

GENERAL

In 1976, the R/V G.B. REED completed 36 trawl hauls, all of which were deemed usable by the authors (Appendix table 1). Numbers within 20-fm depth intervals were 7, 15, 8, and 6, respectively, for 90, 110, 130, and 150 fms (Table 2).

In 1995, total number of hauls was 115 in Goose Island Gully and vicinity; 57 for the F/V OCEAN SELECTOR, and 58 for the F/V FROSTI (Appendix tables 2 and 3). Rejected hauls totaled 10 for OCEAN SELECTOR and 11 for FROSTI (Table 1). Causes of rejection were: deemed unusable by authors (3 and 1); no twin haul (1 and 4); outside depths of Study Area (5 and 4); outside Study Area (1 each); and outside Goose Island Gully (0 and 1). Thus, there were 47 pairs of usable hauls within the Goose Island Gully Study Area; 7 at 90 fms, 24 at 110 fms, and 8 each at 130 and 150 fms (Table 2).

With respect to the GBR LORAN lines, there were 24 pairs of usable trawl hauls—2 at 90 fms, 10 at 110 fms, 7 at 130 fms, and 5 at 150 fms (Table 2).

SAMPLING INTENSITY

G.B. REED overall intensity was 3.6 hauls per 100 sq nm, and 2.0 - 4.8 among depths (Table 2). OCEAN SELECTOR overall intensity on GBR LORAN lines was 2.4 hauls per 100 sq nm (0.6 - 4.2 among depths), and for the entire Study Area, 4.7 hauls per 100 sq nm (2.0 - 7.6 among depths). Compared to the G.B. REED, intensity was relatively similar among vessel-depth cells, with two exceptions. Intensity for the OCEAN SELECTOR was weak on the GBR LORAN lines at 90 fms (0.6 vs. 2.0 hauls/100 sq nm), and excessive for the entire Study Area at 110 fms (7.6 vs. 4.8 hauls/100 sq nm).

CATCH RATES, EFFORT, AND MEAN CATCHES: GBR vs. ALL

Catch Rates

Overall, catch rates on the GBR LORAN lines were larger than ALL hauls for the OCEAN SELECTOR (OS-1 vs. OS-2; +7%), and smaller for both FROSTI (F-1 vs. F-2; -32%),

and the combined vessels (OSF-1 vs. OSF-2; -15%) (Table 3). Among depth intervals, OCEAN SELECTOR catch rates on the GBR LORAN lines (OS-1) were smaller at 90 (-45%) and 150 fms (-20%), but larger at 110 (+1%) and 130 fms (+8%). FROSTI catch rates (F-1) followed the same pattern; -81%, -18%, +21%, and +6%. The relatively high values at 90 fms are probably due to the few hauls (2) on the GBR LORAN lines for each vessel. Eliminating the 90-fm data, reduced the overall difference in catch rates to +4% for OS-1 vs. OS-2, +9% for F-1 vs. F-2, and +6% for OSF-1 *vs.* OSF-2.

Effort

Overall, mean effort of the OCEAN SELECTOR was 0.333 h for both GBR and ALL hauls (Table 4). Among depth intervals, differences between means ranged from –0.008 to +0.003 h. Comparable values for the FROSTI were 0 to +0.011 h. These differences were deemed insignificant.

Mean Catches

Differences between mean catches on the GBR LORAN lines and ALL hauls, among depths and total, were all non-significant for both vessels. "t" values ranged from -0.476 to +0.232 (P >0.50) for the OCEAN SELECTOR, and -0.426 to +0.552 (P > 0.50) for the FROSTI (Table 4). Although all values had a probability of >0.50, coefficients of variation were relatively high overall, and within depth intervals. OCEAN SELECTOR overall values were 106 and 125%, respectively, for GBR and ALL, and among depths, 58 - 137% and 77 - 150%. FROSTI overall values were 100 and 108%, respectively, for GBR LORAN lines and ALL hauls, and among depths, 44 - 143% and 47 - 240%.

Combining the records of the two vessels, yielded similar results. "t" values ranged from -0.681 to +0.439, and all probabilities were >0.50. Coefficients of variation ranged from 69 to 142% on the GBR LORAN lines, and 73 - 209% for ALL hauls.

Pursuant to the 90-fm depth, 14 usable hauls were completed in 1995, and Pacific ocean perch mean catch was 315 kg (S.D. = 659) (Table 4). Only one pair had substantial catches—1,159 kg (OS-27) and 2,332 kg (F-24) (Appendix tables 2 and 3). The remaining 12 catches ranged from 0 to 370 kg. Interestingly, one pair of hauls, on "untrawlable" bottom (LORAN 4100-S) (Figs. 4 and 5), yielded substantial catches of *S. reedi*. On September 16, FROSTI haul 30 yielded 1,451 kg of *S. reedi vs.* 0 kg for Pacific ocean perch; and on September 17, its twin haul, OCEAN SELECTR No. 32, yielded 3,821 kg of *S. reedi* and 68 kg of Pacific ocean perch. In 1976, the G.B REED did not trawl at this station, presumably because the echo sounder indicated the bottom was untrawlable for the G.B. REED net (see Fig. 2).

A somewhat different result occurred on "untrawlable" bottom at 110 fms on LORAN line 4150N (Figs. 3 and 4). On September 20, FROSTI haul No. 47 yielded 641 kg of Pacific ocean perch and 2,179 kg of *S. reedi* (Appendix table 3). On September 21, its twin haul, OCEAN SELECTOR haul No. 51, yielded 5,331 kg of Pacific ocean perch and 5,005 kg of *S. reedi* (Appendix table 2),

CATCH RATES AND MEAN CATCHES: OCEAN SELECTOR *vs.* FROSTI

Catch Rates

Overall, OCEAN SELECTOR catch rates were larger than FROSTI catch rates on both GBR LORAN lines (+115%) and ALL hauls (+35%) (Table 3). Among depth intervals, on the GBR LORAN lines, OCEAN SELECTOR catch rates were larger at 90 (+81%), 110 (+58%), and 130 (+70%) fms, but smaller at 150 (-24%) fms. For ALL hauls, OCEAN SELECTOR catch rates were larger at 110 (+88%) and 130 (+67%) fms, but smaller at 90 (-37%) and 150 (-22%) fms. Excluding the 90-fm depth, OCEAN SELECTOR catches were larger in both comparisons; +38% (GBR) and +44% (ALL).

Mean Catches

Combining depths, differences between vessels on both GBR LORAN lines and ALL hauls ranged from 282 to 348 kg, and none were significant. At 90 - 150 fms, "t" values were +1.046 (P >0.30) (GBR) and +1.288 (P >0.20) (ALL), and at 110 - 150 fms, +1.037 (P >0.30) and +1.363 (P >0.10) (Table 5). Coefficients of variation were large; 100 - 125% at 90 - 150 fms, and 93 - 116% at 110 - 150 fms. Among depths, for both GBR and ALL hauls, mean-catch differences ranged from -176 to +676 kg, and none were significant. Values of "t" ranged from -0.266 to +1.694, and probabilities ranged from >0.10 to >0.50. Coefficients of variation were generally large; 44 - 143% on GBR LORAN lines and 47 - 240% for ALL hauls. Only one value was less than 50%, in each category.

SECTORS: NORTH vs. SOUTH

Use of catch rates and mean catches at 90 fms were precluded by limited data. In the South Sector, the G.B. REED completed only two hauls, whose respective catches of Pacific ocean perch were 0 and 2 kg (Appendix table 1). In the North Sector, there were no usable hauls completed on the GBR LORAN lines by the OCEAN SELECTOR and FROSTI (Appendix tables 2 and 3).

Trawl hauls, at 110 - 150 fms, were not equally divided between the North and South sectors for any of the three vessels (Table 6). Overall, G.B. REED hauls favoured the North Sector 16 to 13, while paired hauls of the F/V OCEAN SELECTOR and F/V FROSTI collectively favoured the South Sector 27 to 17 (GBR) and 50 to 30 (ALL). Differences were not statistically significant, based on a two-way contingency test (Dixon and Massey 1969, p. 242). Chi-square values were +1.320 (P >0.20) for G.B. REED hauls versus OSF-1 (GBR), and +2.049 (P >0.10) for G.B. REED versus OSF-2 (ALL). The South Sector was favoured by the OCEAN SELECTOR and FROSTI, because their trawls were randomly allocated within each depth strata in proportion to the size of the strata relative to the whole study area. On the south side, because the slope of the Gully is more gradual, the area within the depth strata is greater and, hence, more hauls were allocated in the South Sector in 1995.

Catch Rates

Overall, catch rates were larger in the North Sector for the G.B. REED (+41%), but smaller for the OCEAN SELECTOR + FROSTI on both the GBR LORAN lines (OSF-1; -59%) and ALL hauls (OSF-2; -3%) (Table 6).

G.B. REED. Among depths, North Sector catch rates on the GBR LORAN lines were larger at 110 fms (+80%) and 130 fms (+60%), but smaller at 150 fms (-14%) (Table 6).

OCEAN SELECTOR. Among depths, North Sector catch rates on the GBR LORAN lines (OS-1) were smaller at 110 fms (-72%) and 150 fms (-30%), but larger at 130 fms (+13%) (Table 6). For ALL hauls (OS-2), corresponding values were smaller at 110 (-9%) and 130 (-3%) fms, but larger at 150 fms (+130%).

FROSTI. Among depths, North Sector catch rates on the GBR LORAN lines (F-1) were smaller at all three depths (-60, -1, and -63%) (Table 6). For ALL hauls (F-2), corresponding values were smaller at 110 fms (-45%) and 150 fms (-11%), but larger at 130 fms (+9%).

Mean Catches

Overall, North-South differences in mean catches were not significant on the GBR LORAN lines for the G.B. REED, or for the OCEAN SELECTOR (-12 kg), FROSTI (-352 kg), and OCEAN SELECTOR + FROSTI (-437 kg) ("t" = -0.006, -0.284, -1.023; P >0.50, >0.50. >0.30) (Table 7). Similarly, for ALL hauls, comparable differences of +365, -158, and -22 kg, were not significant ("t" = +0.163, -0.133, and -0.017; P >0.50). However, coefficients of variation were large for the OCEAN SELECTOR (100 - 124%), FROSTI (87 - 109%), and OCEAN SELECTOR + FROSTI (76 - 138%).

OCEAN SELECTOR. Among depths, on GBR LORAN lines, differences were -834, -143, and -131 kg (Table 7). They were not significant at 110 and 130 fms ("t" = -1.063 and -0.185; P >0.30 and 0.50), and indeterminate at 150 fms (only one haul). For ALL hauls, mean catches were smaller in the North Sector at 110 fms (-4 kg) and 130 fms (-11 kg), but larger at 150 fms (+1,003 kg). None of the three differences were significant ("t" = -0.007. -0.017, +1.661; P = >0.50, >0.50, >0.10). Coefficients of variation ranged from 28 to 184%, and only two were less than 50%; 28% on GBR LORAN lines at 130 fms, south; and 41% for ALL hauls at 130 fms, south.

FROSTI. Among depths, mean catches on GBR LORAN lines were smaller in the North Sector at 110 fms (-427 kg) and 150 fms (-674 kg), but larger at 130 fms (+6 kg) (Table 7). As with the OCEAN SELECTOR, differences were not significant at 110 fms ("t" = -0.871; P >0.50), and 130 fms ("t" = 0.022; P >0.50), but indeterminate at 150 fms. Comparable values for ALL hauls were smaller at 110 fms (-233 kg), but larger at 130 fms (+77 kg) and 150 fms (+155 kg). None of the three differences were significant ("t" = -1.114, +0.307, +0.241; P = >0.20, >0.50, >0.50). Coefficients of variation ranged from 26 to 133%, and only two were less than 50% -26% on GBR LORAN line at 130 fms, south; and 35% for ALL hauls at 130 fms, south.

CATCH RATES AND MEAN CATCHES: TRAWLING-ORDER 1 vs. TRAWLING-ORDER 2

Inter-depth comparisons were limited to 110, 130, and 150 fms, because only two usable hauls were completed by each vessel at 90 fms on the GBR LORAN lines.

Order-1 hauls were reasonably distributed between the two vessels and proportions did not differ significantly from 50%. On GBR LORAN lines, the OCEAN SELECTOR was first on 12 of the 22 paired hauls, and FROSTI on 10 (Table 8). Assuming 50%, Chi-square was +0.182, and P >0.50). For All haulss, OCEAN SELECTOR was first on 17 of the 40 paired hauls, and FROSTI, 23. Chi-square was +0.900, and P >0.30.

Catch Rates

Overall, results of Order-1 versus Order-2 catch-rate comparisons were variable. On GBR LORAN lines, Order-1 catch rates were smaller for OCEAN SELECTOR (-34%), but larger for FROSTI (+107%), and OCEAN SELECTOR + FROSTI (+14%) (Table 8). For ALL hauls, Order-1 catch rates were smaller for OCEAN SELECTOR (-46%) and OCEAN SELECTOR + FROSTI (-10%), but larger for FROSTI (+125%).

OCEAN SELECTOR. Among depths, Order-1 catch rates on GBR LORAN lines, and ALL hauls were smaller at 110 fms (-87%, -84%) and 150 fms (-7%, -29%), but larger at 130 (+88%, +113%) (Table 8).

FROSTI. Among depths, Order-1 catch rates on GBR LORAN lines were larger at all depths (+501, +23, +93%) (Table 8). For ALL hauls, Order-1 catch rates were smaller at 110 fms (-84%) and 150 fms (-29%), but larger at 130 fms (+113%).

OCEAN SELECTOR + FROSTI. Among depths on GBR LORAN lines and ALL hauls, Order-1 catch rates were smaller at 110 fms (-34 and -47%), and larger at 130 (+71 and +66%) and 150 (+40 and 30%) fms (Table 8).

Mean Catches

For combined vessels and depths, Order-1 mean-catches did not differ significantly from Order-2 mean catches. Differences were +123 kg (GBR) and -98 kg (ALL) ("t" = +0.073 and -0.054; P >0.50) (Table 9). Coefficients of variation were large, 95 - 125%. For combined depths, OCEAN SELECTOR differences were -409 kg (GBR) and -560 kg (ALL), and not significant ("t" = -0.208 and -0.257; P >0.50). FROSTI differences were +596 kg and +466 kg, and also were not significant ("t" = +0.545 and +0.440; P >0.50). Coefficients of variation were relatively large for both vessels, 87 - 134% for OCEAN SELECTOR and 76 - 85% for FROSTI.

OCEAN SELECTOR. Among depths, differences between Order-1 and Order-2 mean catches on GBR LORAN lines were -1,626, +1,357, and +61 kg, respectively, at 110, 130, and 150 fms. The difference was significant at 110 fms ("t" = 2.664; P <0.05>0.02), but not at 130 fms ("t" = 1.791; P >0.10) or 150 fms ("t" = 0.132; P >0.50)). Coefficients of variation were relatively small (44, 72, 24%) for Order-1 catches, but not so for Order-2 catches (82, 53, 83%).

For ALL hauls, corresponding differences in mean catches were -1,207, +944, and -209 kg. Differences were significant at 110 fms ("t" = -2.596; P <0.02), but not at 130 ("t" = +1.448; P >0.10) or 150 fms ("t" = -0.289; P >0.50). Coefficients of variation were usually small for Order-1 catches (44, 72, 24%), but not so for Order-2 catches (108, 37, 97%).

FROSTI. Among depths, on GBR LORAN lines, differences between Order-1 and Order-2 mean catches were +885, +111, and +563 kg, respectively, at 110, 130, and 150 fms (Table 9). None were significant ("t" = +2.191, +0.801, and +0.806; P >0.05, >0.40, and >0.40). Coefficients of variation were generally large for Order-1 catches (97,36, 81%), and small for Order-2 catches (48, 55, 48%). For ALL hauls, differences were +448, +6, and +705 kg. They were significant at 110 fms ("t" = 2.439; P <0.05>0.02), but not at 130 fms ("t" = +0.038; P >0.40) or 150 fms ("t" = +1.235; P >0.20). Coefficients of variation, for ALL hauls, were generally small for both Order-1 (95, 46, 59%) and Order-2 (51, 55, 48%) catches.

SUMMARY AND DISCUSSION

On-bottom trawl surveys, for stock assessment, have been conducted since 1967 for Pacific ocean perch (*Sebastes alutus*) in Goose Island Gully (Queen Charlotte Sound, British Columbia). Prior to 1995, all surveys involved a single vessel, and employed the stratified systematic method. Trawling stations were established along six pre-determined LORAN lines, at the mid-points of four 20-fm depth intervals. In 1995, the stratified random method was introduced, using two vessels, and was not limited to the six LORAN lines, or depth intervals, of previous surveys. Usable hauls, for this study, were defined as: (1) deemed usable by the authors; (2) paired; and (3) lying within the Study Area. The Study Area was defined geographically in a 1974 report, and bathymetrically, in all previous reports, as 80 - 159 fms. Two sets of data were created: (1) those hauls completed on the six LORAN lines (GBR) used in the stratified systematic method; and (2) all hauls (ALL) completed in the Study Area. The primary purposes of this report were to compare sampling intensity, catches, and mean catches, of the two methods, for Pacific ocean perch. Additional studies involved comparable comparisons with respect to: (1) North versus South sectors of the Study Area (1976 & 1995); and (2) order of trawling (1995).

Sampling intensity (hauls/100 sq nm) was relatively similar among vessel-depth cells, with two exceptions. With respect to the 1976 stratified systematic method, intensity was weak on the GBR LORAN lines at 90 fms, and excessive for ALL hauls at 110 fms.

Within the Study Area, the catch rates of the F/V OCEAN SELECTOR and F/V FROSTI did not differ substantially among survey methods, except for the anomalous results at 90 fms (few hauls). Mean catches did not differ significantly at 110, 130, or 150 fms. Presumably, if catch rates, and mean catches, do not differ, then neither will biomass estimates. Hence, the stratified random method is equivalent to that of the stratified systematic method, in this case.

The numbers of hauls completed for ALL hauls was excessive, since the catch rates did not differ substantially from those based only on the GBR LORAN lines. Furthermore, a single vessel in 1995 could have achieved the same results as catch rates were not significantly different

between the two vessels. The 90-fm depth interval was not well covered by the GBR LORAN line design, in part because of bottom deemed untrawlable for the G.B. REED trawl.

Trawl hauls were not equally divided between the North and South Sectors of the Study Area for any of the three vessels. G.B. REED hauls favoured the North Sector, while paired hauls of the F/V OCEAN SELECTOR and F/V FROSTI favoured the South Sector. The differences were not statistically significant, nor were mean catches.

Order of trawling was reasonably alternated between the paired vessels. Effects on catch rates were variable, but differences between mean catches were not significant, when vessels and depth, or depths, were combined. However, within depths, at 110 fms, OCEAN SELECTOR Order-1 mean catches were significantly smaller than Order-2 mean catch rates, and those of FROSTI were significantly larger.

Although statistical tests indicated, in most cases, non-significant differences between mean catches, it is troubling to note that the corresponding coefficients of variation were usually large.

The relative merits of the stratified systematic and stratified random methods, using on-bottom trawls, for stock assessment of Pacific ocean perch may be academic. A recent report provided evidence of substantial off-bottom concentrations of Pacific ocean perch in Goose Island Gully, and elsewhere off British Columbia (Westrheim and Stanley 2006). These fish, of course, are not available to on-bottom trawls, and their relationship, if any, with their on-bottom counterparts has not been determined.

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Table 1. List of, and reasons for, rejected trawl hauls, undertaken by the F/Vs OCEAN SELECTOR and FROSTI in Goose Island Gully and vicinity, September 1995. (Source: Appendix tables 2 and 3)

Reason	Haul Number	
	OCEAN SELECTOR	FROSTI
Deemed unusable by authors.	14, 33, 42	29
No twin haul	41	8, 40, 43, 58
Outside study area, 70 fms	6, 57	13
Outside study area, 170 fms	28, 30, 37[a]	25, 27, 34[a]
Outside study area	34	38
Outside Goose Island Gully	(42)	39, (40)
Total rejected	10	11

[a] Reported depths at start and end of haul 37 were 159 and 160 fms, respectively. Corresponding depths for the "twin" haul (F 34) were 160 and 160 fms. Both hauls were assigned to the 170-fm depth interval.

Table 2. Numbers of usable hauls per 100 sq nm, by 20-fm depth interval, of the R/V G.B. REED and F/V OCEAN SELECTOR (OS) in the Goose Island Gully Study Area, September 1976 and 1995. (Source: Appendix tables 1 and 2)

Depth[a]		Area[b]		G.B. REED			OS-1[c]			OS-2[d]		
(m)	(fms)	(sq nm)	(%)	(nos)	(%)	(nos/ 100 sq nm)	(nos)	(%)	(nos/ 100 sq nm)	(nos)	(%)	(nos/ 100 sq nm)
165	90	353	35.5	7	19.4	2.0	2	8.3	0.6	7	14.9	2.0
201	110	314	31.6	15	41.7	4.8	10	41.7	3.2	24	51.1	7.6
238	130	165	16.6	8	22.2	4.8	7	29.2	4.2	8	17.0	4.8
275	150	161	16.2	6	16.7	3.7	5	20.8	3.1	8	17.0	5.0
	Total	993	100.0	36	100.0	3.6	24	100.0	2.4	47	100.0	4.7

[a] Mid-points of 20-fm depth intervals (90 = 80-99, *etc*.). Equivalent values in meters
[b] Text table in Gunderson *et al*. (1974, p. 7)
[c] OS-1 = OCEAN SELECTOR, G.B. REED LORAN lines
[d] OS-2 = OCEAN SELECTOR, All usable hauls in the Study Area

Table 3. Pacific ocean perch (POP) mean catch rates (kg/h), by 20-fm depth interval and vessel, from usable trawl hauls on GBR LORAN lines, and ALL usable trawl hauls in the Goose Island Gully Study Area, September 1976 and 1995. (Source: Appendix tables 1-3)

Depth[a]		Vessel[b]	No. hauls	Duration	POP		POP kg/h	
(m)	(fms)			(hrs)	(kg)	(kg/h)	1 vs 2 (%)	OS *vs* F (%)
165	90	GBR	7	3.50	625	179		
		OS-1	2	0.66	299	453	**-45**	**+81**
		OS-2	7	2.28	1866	818		**-37**
		F-1	2	0.58	145	250	**-81**	
		F-2	7	1.95	2538	1302		
201	110	GBR	15	7.50	8920	1189		
		OS-1	10	3.22	8910	2767	**+1**	**+58**
		OS-2	24	7.54	20593	2731		**+88**
		F-1	10	3.00	5249	1750	**+21**	
		F-2	24	7.14	10363	1451		
238	130	GBR	8	4.00	4461	1115		
		OS-1	7	2.40	9840	4100	**+8**	**+70**
		OS-2	8	2.72	10285	3781		**+67**
		F-1	7	2.12	5112	2411	**+6**	
		F-2	8	2.42	5486	2267		
275	150	GBR	6	2.75	4319	1570		
		OS-1	5	1.72	3781	2211	**-20**	**-24**
		OS-2	8	2.76	7594	2751		**-22**
		F-1	5	1.61	4659	2894	**-18**	
		F-2	8	2.55	8980	3522		
	Total	GBR	36	17.75				
		OS-1	24	8.00	22830	2854	**+7**	**+115**
		OS-2	47	15.30	40338	2636		**+35**
		F-1	24	11.45	15165	1324	**-32**	
		F-2	47	14.06	27367	1946		
		OSF-1	48	19.45	37995	1953	**-15**	
		OSF-2	94	29.36	67705	2306		
	110-150	GBR	29	14.25				
		OS-1	22	7.34	22531	3070	**+4**	**+38**
		OS-2	40	13.02	38472	2955		**+44**
		F-1	22	6.73	15020	2232	**+9**	
		F-2	40	12.11	24829	2050		
		OSF-1	47	14.07	37551	2669	**+6**	
		OSF-2	77	25.13	63301	2519		

[a] Mid-point of 20-fm depth interval (90 = 80-99, *etc.*). Equivalent values in meters
[b] Vessel: F = F/V FROSTI (1995); GBR = R/V G.B. REED (1976); OS = F/V OCEAN SELECTOR (1995); 1 = hauls on GBR LORAN lines; 2 = ALL usable hauls in Study Area

Table 4. "t" tests of differences between mean catches (kg), by 20-fm depth interval, GBR LORAN lines, ALL hauls and vessel, of Pacific ocean perch from usable hauls in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	90		110		130		150		Total	
	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL
Hauls (pairs)	2	7	10	24	7	8	5	8	24	47
					F/V OCEAN SELECTOR					
Effort (h)										
Total	0.66	2.28	3.22	7.89	2.40	2.72	1.72	2.76	8.00	15.65
Mean	0.330	0.330	0.322	0.330	0.343	0.340	0.344	0.345	0.333	0.333
$M_{GBR} - M_{ALL}$	0		-0.008		0.003		-0.001		0	
Catch (kg)										
Total	299	1866	8910	20889	9840	10285	3781	7594	22830	40634
Mean	150	267	891	870	1406	1286	756	949	951	865
S.D.	118	401	1225	1268	1006	992	439	827	1007	1081
C.V.	79	150	137	146	72	77	58	87	106	125
$M_{GBR} - M_{ALL}$	-117		21		120		-193		87	
"t"	-0.390		0.044		0.232		0.232		-0.476	
Df	7		32		13		11		69	
P	>0.50		>0.50		>0.50		>0.50		>0.50	

Table 4 cont'd. "t" tests of differences between mean catches (kg), by 20-fm depth interval, GBR LORAN lines, ALL hauls and vessel, of Pacific ocean perch from usable hauls in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	90		110		130		150		Total	
	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL
					F/V FROSTI					
Effort (h)										
Total	0.58	1.95	3.00	7.14	2.12	2.42	1.61	2.55	7.31	14.06
Mean	0.290	0.279	0.300	0.298	0.303	0.303	0.322	0.319	0.305	0.299
$M_{GBR} - M_{ALL}$	0.011		0.002		0		0.003		0.006	
Catch (kg)										
Total	145	2538	5249	10363	5112	5486	4659	8980	15165	27367
Mean	73	363	525	432	730	686	932	1123	632	582
S.D.	103	870	749	498	319	321	745	733	631	626
C.V.	141	240	143	115	44	47	80	65	100	108
$M_{GBR} - M_{ALL}$	-290		93		44		-191		50	
"t"	0.449		-0.426		-0.265		0.552		-0.318	
Df	7		32		13		11		69	
P	>0.50		>0.50		>0.50		>0.50		>0.50	

Table 4 cont'd. "t" tests of differences between mean catches (kg), by 20-fm depth interval, GBR LORAN lines, ALL hauls and vessel, of Pacific ocean perch from usable hauls in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	90		110		130		150		Total	
	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL
					F/Vs OCEAN SELECTOR + FROSTI					
Hauls (nos)	4	14	20	48	14	16	10	16	48	94
Catch (kg)										
Total	444	4404	14159	31252	14952	15771	8440	16574	37995	68001
Mean	111	315	708	651	1068	986	844	1036	792	723
S.D.	100	659	1006	979	798	777	584	760	847	890
C.V.	90	209	142	150	75	79	69	73	107	123
$M_{GBR} - M_{ALL}$	-204		57		82		-192		68	
"t"	-0.604		0.217		0.285		-0.681		0.439	
Df	16		66		28		24		140	
P	>0.50		>0.50		>0.50		>0.50		>0.50	

Table 5. "t" tests of differences between mean catches (kg), by 20-fm depth interval, GBR LORAN lines, ALL hauls of Pacific ocean perch by the F/Vs OCEAN SELECTOR and FROSTI in the Goose Island Gully Study Area, September 1995. (Source: Table 4)

Parameter	90				110				130			
	GBR		ALL		GBR		ALL		GBR		ALL	
Vessel[a]	OS-1	F-1	OS-2	F-2	OS-1	F-1	OS-2	F-2	OS-1	F-1	OS-2	F-2
Hauls	2	2	7	7	10	10	24	24	7	7	8	8
Total (kg)	299	145	1866	2538	8910	5249	20889	10363	9840	5112	10285	5486
Mean (kg)	150	73	267	363	891	525	870	432	1406	730	1286	686
S.D.	118	103	401	870	1225	749	1268	498	1006	319	992	321
C.V.(%)	79	141	150	240	137	143	146	115	72	44	77	47
$M_{GBR} - M_{All}$	77		-96		366		438		676		600	
"t"	0.691		-0.266		0.806		1.576		1.694		1.627	
Df	2		12		18		46		12		14	
P	>0.50		>0.50		>0.40		>0.10		>0.10		>0.10	

	150				90-150 fms				110-150 fms			
	GBR		ALL		GBR		ALL		GBR		ALL	
	OS-1	F-1	OS-2	F-2	OS-1	F-1	OS-2	F-2	OS-1	F-1	OS-2	F-2
Hauls	5	5	8	8	24	24	47	47	22	22	40	40
Total (kg)	3781	4659	7594	8980	22830	15165	40634	27367	22531	15020	38768	24829
Mean (kg)	756	932	949	1123	951	632	865	582	1024	683	969	621
S.D.	439	745	827	733	1007	631	1081	626	1021	634	1129	580
C.V.(%)	58	80	87	65	106	100	125	108	100	93	116	93
$M_{GBR} - M_{All}$	-176		-174		319		282		341		348	
"t"	-0.455		-0.359		1.047		1.288		1.037		1.363	
Df	8		14		46		92		42		78	
P	>0.50		>0.50		>0.30		>0.20		>0.30		>0.10	

a Vessel: F = F/V FROSTI; OS = F/V OCEAN SELECTOR; 1 = GBR LORAN lines; 2 = All usable hauls in the Study Area

Table 6. Pacific ocean perch (POP) mean catch rates (kg/h), by vessel and sector; North (N) and South (S), at 110, 130, and 150 fms, in usable hauls on GBR LORAN lines, and ALL usable hauls, in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 1-3)

Depth (fms)	Vessel[a]	Sector	Hauls	Dur. (hr)	POP (kg)	POP (kg/h)	N vs S (kg/h) (%)
110	GBR	N	8	4.00	5990	1498	**+80**
		S	7	3.50	2913	832	
	OS-1	N	4	1.40	1563	1116	**-72**
		S	6	1.82	7347	4037	
	F-1	N	4	1.18	1076	912	**-60**
		S	6	1.82	4173	2293	
	OS-2	N	10	3.46	8676	2508	**-9**
		S	14	4.43	12213	2757	
	F-2	N	9	2.68	2575	961	**-45**
		S	15	4.46	7788	1746	
130	GBR	N	5	2.50	3240	1296	**+60**
		S	3	1.50	1213	809	
	OS-1	N	4	1.37	3312	2418	**+13**
		S	3	1.36	2912	2141	
	F-1	N	3	0.92	2202	2393	**-1**
		S	4	1.20	2910	2425	
	OS-2	N	4	1.37	3312	2418	**-3**
		S	4	1.35	3357	2487	
	F-2	N	3	0.92	2202	2393	**+9**
		S	5	1.50	3284	2189	

Table 7. "t" tests of differences between mean catches (kg), by vessel, sector; North (N) and South (S), and 20-fm depth interval, of Pacific ocean perch in usable hauls at 110, 130, and 150 fms, on GBR LORAN lines, and for ALL hauls in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	110				130				150			
	GBR		ALL		GBR		ALL		GBR		ALL	
	N	S	N	S	N	S	N	S	N	S	N	S
					F/V OCEAN SELECTOR							
Hauls	4	6	10	14	4	3	4	4	1	4	2	6
Total	1563	7347	8676	12213	3312	2912	3312	3357	658	3123	3403	4191
Mean	391	1225	868	872	828	971	828	839	650	781	1702	699
S.D.	331	1517	1597	1040	1283	270	1283	343	0	503	1476	470
C.V.	85	124	184	119	155	28	155	41	0	64	87	67
$M_N - M_S$	-834		-4		-143		-11		-131		1003	
"t"	-1.063		-0.007		-0.185		-0.017		Nil		1.661	
Df	8		22		5		6		3		6	
P	>0.30		>0.50		>0.50		>0.50		Nil		>0.10	
					F/V FROSTI							
Hauls	4	6	9	15	3	4	3	5	1	4	2	6
Total	1076	4173	2575	7788	2202	2910	2202	3284	393	4266	2477	6503
Mean	269	696	286	519	734	728	734	657	393	1067	1239	1084
S.D.	340	924	259	590	501	190	501	228	0	787	1196	678
C.V.	126	133	91	114	68	26	68	35	0	74	97	63
$M_N - M_S$	-427		-233		6		77		-674		155	
"t"	-0.871		-1.114		0.022		0.307		Nil		0.241	
Df	8		22		5		6		3		6	
P	>0.50		>0.20		>0.50		>0.50		Nil		>0.50	

Table 7 cont'd. "t" tests of differences between mean catches (kg), by vessel, sector; North (N) and South (S), and 20-fm depth interval, of Pacific ocean perch in usable hauls at 110, 130, and 150 fms, on GBR LORAN lines and for ALL hauls in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	110-150											
	GBR		ALL		GBR		ALL		GBR		ALL	
	N	S	N	S	N	S	N	S	N	S	N	S
	OCEAN SELECTOR				FROSTI				OCEAN SELECTOR + FROSTI			
Hauls	9	13	16	24	8	14	14	26	16	28	29	51
Total	9149	13382	19007	19761	3671	11349	7254	17575	9204	28347	22645	40952
Mean	1017	1029	1188	823	459	811	518	676	575	1012	781	803
S.D.	1061	1037	1479	824	418	713	564	591	436	997	1077	809
C.V.	104	101	124	100	91	88	109	87	76	99	138	101
$M_N - M_S$	-12		365		-352		-158		-437		-22	
"t"	-0.006		0.163		-0.284		-0.133		-1.023		-0.017	
Df	20		38		20		38		42		78	
P	>0.50		>0.50		>0.50		>0.50		>0.30		>0.50	

Table 8. Records of F/Vs OCEAN SELECTOR and FROSTI usable trawl hauls, by 20-fm depth interval, trawling order (1,2), and GBR LORAN lines and ALL hauls, at 110, 130, and 150 fms, in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Depth[a] (fms)	Order[b]	No. of Hauls		Effort (h)		Catch (kg)		CPUE (kg/h)		1 vs 2 (%)	
		GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL	GBR	ALL
110	1	6	11	1.91	3.56	1443	2383	755	669	**-87**	**-84**
	2	4	13	1.31	4.33	7467	18506	5700	4274		
130	1	4	4	1.37	1.37	7031	7031	5132	5132	**+88**	**+113**
	2	3	4	1.03	1.35	2809	3254	2727	2410		
150	1	2	2	0.75	0.75	1585	1585	2113	2113	**-7**	**-29**
	2	3	6	0.97	2.01	2196	6009	2264	2990		
Total	1	12	17	4.03	5.68	10059	10999	2496	1936	**-34**	**-46**
	2	10	23	3.31	7.69	12472	27769	3768	3611		
	1>2									**1/3**	**1/3**
110	1	4	13	1.22	3.86	4224	8287	3462	669	**+501**	**-84**
	2	6	11	1.78	3.28	1025	2076	576	4274		
130	1	3	4	0.88	1.18	2381	2755	2706	5132	**+23**	**+113**
	2	4	4	1.24	1.24	2731	2731	2202	2410		
150	1	3	6	0.97	1.91	3472	7793	3579	2113	**+93**	**-29**
	2	2	2	0.64	0.64	1187	1187	1855	2990		
Total	1	10	23	3.65	8.6	10222	21334	2801	2481	**+107**	**+125**
	2	12	17	3.66	5.46	4943	6033	1351	1105		
	1>2									**3/3**	**1/3**

Table 9. "t" tests of differences between mean catches (kg) of the F/Vs OCEAN SELECTOR and FROSTI, by trawling order (1, 2) and GBR LORAN lines and ALL hauls, of Pacific ocean perch in usable hauls at 110, 130, and 150 fms, in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	110				130				150			
	GBR		ALL		GBR		ALL		GBR		ALL	
	1	2	1	2	1	2	1	2	1	2	1	2
					F/V OCEAN SELECTOR							
Hauls	6	4	11	13	4	3	4	4	2	3	2	6
Total	1443	7467	2383	18506	7031	2809	7031	3254	1585	2196	1585	6009
Mean	241	1867	217	1424	1758	401	1758	814	793	732	793	1002
S.D.	105	1538	94	1534	1269	213	1269	301	190	604	190	968
C.V.	44	82	43	108	72	53	72	37	24	83	24	97
$M_1 - M_2$	-1626		-1207		1357		944		61		-209	
"t"	-2.664		-2.596		1.791		1.448		0.132		-0.289	
Df	8		22		5		6		3		6	
P	<0.05>0.02		<0.02		>0.10		>0.10		>0.50		>0.50	
					F/V FROSTI							
Hauls	4	6	13	11	3	4	4	4	3	2	6	2
Total	4224	1025	8287	2076	2381	2731	2755	2731	3472	1187	7793	1187
Mean	1056	171	637	189	794	683	689	683	1157	594	1299	594
S.D.	1022	82	607	96	287	376	315	376	937	284	766	284
C.V.	97	48	95	51	36	55	46	55	81	48	59	48
$M_1 - M_2$	885		448		111		6		563		705	
"t"	2.191		2.439		0.801		0.038		0.806		1.235	
Df	8		22		5		6		3		6	
P	>0.05		<0.05>0.02		>0.40		>0.40		>0.40		>0.20	

Table 9 cont'd. "t" tests of differences between mean catches (kg) of the F/Vs OCEAN SELEFCTOR and FROSTI, by trawling order (1,2), GBR LORAN lines and ALL hauls, for Pacific ocean perch in usable hauls at 110, 130, and 150 fms, in the Goose Island Gully Study Area, September 1995. (Source: Appendix tables 2 and 3)

Parameter	110-150											
	GBR		ALL		GBR		ALL		GBR		ALL	
	1	2	1	2	1	2	1	2	1	2	1	2
	OCEAN SELECTOR				FROSTI				OCEAN SELECTOR + FROSTI			
Hauls	12	10	17	23	10	12	23	17	22	22	40	40
Total	10059	12472	10999	27769	10077	4943	18835	5994	20136	17415	29834	33763
Mean	838	1247	647	1207	1008	412	819	353	915	792	746	844
S.D.	975	1082	865	1255	765	337	658	300	870	862	747	1053
C.V.	116	87	134	104	76	82	80	85	95	109	100	125
$M_1 - M_2$	-409		-560		596		466		123		-98	
"t"	-0.208		-0.257		0.545		0.440		0.073		-0.054	
Df	20		38		20		38		42		78	
P	>0.50		>0.50		>0.50		>0.50		>0.50		>0.50	

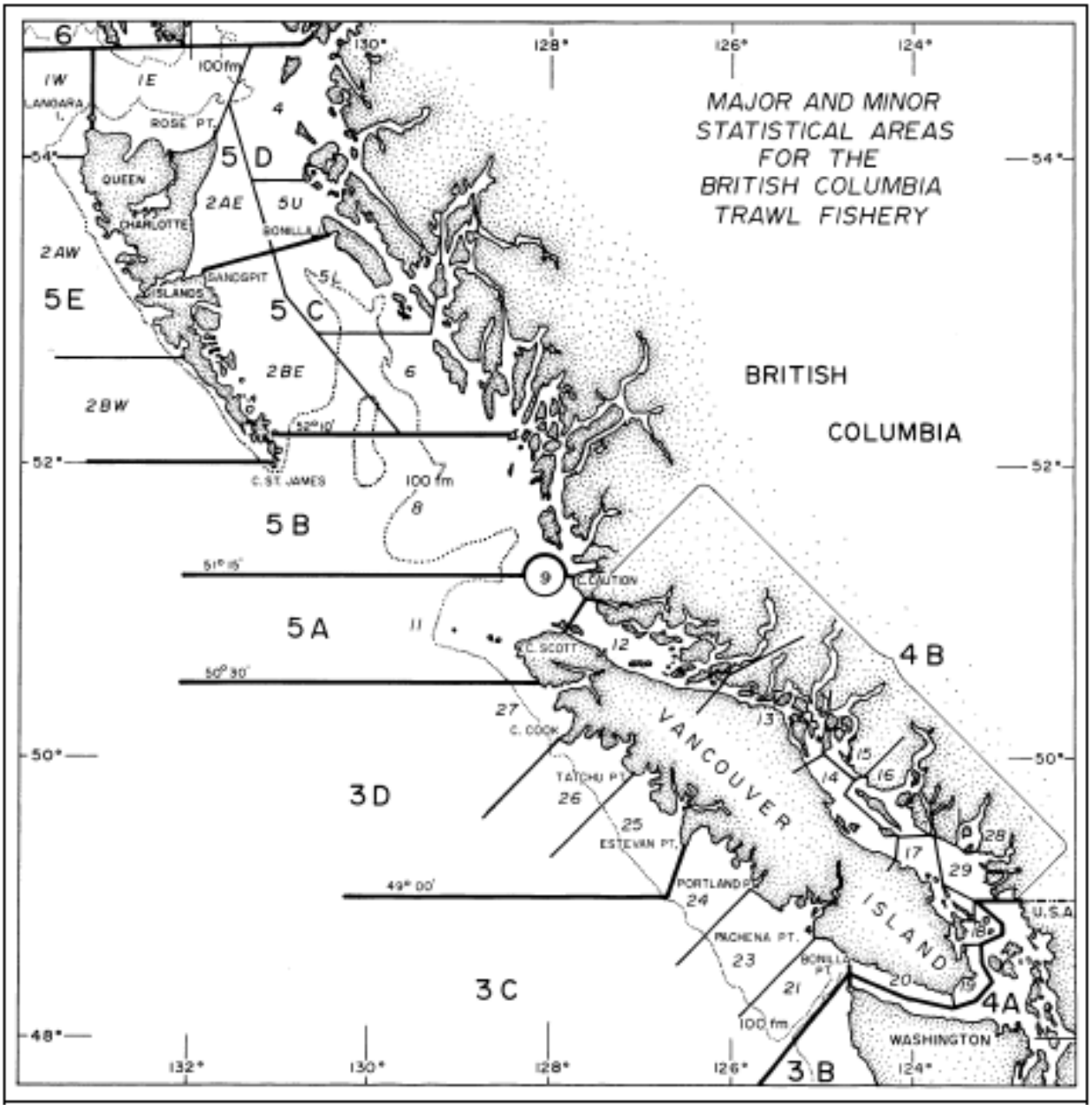

Figure 1. International groundfish statistical areas off British Columbia.

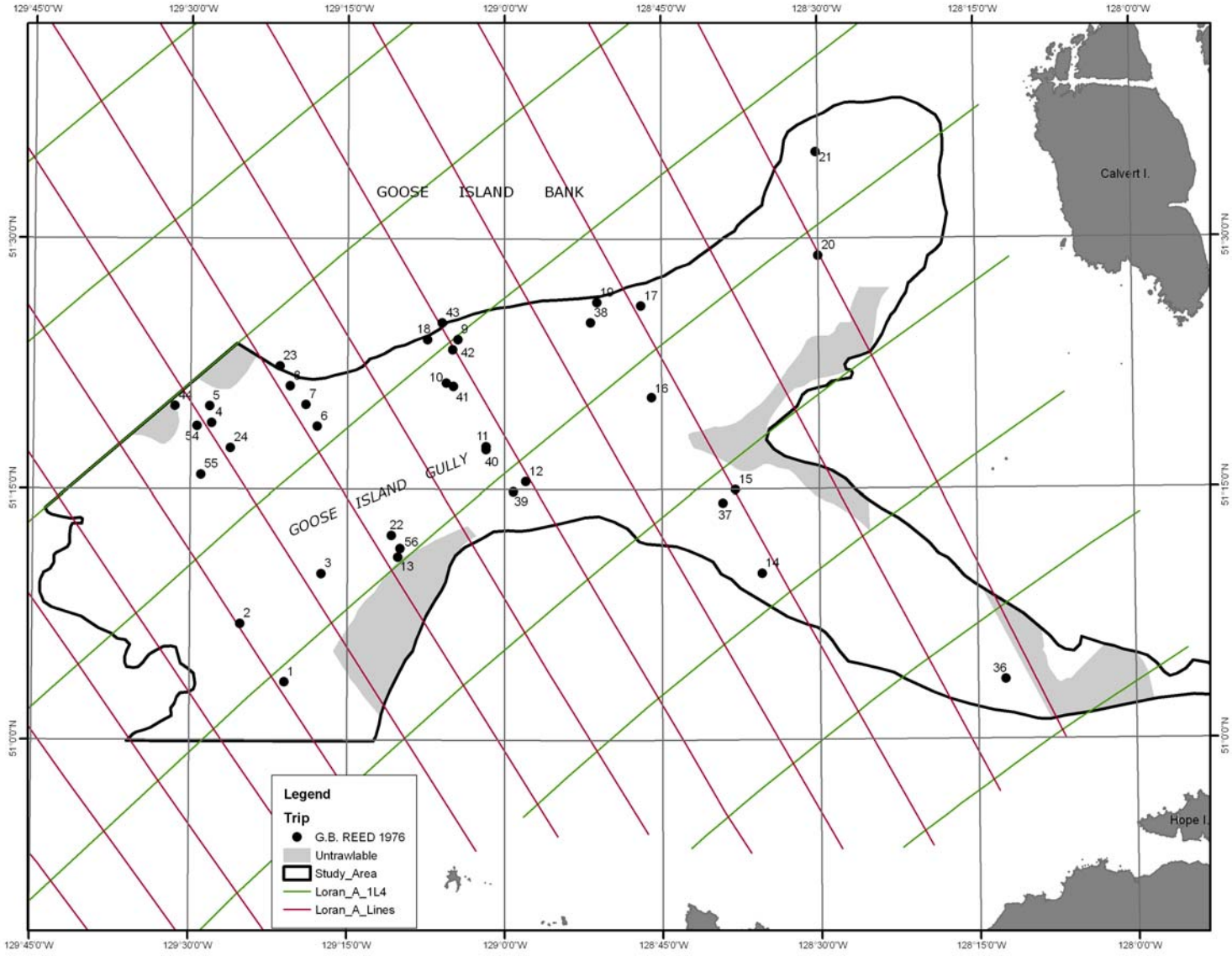

Figure 2. Locations of the R/V G. B. REED trawl hauls in the Study Area. September 8 - 27, 1976.

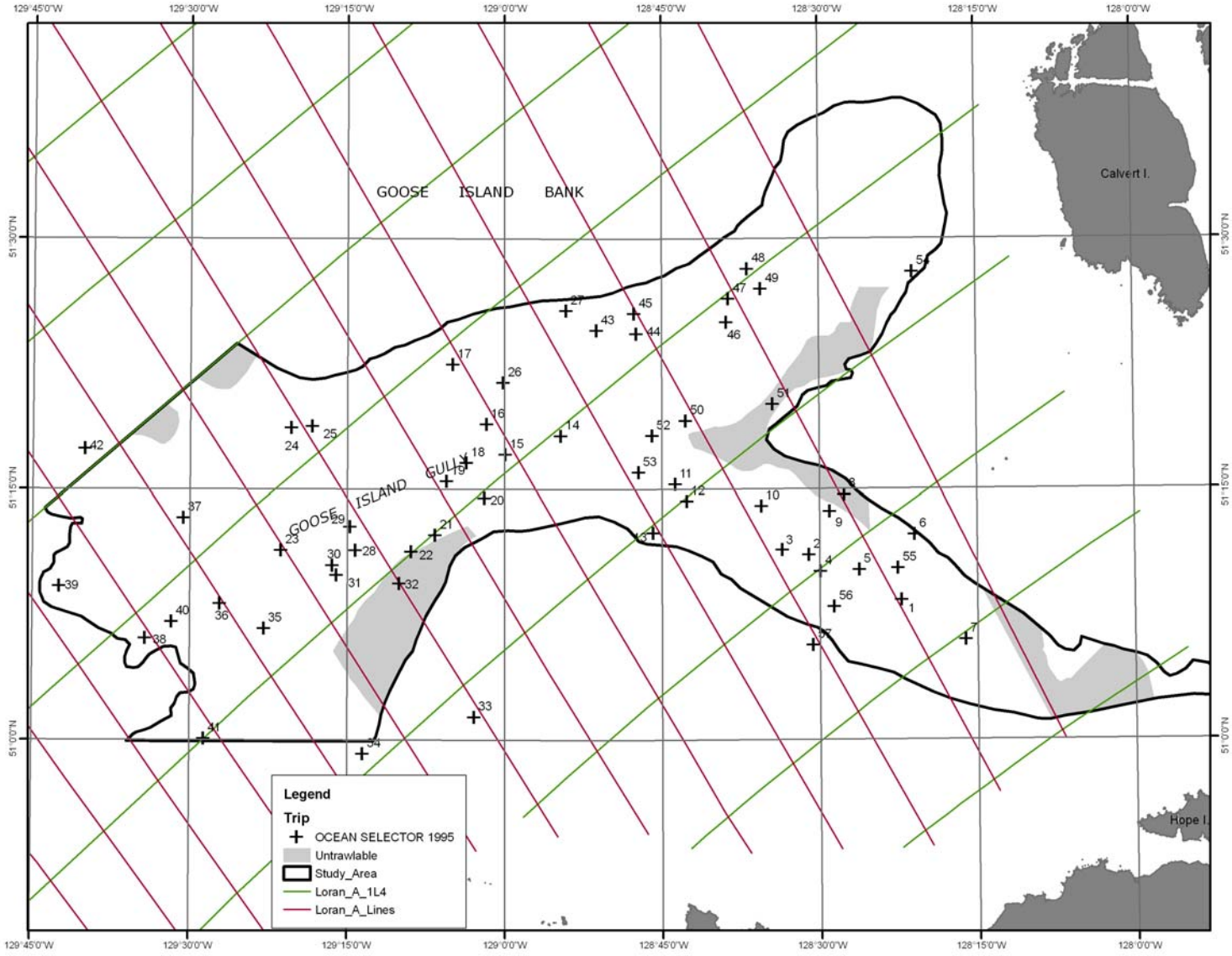

Figure 3. Locations of F/V OCEAN SELECTOR trawl hauls in the Study Area and vicinity, September 11 – 22, 1995.

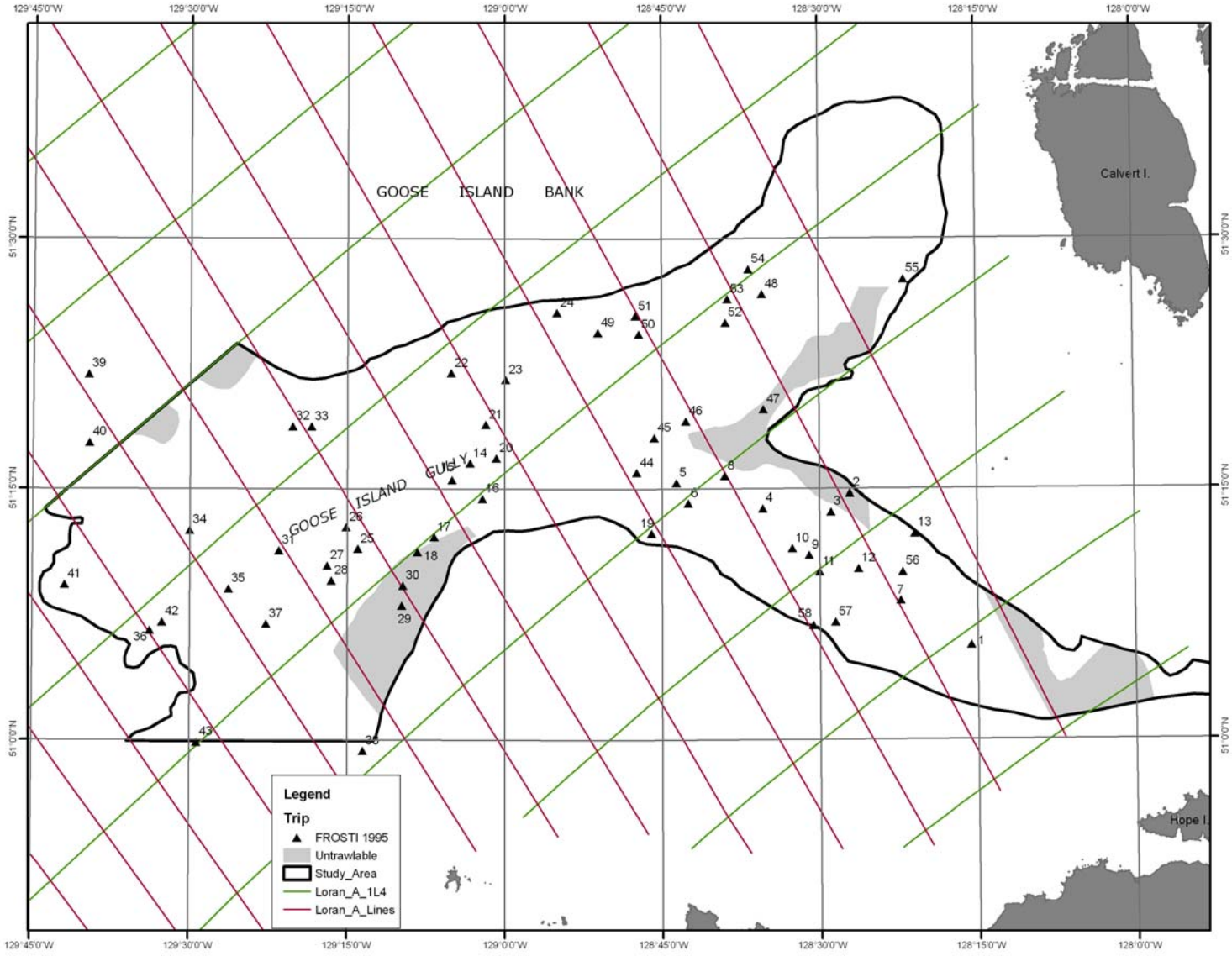

Figure 4. Locations of F/V FROSTI trawl hauls in the Study Area and vicinity, September 11 – 22, 1995.

Appendix Table 1. Records of G.B. REED trawl hauls in Goose Island Gully, September 8-27, 1976. (Source: Westrheim et al.1976)

Haul	Dur.	Start		LORAN	Depth interval[b]		Catch (lbs)	
	(min)	N. lat.	W. long.	(2H4)	(fms)	(m)	Total	POP[c]
1	30	51 03.5	129 21.0	4080-S	110	201	2317	508
2	30	51 07.0	129 25.2	4080-S	150	275	3969	2796
3	15	51 10.0	129 17.5	4090-S	150	275	1176	641
4	30	51 19.0	129 28.0	4090-N	130	238	5188	2141
5	30	51 20.0	129 28.2	4090-N	110	201	3063[d]	0
6	30	51 18.8	129 17.9	4100-N	150	275	2141	757
7	30	51 20.1	129 19.0	4100-N	130	238	1489	905
8	30	51 21.2	129 20.5	4100-N	110	201	6434	5796
9	30	51 24.0	129 04.5	4120-N	110	201	3602	1315
10	30	51 21.4	129 05.6	4120-N	130	238	3395	691
11	30	51 17.6	129 01.8	4120-S	130	238	1335	520
12	30	51 15.5	128 58.0	4120-S	110	201	2826	1747
13	30	51 11.0	129 10.2	4100-S	110	201	3109	475
14	30	51 10.0	128 35.5	4140-S	90	165	3780[e]	0
15	30	51 15.0	128 38.0	4140-S	110	201	3386	1691
16	30	51 20.5	128 46.0	4140-S	130	238	2249	1190
17	30	51 26.0	128 47.0	4140-N	110	201	12465	715
18	30	51 24.0	129 07.4	4120-N	90	165	2719	321
19	30	51 26.2	128 51.2	4140-N	90	165	6371	217
20	30	51 29.0	128 30.0	4160-N	110	201	596	162
21	30	51 35.2	128 30.2	4160-N	90	165	2451	552
22	30	51 12.3	129 10.8	4100-S	150	275	3068	1238
23	30	51 22.4	129 21.5	4100-N	90	165	1280[f]	0
24	30	51 17.5	129 26.2	4090-N	150	275	3643	2127
36	30	51 03.6	128 12.4	4160-S	90	165	3124[g]	2
37	30	51 14.2	128 39.2	4140-S	110	201	2546	215
38	30	51 25.0	128 51.8	4140-N	110	201	2379	273
39	30	51 14.9	128 59.2	4120-S	110	201	2442	1092
40	30	51 17.4	129 01.8	4120-S	130	238	2180	964
41	30	51 21.2	129 04.9	4120-N	130	238	3441	1501
42	30	51 23.4	129 05.0	4120-N	110	201	7577	3318
43	30	51 25.0	129 06.0	4120-N	90	165	1798	283
44	30	51 20.0	129 31.5	4090-N	110	201	2283	1624
54	30	51 18.8	129 29.4	4090-N	130	238	4168	1902
55	30	51 15.9	129 29.0	4090-N	150	275	4742	1942
56	30	51 11.5	129 10.0	4100-S	110	201	9001[h]	693

Appendix table 1 cont'd. Records of G.B. REED trawl haulsa in Goose Island Gully, September 8-27, 1976. (Source: Westrheim et al.1976)

[a] Authors deemed all hauls usable Hauls not listed here were completed in nearby Mitchell's Gully.
[b] Mid-points of 20-fm depth intervals (90 = 80-99, etc.). Equivalent values in meters.
[c] POP = Pacific ocean perch
[d] Most important: *S. aleutianus*, 1804 lbs
[e] Most important: pollock (Pacific pollock), 2423 lbs
[f] Most important: turbot (arrowtooth flounder), 598 lbs
[g] Most important: turbot (arowtooth flounder), 2044 lbs
[h] Most important: *S. brevispinis*, 4014 lbs

Appendix Table 2. Records of F/V OCEAN SELECTOR trawl hauls in Goose Island Gully and vicinity, September 11-22, 1995. (Source: Yamanaka et al. 1996)

Haul	Date	Ord[a]	Dur.	Start		LORAN	Depth interval[b]		Catch (kg)	
			(hr)	N. lat. (51^{o})	W. long.	(2H4)	(fms)	(m)	Total	POP[c]
1	11	1	0.32	8.4	128 22,2	4150-S	110	201	279	100
2	12	1	0.28	11.1	128 31.0	4140-S	110	201	544	366
3	12	1	0.30	11.4	128 33.5	4140-S	110	201	544	304
4	12	1	0.28	10.1	128 29.9	4140-S	110	201	464	88
5	12	1	0.30	10.2	128 26.2	4150-S	110	201	454	253
6	12	0	0.32	12.3	128 20.9	4150-S	70	128	398[d]	6
7	12	2	0.32	6.0	128 16.1	4150-S	90	165	856	370
8	13	2	0.32	14.7	128 27.6	4150-S	90	165	278[e]	0
9	13	2	0.32	13.7	128 29.0	4150-S	110	201	659	230
10	13	2	0.28	14.0	128 35.5	4140-S	110	201	2586	1465
11	13	2	0.33	15.3	128 43.7	4130-S	110	201	1309	835
12	13	2	0.35	14.3	128 42.6	4130-S	110	201	2268	736
13	13	1	0.30	12.4	128 45.8	4130-S	90	165	234[f]	21
14[d]	13	0	0.27	18.2	128 54.6	4150-S	130	238	0	
15	14	1	0.35	17.1	128 59.9	4120-S	130	238	1414	1271
16	14	1	0.33	18.9	129 01.7	4120-N	130	238	3849	3616
17	14	1	0.37	22.5	129 04.9	4120-N	130	238	1575	1388
18	15	2	0.33	16.6	129 03.6	4120-S	130	238	1031	892
19	15	2	0.32	15.5	129 05.5	4110-S	130	238	557	445
20	15	2	0.33	14.5	129 01.9	4120-S	110	201	1557	982
21	15	2	0.33	12.3	129 06.6	4110-S	110	201	1800	1371
22	15	2	0.35	11.3	129 08.9	4100-S	110	201	5252	4142
23	16	1	0.35	11.4	129 21.3	4090-S	150	275	1065	927
24	16	1	0.32	18.7	129 20.3	4100-N	130	238	1207	756
25	16	1	0.40	18.8	129 18.3	4100-N	150	275	971	658
26	16	2	0.35	21.4	129 00.1	4120-N	130	238	1378	1168
27	16	2	0.33	25.7	128 54.1	4130-N	90	165	1551	1169
28	17	0	0.37	11.4	129 14.2	4100-S	170	311	488	314
29	17	2	0.32	12.8	129 14.7	4100-S	150	275	683	424
30	17	0	0.32	10.5	129 16.4	4080-S	170	311	1032	645
31	17	2	0.32	9.9	129 16.0	4090-S	150	275	1645	1428
32	17	2	0.33	9.4	129 10.0	4100-S	90	165	4954[g]	68
33[g]	17	0	0.33	1.4	129 12.9	4100-S	90	165	0	
34	17	1	0.33	50 59.2	129 13.5	4090-S	90	165	180[h]	2
35	19	2	0.35	6.7	129 22.9	4080-S	130	238	1186	749
36	19	2	0.33	8.2	129 27.1	4080-S	150	275	451	344
37	19	0	0.35	13.3	129 30.6	4080-N	170[j]	311	401	237
38	19	2	0.35	6.1	129 34.2	4070-S	150	275	1702	898
39	19	2	0.32	9.2	129 42.4	4070-N	150	275	4293	2745
40	19	2	0.37	7.1	129 31.7	4070-S	150	275	366	170
41	19	0	0.35	0.1	129 28.6	4070-S	130	238	648	379
42[g]	20	0	0.08	17.4	129 40.0	GIBS[g]	130	238	0	

Appendix table 2 cont'd. Records of F/V OCEAN SELECTOR trawl hauls in Goose Island Gully, September 11-22, 1995. (Source: Yamanaka et al. 1996)

Haul	Date	Ord[a]	Dur.	Start		LORAN	Depth interval[b]		Catch (kg)	
			(hr)	N. lat.	W. long.	(2H4)	(fms)	(m)	Total	POP[c]
43	20	1	0.35	24.5	128 51.2	4140-N	110	201	516	296
44	20	1	0.35	24.3	128 47.4	4140-N	110	201	446	245
45	20	1	0.35	25.5	128 47.6	4140-N	110	201	454	144
46	20	1	0.33	25.0	128 38.8	4150-N	110	201	495	255
47	20	1	0.35	26.4	128 38.6	4150-N	110	201	476	227
48	21	1	0.35	28.2	128 36.8	4150-N	110	201	345	105
49	21	2	0.33	27.0	128 35.5	4150-N	110	201	531	229
50	21	2	0.35	19.1	128 42.7	4140-N	110	201	1458	878
51	21	2	0.35	20.1	128 34.4	4150-N	110	201	11340[i]	5331
52	21	2	0.35	18.2	128 45.9	4130-N	110	201	1324	966
53	21	2	0.33	16.0	128 47.2	4130-S	110	201	1361	840
54	22	2	0.35	28.0	128 21.0	4170-N	90	165	470[j]	7
55	22	2	0.33	10.3	128 22.5	4150-S	110	201	1233	501
56	22	2	0.33	8.0	128 28.6	4140-S	90	165	555	231
57	22	0	0.33	5.7	128 30.6	4140-S	70	128	131[k]	10

[a] Ord = order of trawling: 1 = first; 2 = second; 0 = not usable (see Table 1)
[b] Mid-points of 20-fm depth intervals (90 = 80-99, etc.). Equivalent values in meters.
[c] POP = Pacific ocean perch
[d] Most important: arrowtooth flounder, 94 kg
[e] Most important: arrowtooth flounder, 107 kg
[f] Most important: arrowtooth flounder, 150 kg
[g] Unusable
[h] Most important: *S. reedi*, 3821 kg
[i] Most important: *S. flavidus*, 37 kg
[j] Reported starting and ending depths were 159 and 160 fms, respectively. Comparable depths reported for the "twin" haul (F-34) were 160 and 160 fms. Hence 170 fms was assigned to both hauls.
[k] GIBS = Goose Island Bank Slope. Not in Goose Island Gully (see Fig. 2)
[l] Next most important: *S. reedi*, 5,007 kg
[m] Most important: *S. babcocki*, 192 kg
[n] Most important: arrowtooth flounder, 72 kg

Appendix Table 3. Records of F/V FROSTI trawl hauls, in Goose Island Gully and vicinity, September 11-22, 1995. (Source: Yamanaka et al. 1996)

Haul	Date	Ord.[a]	Dur.	Start		LORAN	Depth interval[b]		Catch (kg)	
			(hr)	N. lat. (51^{o})	W. long.	(2H4)	(fms)	(m)	Total	POP[c]
1	11	1	0.25	5.7	128 15.6	4150-S	90	165	291[d]	18
2	12	1	0.25	14.8	128 27.1	4150-S	90	165	182[e]	0
3	12	1	0.32	13.7	128 28.9	4150-S	110	201	557	249
4	12	1	0.32	13.9	128 35.4	4140-S	110	201	907	627
5	12	1	0.30	15.4	128 43.6	4130-S	110	201	680	461
6	12	1	0.30	14.2	128 42.5	4130-S	110	201	984	474
7	12	2	0.30	8.4	128 22.3	4150-S	110	201	384	163
8	13	0	0.25	15.8	128 39.0	4140-S	110	201	213[f]	45
9	13	2	0.28	11.1	128 31.0	4140-S	110	201	537	236
10	13	2	0.30	11.5	128 32.6	4140-S	110	201	492	224
11	13	2	0.30	10.1	128 30.0	4140-S	110	201	451	267
12	13	2	0.30	10.3	128 26.3	4150-S	110	201	647	408
13	13	0	0.30	12.4	128 20.9	4150-S	70	128	475[g]	29
14	14	1	0.28	16.6	129 03.3	4120-S	130	238	568	468
15	14	1	0.30	15.6	129 05.0	4110-S	130	238	488	374
16	14	1	0.30	14.5	129 02.1	4120-S	110	201	907	264
17	14	1	0.28	12.2	129 06.7	4110-S	110	201	1134	829
18	14	1	0.32	11.3	129 08.3	4100-S	110	201	3629	2555
19	14	2	0.30	12.4	128 46.0	4130-S	90	165	168[h]	39
20	15	2	0.30	16.9	129 00.8	4120-S	130	238	907	832
21	15	2	0.32	18.9	129 01.8	4120-N	130	238	794	709
22	15	2	0.30	22.0	129 05.1	4120-N	130	238	1134	1034
23	15	1	0.30	21.6	128 59.9	4120-N	130	238	1134	1012
24	15	1	0.30	25.6	128 55.0	4130-N	90	165	2495	2332
25	16	0	0.30	11.5	129 14.0	4100-S	170	311	680	490
26	16	1	0.33	12.8	129 15.1	4100-S	150	275	424	245
27	16	0	0.32	10.5	129 16.9	4090-S	170	311	1814	1597
28	16	1	0.32	9.6	129 16.5	4090-S	150	275	2268	2118
29[i]	16	0	0.17	8.1	129 09.8	4100-S	90	165	0	
30	16	1	0.30	9.3	129 09.7	4100-S	90	165	2495[j]	0
31	17	2	0.32	11.4	129 21.5	4090-S	150	275	907	794
32	17	2	0.32	18.8	129 20.2	4100-N	130	238	185	156
33	17	2	0.32	18.8	129 18.4	4100-N	150	275	680	393
34	17	0	0.32	12.6	129 30.0	4080-N	170[k]	311	336	156
35	17	1	0.32	9.1	129 26.3	4080-S	150	275	1225	1109
36	18	1	0.32	6.6	129 33.8	4070-S	150	275	2268	1585
37	18	1	0.30	7.0	129 22.7	4080-S	130	238	1361	901
38	18	2	0.28	50 59.4	129 13.5	4090-S	90	165	116[l]	10
39	19	0	0.28	21.9	129 39.7	GIBS[m]	110	201	303[n]	1
40	19	0	0.30	17.8	129 39.6	GIBS[m]	130	238	816	432
41	19	1	0.32	9.3	129 41.9	4060-N	150	275	4082	2084
42	19	1	0.30	7.1	129 32.6	4070-S	150	275	771	652

Appendix table 3 cont'd. Records of F/V FROSTI trawl hauls, in Goose Island Gully and vicinity, September 11-22, 1995. (Source: Yamanaka et al. 1996)

Haul	Date	Ord.[a]	Dur.	Start		LORAN	Depth interval[b]		Catch (kg)	
			(hr)	N. lat. (51°)	W. long.	(2H4)	(fms)	(m)	Total	POP[c]
43	19	0	0.30	50 59.9	129 29.3	4070-S	130	238	419	219
44	20	1	0.28	16.0	128 47.4	4130-S	110	201	816	435
45	20	1	0.28	18.1	128 45.7	4130-N	110	201	998	327
46	20	1	0.28	19.1	128 42.7	4140-N	110	201	1361	778
47	20	1	0.30	19.8	128 35.3	4150-N	110	201	3175[o]	641
48	20	1	0.30	26.7	128 35.4	4150-N	110	201	680	378
49	21	2	0.30	24.4	128 51.1	4140-N	110	201	247	127
50	21	2	0.30	24.3	128 47.2	4140-N	110	201	177	103
51	21	2	0.30	25.4	128 47.5	4140-N	110	201	250	68
52	21	2	0.30	25.0	128 38.9	4150-N	110	201	333	217
53	21	2	0.30	26.4	128 38.7	4150-N	110	201	328	153
54	21	2	0.30	28.2	128 36.7	4150-N	110	201	277	110
55	22	1	0.27	27.6	128 21.9	4170-N	90	165	265[p]	4
56	22	1	0.28	10.1	128 22.1	4150-S	110	201	464	269
57	22	1	0.28	7.1	128 28.5	4140-S	90	165	264	145
58	22	0	0.28	6.9	128 30.6	4140-S	90	165	97[q]	13

[a] Ord = order of trawling: 1 = first; 2 = second; 0 = not usable (see Table 1)
[b] Mid-points of 20-fm depth intervals (90 = 80-99, etc.). Equivalent values in meters.
[c] POP = Pacific ocean perch
[d] Most important: rex sole, 62 kg
[e] Most important: *S. diploproa*, 36 kg
[f] Most important: *S. proriger*, 54
[g] Most important: arrowtooth flounder, 137 kg
[h] Most important: arrowtooth flounder, 102 kg
[i] Unusable
[j] Most important: *S. reedi*, 1451 kg
[k] Reported starting and endings depths were both 160 fms. Comparable depths reported for the "twin" haul (OS-37) were 159 and 160 ms, respectively. Hence, 170 fms was assigned to both hauls.
[l] GIBS = Goose Island Bank Slope. Not in Goose Island Gully. See Fig. 2
[m] Most important: *S. brevispinis*, 30 kg
[n] Most important: *S. zacentrus*, 221
[o] Most important: *S. reedi*, 2179 kg
[p] Most important, arrowtooth flounder, 54 kg