# Tagging Mortality, Recovery Rate, and Mortality Rate of English Sole (*Parophrys vetulus*) Tagged in Hecate Strait, June 9-18, 1983, and Records of Other Migrations Elsewhere

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2012

**TAGGING MORTALITY, RECOVERY RATE, AND MORTALITY RATE
OF ENGLISH SOLE (*Parophrys vetulus*) TAGGED IN HECATE STRAIT,
JUNE 9-18, 1983, AND RECORDS OF OTHER MIGRATIONS ELSEWHERE**

by

J.J. Fargo and S.J. Westrheim

ABSTRACT

Fargo, J.J., and Westrheim, S.J. 2012. Tagging mortality, recovery rate, and mortality rate of English sole (*Parophrys vetulus*) tagged in Hecate Strait, June 9-18, 1983, and records of other migrations elsewhere. Can. Tech. Rep. Fish. Aquat. Sci. 2994: iv + 65 p.

During June 9-18, 1983, in Hecate Strait (Areas 5D+5C), 5,433 English sole were tagged, and 5,376 released, on four trawling grounds—three in Area 5D (Butterworth, White Rocks, and Bonilla), and one in Area 5C (West Horseshoe), of which 227 (4.2%) were subsequently recovered.   The primary purpose of the project was to validate a new method of age determination. Results of this study including tagging mortality, recovery rate, migration, and mortality rate were compared with previous studies on the B.C. coast as well as with studies done in the United States.

Recovery rates in this study were low compared to other studies. However, there was no relationship for numbers released, percent males among releases, or proportions of other species in the catches. Among Areas, from British Columbia to California, recoveries occurred primarily in the release Area. Percentage of recoveries in the release Area ranged from 68% to 100%, for Area 5D releases.   Most of the fish that did migrate were encountered southward of their release Area. The estimate of the annual exponential "dispersion rate" southward was 0.16% in this study. The most recent dispersion rate estimated in a U.S. study off the Washington coast was 2% per month to the north and 4% per month to the south.

The instantaneous total mortality rate (Z; sexes combined) was estimated to be 0.41 based on the linear regression of the natural logarithm of recovered tags per tonne of landing for Qtr IV 1983 through Qtr III 1985 (or Qtr I 1984 through Qtr III 1985). For the same Area, estimates of Z were 0.48-0.51 for males, and 0.32-0.42 for females, based on age compositions (otoliths) of commercial landings during 1945-46. In north Puget Sound, an estimate of Z from age composition data was 0.57 (F = 0.47; M = 0.10), in an area newly opened to trawling. In central Puget Sound, on an unfished stock, Z (actually M) was estimated to be 0.50 for males, and 0.49 for females. In south Puget Sound, also on an unfished stock, Z was estimated to be 0.75 for males, and 0.56 for females. Off Washington and Oregon, M was estimated to be 0.26 for each sex using age composition data.

RÉSUMÉ

Fargo, J.J., and Westrheim, S.J. 2012. Tagging mortality, recovery rate, and mortality rate of English sole (*Parophrys vetulus*) tagged in Hecate Strait, June 9-18, 1983, and records of other migrations elsewhere. Can. Tech. Rep. Fish. Aquat. Sci. 2994: iv + 65 p.

Du 9 au 18 juin 1983, dans le détroit d'Hécate (zones 5D+5C), 5 433 carlottins anglais ont été marqués et 5 376 relâchés dans quatre lieux de chalutage; trois dans la zone 5D (Butterworth, White Rocks et Bonilla) et un dans la zone 5C (ouest de Horseshoe), desquels 227 (4,2 %) ont été récupérés par la suite. Le but premier du projet consistait à valider une nouvelle méthode de détermination de l'âge. Les résultats de la présente étude comprenant la mortalité par marquage, le taux de rétablissement, la migration et le taux de mortalité ont été comparés à des études précédentes réalisées sur la côte de la C.-B. et à des études effectuées aux États-Unis.

Les taux de rétablissement dans la présente étude étaient bas comparativement aux autres études. Toutefois, il n'y avait aucune relation entre le nombre de prises relâchées, le pourcentage de mâles relâchés ou les proportions d'autres espèces dans les prises. Parmi les zones, de la Colombie-Britannique à la Californie, les rétablissements ont eu lieu principalement dans la zone de remise à l'eau. Le pourcentage de rétablissements dans la zone de remise à l'eau oscillait entre 68 % et 100 % pour les remises à l'eau de la zone 5D. La plupart des poissons qui ont migré ont été retrouvés au sud de leur zone de remise à l'eau. L'estimation du taux de dispersion annuelle exponentielle vers le Sud était de 0,16 % dans cette étude. Le taux de dispersion estimé le plus récent dans une étude réalisée par les É.-U. au large de la côte de Washington était de 2 % par mois vers le Nord et de 4 % par mois vers le Sud.

Le taux de mortalité instantanée total (Z : les deux sexes combinés) était estimé à 0,41 selon la régression linéaire du logarithme naturel d'étiquettes retrouvées par tonne de débarquements pour le quatrième semestre de 1983 jusqu'au troisième trimestre de 1985 (ou du premier trimestre de 1984 au troisième trimestre de 1985). Pour la même zone, l'estimation de Z était de 0,48 à 0,51 pour les mâles et de 0,32 à 0,42 pour les femelles, basée sur la composition selon l'âge (otolithes) des débarquements commerciaux de 1945 à 1946. Au nord de la baie Puget, une estimation de Z basée sur les données de la composition selon l'âge était de 0,57 ($F = 0,47$; $M = 0,10$) dans une zone ouverte récemment au chalutage. Au centre de la baie Puget, pour un stock non pêché, Z (M en fait) était estimé à 0,50 pour les mâles et à 0,49 pour les femelles. Au sud de la baie Puget, aussi pour un stock non pêché, Z était estimé à 0,75 pour les mâles et à 0,56 pour les femelles. Au large de Washington et de l'Oregon, M a été estimé à 0,26 pour chaque sexe en utilisant les données de composition selon l'âge.

INTRODUCTION

Chilton and Beamish (1982) reported that a new age-determination method for English sole (*Parophrys vetulus*) indicated a longer life span than previously believed. Validation of the new method was undertaken in June 1983, with a tagging study in Hecate Strait (Fargo *et al* 1984). The specimens were injected with oxytetracycline prior to release, to provide a "time mark". Results were reported by MacLellan and Fargo (1995).

Potential by-products of the aforementioned tagging study are estimates of tagging mortality, recovery rate, migration, and mortality rate. The purpose of this report is to explore the tagging results for information on these four items, and make comparisons with similar studies elsewhere. The results of this tagging study were compared with the results of previous English sole tagging studies in British Columbia and also with results from English sole tagging studies in the United States.

MATERIALS AND METHODS

MATERIALS

Records

Summary records of released English sole were reported in Fargo *et al* (1984). Detailed records of released, and recovered, specimens were obtained from the PBS Groundfish database GFBIO. For individual specimens, the following data (if known) were included: tag number, time of release and recovery (day[1], month, and year), location of release and recovery (major area[2], minor area[1], and ground), fork length at release and recovery, sex (at recovery), otoliths[1] (at recovery), quality[1] (at recovery: fresh or frozen), and condition[1] (at release).

Tag

Tag type was a Floy FD688 (9.5 cm long, with a 2.5-cm nylon shank attached to 7.0-cm length of #20 yellow vinyl tubing.

METHODS

Capture and Tagging

English sole were caught by trawl. Refer to Fargo *et al* (1984) for details. Each fish selected from the catch was examined for injuries. If acceptable, it was tagged, measured fork length to the nearest centimeter, injected with

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[1] Not used in this analysis.
[2] Hereafter referred to as Area.

oxytetracyclene and placed in a holding tank that was hinged to the vessel's rail. Sex was not recorded, nor was anesthetic applied. When tagging was complete, moribund specimens (if any) were removed, and the tank was tilted so that its contents were discharged into the sea. Full details of the discharge method are described in Harling *et al* (1982).

Tag recovery

No effort was expended to directly determine the incidence of tags in the English sole landings. Recoveries were dependent upon the vigilance and cooperation of fishermen, processing-plant employees and our full time port samplers stationed in Vancouver and Prince Rupert. The principal port of landing was Prince Rupert adjacent to the tagging area. Occasionally, tagged fish were detected in catches at sea and reported by the captain or a crew member. The port samplers collected landing records (quantity and location of catch and effort) from most trawl landings over that time period. They also collected biological samples including length, sex, age structures and gonad condition of individual fish from landings and tag recoveries. For each tagged English sole, they collected the following information: time and location of recovery, fork length (cm), sex, otoliths, gonad condition, and fish condition – fresh, frozen or frame (carcass after the fillets had been removed).

The following criteria were used to assign recovery location from information provided by the vessel captain:

1. If at least 90% of the English sole catch was made in a single major area, minor area or locality (fishing ground), the recovered tag was assigned to that location.

2. If the English sole catch was made in two or more minor areas or localities within a single major area, the recovery was assigned to the major area.

3. If the English sole catch originated in two or more major areas, recovery location was listed as unknown.

Sex determination

Sex was not determined at time of tagging, and the length-frequencies by sex of tagged fish were determined indirectly. Length-frequencies of samples from commercial landings were available by sex. For these, proportions of males were calculated for 3-cm (or 4-cm) length intervals, and applied to similar groupings of tagged fish.

Factors affecting recovery rate

Four factors which might have affected recovery rate were investigated: length at release, condition at release, overnight holding and numbers tagged per haul.

Four types of Chi-square tests were employed to compare recovery rates. Three were two-way tests of independence (Types 1-3 Dixon and Massey 1969), and the fourth was the classical single classification. The correction for continuity was omitted for the two-way tests of independence because observed values were generally large. Finally, recoveries were arranged by quarter-year (January-March, etc.) for assessing time at liberty.

Length-Frequencies

Comparisons of length-frequencies were undertaken with respect to modal size and differences between mean lengths (*t*-test). All comparisons of tagged fish involved only lengths at release to maximize sample size of recoveries.

Length-frequencies by sex of fish at release were determined indirectly. Length-frequencies of samples from commercial landings were available by sex. For these, proportions of males were calculated for 3-cm length intervals, and applied to identical groupings of released fish.

RESULTS

GENERAL

In Hecate Strait (Areas 5D + 5C), during June 9-18, 1983, there were 5,433 English sole tagged and 5,376 released, of which 227 (4.2%) were subsequently recovered (Table 1; Fig. 2). The 57 not released were found dead in the recovery tank. Of these, 42 were the result of a delayed release of 100 fish to estimate tagging mortality. Number with known time of recovery was 216 (4.0%) by year, and 215 (4.0%) by month. Number with known location of recovery was 205 (3.8%) by Area, and 148 (2.8%) by ground. Fork length and sex were recorded from only 205 of the 206 tag recoveries because sex was not recorded for the remaining recovery (tag #041733 in Appendix table 1).

The tagging vessel completed 26 trawl hauls (Table 2). No English sole were released from hauls 14 and 26. Haul duration ranged from 15 to 30 minutes (0.25-0.50 h), with a mean of 21 minutes (0.35 h), and standard error of 1.2 minutes (0.02 h).

English sole were tagged and released on four grounds—West Horseshoe (N = 834; hauls 1-7); Bonilla (1,471; 8, 9, and 25); White Rocks (2,770; 10-13, 15, and 20-24); and Butterworth (301; 16-19) (Table 2; Fig. 2).

TAGGING MORTALITY

On June 15, the 100 tagged fish from haul 16 (0821-0851 PDT) were held overnight until June 16, to investigate tagging mortality (Fargo *et al* 1984). Mortalities totaled 42, or an "immediate" mortality rate of 42%.   Manzer (1952) held tagged (Petersen disc), and untagged, English sole in a large outdoor pond for three months. He estimated the annual mortalities of males to be 53.2% for tagged specimens, and 21.3% for the untagged. Comparable values for females were 64.6% and 30.2% (*op. cit.*, Table 1). Thus, the mortality due to tagging was some 32-34%.

AGE VALIDATION

A total of 197 tagged English sole were recovered from which otoliths were collected (Table 2). Most (108; 55%) of the recoveries occurred during the first year at liberty (June 1983-May 1984). Subsequent recoveries were 74 (38%) in "year" 2; 2 (8%) in "year" 3, none in "year" 4, 1 (0.5%) in "year" 5, and 2 (1.0%) in "year" 6. The last recovery occurred in December 1988. Those results were presented by Fargo and MacLellan (1995).

RECOVERY RATE

5D Releases

In 1983, releases totaled 4,452, and the subsequent recovery rate was 4.4% (198) for those for which recovery Area was known (Table 3).

During 1945-52, releases totaled 8,353 (Forrester 1967, Table 2). The subsequent recovery rate, through 1964, was 31.2% (2,602), excluding 57 recoveries for which recovery location was unknown.   The author provided detailed results on three studies—March 1945; April 1950; and June 1952. Releases totaled 6,727, and recoveries by 1964, 2,458 (36.5%) whose recovery Area was known (*op. cit.,* Table 4). Recovery rates were 21.2% (316/1,490) for the March 1945 release; 46.6% (1,405/3,018) for the April 1950 release; and 33.2% (737/2,219) for the June 1952 release.

5C Releases

Releases totaled 834, and the recovery rate, from known Areas, was 0.8% (7) (Table 3).

No tagging occurred in Area 5C prior to 1983.

MIGRATION

Area 5D

    1983. Recoveries totaled 198 (4.4%) (Table 3). Principal recovery Area was 5D (191; 96.5% of recoveries), followed by 5C (4; 2.0%), 5B (2; 1.0%), and 3Cn[3] (1; 0.5%) (Fig. 1).

    1945-52. Recoveries from the aforementioned three studies, totaled 2,458 (36.5%) (Table 3). Principal recovery Area was 5D (2,437; 99.1% of recoveries), followed by 5C/5A (6 each; 0.2% each), 5B (4; 0.2%), 3B (3; 0.1%), 3D (1; 0.04%), and 6 (1; 0.04%; Cape Spencer, Alaska).

    1950. Exploratory trawling revealed a spawning ground for English sole in an inlet northeast of Butterworth Ground (Forrester 1967). In April 1950, 962 English sole were tagged and released in the inlet. Recoveries totaled 35 (3.5%), 24 by shrimp trawlers at the release site, and 11 by groundfish trawl on the "outside" grounds.   The author suggested that weighting of recoveries would indicate that the emigration from the inlet was negligible.

5C

    1983. All seven were recovered in Area 5D (Table 3).

5B

    1952-54. Releases totaled 1,877, and recoveries, 202 (10.8%) (Table 3). Principal recovery Area was 5B (167; 82.7% of recoveries), followed by 5A (18; 8.9%); 5D/3B (5 each; 2.5% each); 3Cn (3; 1.5%), and 3D/2D/2B/1C (1 each; 0.5% each).

4B

    1944-60. Releases totaled 14,100, and recoveries, 3,381 (24.0%) (Table 3). Principal recovery Area was: 4B (3,309; 97.9% of recoveries), followed by 4A (103; 3.0%), 3B (6; 0.2%); 2D (4; 0.1%), and 3Cn/1C (1 each; 0.03% each).

3D

    1945. Releases totaled 23, with one recovery (4.3%) in Area 3B.

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[3] Area 3Cn, is that portion of Area 3C which lies within the Canadian Extended Economic Zone (established in 1977). It comprises approximately the northern two-thirds of Area 3C.

3Cn

1945. Releases totaled 132, and recoveries, 29 (22.0%) (Table 3). Principal recovery Areas were 3Cn/3B (13 each; 44.8% each of recoveries), and 3A/2D/2C (1 each; 3.4% each). Although limited, recoveries suggested a southward movement occurred in autumn, and a return to the release area in summer (Manzer 1946).

3B

1956 (Washington State Dept. of Fisheries). Releases totaled 862, and recoveries, 76 (8.8%) (Table 3). Principal recovery Area was 3B (55; 72.4% of recoveries), followed by 2D (8; 10.5%), 2C (6; 7.9%), 3A (3; 3.9%), and 2B/1C (2 each; 2.6% each). Recoveries occurred throughout the year in the release Area, but movements southward occurred in the fall, and a return northward occurred in the spring (Pattie 1969).

2C

1959 (Fish Commission of Oregon). Recoveries occurred from 2C to 3B, but details were not provided (Pattie 1969). Movement occurred in both directions, but mostly northward.

1C

1938-58 (California Dept. of Fish and Game). Releases totaled 5,595, and recoveries, 771 (13.8%) (Table 3). Principal recovery Area was 1C (727; 94.3% of recoveries), followed by 1B (28; 3.6%), 2A (13; 1.7%), and 2B (3; 0.4%).

1B

1938-58 (California Dept. of Fish and Game). Releases totaled 3,355, and recoveries, 111 (3.3%) (Table 3). Principal recovery Area was 1B (75; 67.6% of recoveries), followed by 1C (35; 31.5%), and 2D (1; 0.9%).

1A

1963 (California Dept. of Fish and Game). Releases totaled 115, and recoveries, 9 (7.8%) (Jow, 1969, p. 19). Principal recovery Area was: 1A (8; 88.9%), followed by 1B (1; 11.1%) (Table 3).

Migration / Dispersion

Quasi-quantitative recovery rates (tags/100t landed) were determined for all fishing grounds where tags were recovered (Table 5). Approximate distance of recoveries from the tagging grounds was estimated using the centroid latitude

and longitude for each ground. The slope of the linear relationship of the natural logarithm of the recovery rate (tags/100t) on distance, 0.00412, is an estimate of the exponential "dispersion rate" southward from 1983-85 (Figure 3). The corresponding annual rate ($1-e^{-(0.0041/2.5)}$) was 0.00164, or 0.16%.

Recently a Bayesian analysis was completed on English sole taggings conducted south of British Columbia (Stewart 2007) to estimate the rate of English sole migration among areas. English sole migration rates were found to be 2% per month to the north and 4% per month to the south.

Subsequent analyses in this report will be limited to the 1983 tagging study.

Area/Time

Year

No recoveries were reported in 1987 (Table 4).

<u>5D releases</u>. From the 1983 releases, Area 5D recoveries totaled 191, with 37 in 1983; 127 in 1984; 25 in 1985; and 1 each in 1986 and 1988 (Table 4). Area 5C recoveries (4) occurred in 1983 (1) and 1984 (3). Area 5B recoveries (2) occurred in 1984 (1) and 1985 (1). Area 3Cn yielded a single recovery in 1988.

Landings from Area 5D, during 1983-88, comprised 76% (2,938 t) of the total from British Columbia waters, excluding landings from Areas 5E (negligible) and 4B (not relevant to recoveries) (Table 6). Area 3Cn had 9.3% of the BC landings, followed by 5C (7.8%), 5B (3.5%), 5A (2.1%), and 3D (1.1%). Among years, Area 5D proportions were 71-84%.

<u>5C releases</u>. Recoveries totaled seven in 5D, with six in 1984, and one in 1985 (Table 4). An additional recovery from the 5C releases lacked length, sex and area information (tag# 039259 in Appendix table 1). Landings from 5C accounted for 8% of the 1983-88 total, and 2-14% among years (Table 6).

Quarter-year

<u>5D releases</u>. Principal quarter-year for 5D recoveries of 191 tags was II (42%; 81 recoveries), followed by IV (21%; 40), III (19%; 36), and I (18%; 34) (Table 4). Qtr II recoveries predominated most years — 49% (62/127 in 1984; 60% (15/25) in 1985; and 100% (1/1) each in 1986 and 1988. Qtr IV had the most recoveries in 1983 at 89% (33/37).

The 1983-88 landings followed the same pattern (Table 6). Qtr II predominated overall, 46% (1340/2938 t), and was at least maximal among

years—65% (210/324) in 1983; 43% (261/605); in 1984; 57% (322/569) in 1985; 45% (145/320) in 1986; and 29% (175/601) in 1988. The higher recovery rate from Qtr IV in 1983 does not correspond with the 20% landings that year.

Principal quarter-year for other Area recoveries from 5CD releases was I for Area 5C (3/4), II (1/2) and III (1/2) for 5B, and IV (1/1) for 3Cn (Table 4). Principal quarter-year for landings from 5C was IV (44%; 133/300); from 5B, III (43%; 58/135); from 5A, II (40%; 35/80); 3D, II (49%; 21/43); and from 3Cn, III (40%; 144/360) (Table 6).

5C releases. The seven recoveries, all in Area 5D, occurred in Qtrs I (29%; 2) and II (71%; 5) (Table 4).

Ground

Recoveries totaled 148 (2.8%), from nine grounds (Table 7). Area 5D recoveries totaled 145, from six grounds. Principal recovery ground was Butterworth (44%; 64 recoveries), followed by White Rocks (33%; 48), Two Peaks (19%; 27), Shell (2.8%; 4), and Dundas (1.4%; 2) (Fig. 2). Although Butterworth accounted for 44% of the recoveries, it only accounted for 6% of the releases. Butterworth was also the principal recovery ground for all four release sites—58% (11/19) from Butterworth releases; 39% (40/102) from White Rocks; 45% (10/22) from Bonilla; and 60% (3/5) from West Horseshoe (Table 7). The three recoveries reported outside Area 5D were: a single Butterworth release recovered on Cape Flattery Spit (3Cn), and two White Rocks releases recovered, respectively on West Horseshoe (5C) and on Northwest Goose (5B).

Principal source of the 1983-85 landings from Area 5D was also Butterworth, 46%, compared to 40% from Two Peaks, and 10% from White Rocks (Table 8). No other ground accounted for more than 1%.

Butterworth releases (N = 301). Recoveries totaled 19 (6.3%)—all in Area 5D, except a single specimen recovered on Cape Flattery Spit (3Cn) (Table 7). Within Area 5D, proportions of recoveries were 61% (11) on Butterworth; 28% (5) on Two Peaks, and 11% (2) on White Rocks.

White Rocks releases (N = 2,770).   Recoveries totaled 102 (3.7%), all in Area 5D, except for one each on West Horseshoe (5C) and Northwest Goose (5B) (Table 7). Within Area 5D, proportions of recoveries were 40% (40) on Butterworth; 36% (36) on White Rocks; 20% (20) on Two Peaks; 3% (3) on Shell; and 1% (1) on Dundas.

Bonilla releases (N = 1,471). Recoveries totaled 22 (1.5%), all in Area 5D (Table 7). Proportions were 46% (10) on Butterworth; 41% (9) on White Rocks; and 4.5% (1) each on Dundas, Two Peaks, and Shell. The relatively low recovery rate may have been due in part to fishermen not always distinguishing between Bonilla and the adjacent White Rocks, or that their trawls traverse

portions of both grounds in a single haul. If either is true, the recovery rate for White Rocks was overestimated.

West Horseshoe (N = 834). Recoveries totaled five (0.6%), all in Area 5D (Table 7). Proportions were 60% (3) on Butterworth, and 20% (1) each on Two Peaks and White Rocks. The relatively low recovery rate may be due to relatively less fishing effort expended. Indeed, the Area 5C contribution to the landings within the "study area" (5D-3Cn, excluding 4B) was only 7.8% (Table 6).

Ground/Quarter-Year

Butterworth releases. Recoveries totaled 18 in Area 5D, and one in 3Cn (Table 7). Principal quarter-year of recovery in Area 5D was II (50%; 9 recoveries), followed by Qtr III (33%; 6), Qtr I (11%; 2); and IV (6%; 1). Among recovery grounds, principal quarter-year was II for Butterworth (6/11), III for Two Peaks (3/5), and II (1/1) and IV (1/1) for White Rocks. Outside Area 5D, one specimen was recovered on Cape Flattery Spit (3Cn), in Qtr IV.

Principal quarter-years, for the 1983-85 landings from Area 5D, were II for Butterworth (60%; 415/688 t) and Two Peaks (50%; 297/599 t), and I for White Rocks (42%; 64/154 t) (Table 8).

White Rocks releases. Recoveries totaled 102, 100 in Area 5D, and 1 each in 5C and 5B (Table 7). Principal quarter-year of recovery in Area 5D was II (36%), followed by IV (29%), III (18%), and I (17%). Among grounds in Area 5D, principal quarter-year was II for Two Peaks (10/20) and Butterworth (23/40), III for Dundas (1/1); and IV for White Rocks (22/36) and Shell (3/3). Outside Area 5D, single specimens were recovered on West Horseshoe (5C) in Qtr III, and on Northwest Goose (5B) in Qtr II.

Bonilla releases. Recoveries totaled 22, all in Area 5D (Table 7). Principal quarter-year of recovery was I (36%), followed by II (32%) and IV (32%). Among grounds, the principal quarter-year was II for Butterworth (7/10), IV for White Rocks (7/9), and I for Dundas (1/1), Two Peaks (1/1), and Shell (1/1).

West Horseshoe. Recoveries totaled five, all in Area 5D (Table 7). Principal quarter-year was II (60%), followed by I (40%) (Table 7). Among grounds, the principal quarter-year was II for Butterworth (2/3) and Two Peaks (1/1), and I for White Rocks (1/1).

Summary

Recoveries from the 1983 releases in Area 5D extended through 1988, but few after 1985, and none in 1987. Area 5C releases were only recovered in 1984 and 1985.

Among Areas, from British Columbia to California, recoveries occurred primarily in the release Area. Percentage of recoveries in the release Area ranged from 68% to 100%, except for the releases in 5C and 3Cn. Proportions were particularly high for 5D releases—97% for the 1983 study, and 99% for the three in 1945-52. The single recovery from the 23 released in Area 3D occurred in Area 3D. Other recoveries were generally southward of, and often substantial distances from, their release Area. All recoveries of 5C releases occurred in 5D, where landings were large, compared to those in 5C. Perhaps profitable concentrations of English sole were difficult to find in 5C, particularly during spring and summer. Distribution of recoveries from the Area 3Cn releases was 45% in the release Area, and 45% in adjacent 3B. Few fish were released, and perhaps profitable concentrations were difficult to find.

Principal quarter-year of recovery in Area 5D was II (42%), followed by Qtrs IV (21%), III (20%), and I (18%). Comparable values for Area 5C were II (71%), and I (29%). Recovery pattern did not follow that of landings, where Qtr II predominated.

Three grounds in Area 5D accounted for 96% of the recoveries—Butterworth (44%), White Rocks (33%), and Two Peaks (19%). Secondary grounds were Dundas (1%) and Shell (3%). Principal quarter-years of recovery were: II and III for Two Peaks and Butterworth; I and IV for White Rocks; I and III for Dundas; and IV for Shell. This seasonal, north-south oscillation was first reported by Ketchen (1950), and subsequently in more detail by Ketchen (1953, 1956) and Forrester (1967). The phenomenon was also reported for Area 3B (Pattie 1969).

MORTALITY RATE

Area 5D

1983-85. Analysis of recovered tags per tonne of landings was limited to releases, and subsequent recoveries, in Area 5D, because of negligible recoveries elsewhere (Table 3).

There was a linear relationship between tags per tonne of landings and eight consecutive quarter-years, from Qtr IV 1983 through Qtr III 1985 (Table 9; Fig. 4). Regression parameters were Y = 4.276 – 0.406X and r = -0.981. If Qtr IV 1983 were omitted, there would be little change (Y = 4.241-0.400X; r = -0.971). Estimated instantaneous total mortality rate was 0.41 (or 0.40).

1945-46. Ketchen (1947) reported total instantaneous rates, based on age-compositions (otoliths) of males and females sampled from commercial landings during spring 1945, and spring and summer 1946. The rates for males were 0.48 each for Butterworth Rocks and Triple Island, and 0.51 for Rose Spit.

Comparable values for females were 0.34, 0.32, and 0.42. Butterworth Rocks and Triple Island are now included in Butterworth Ground. Rose Spit lies southwest of Two Peaks Ground.

Area 4A

1950-52. Holland (1969) reported on the natural mortality rates for unfished stocks of English sole in central and south Puget Sound. Rates were based on age-frequency (otolith) samples collected from trawl catches of a research vessel. Our estimates of instantaneous natural mortality rate (M) were obtained from age-frequencies, converted to natural logarithms, for two of the four data sets in his Table 5—Golden Gardens (central) and Carr Inlet (south). Data sets for Port Madison (central) and Case Inlet (south) were of limited value. For Golden Gardens (age-classes 3-8), M was 0.50 for males, and 0.49 for females. Respective correlation coefficients were -0.926 and -0.871. For Carr Inlet, estimates of M, for age-classes 7-11, were 0.75 for males, and 0.56 for females. Respective correlation coefficients were -0.966 and -0.912. The author speculated that the unusual age distribution in Carr Inlet, might have been caused by increase in natural mortality rate with age, variation in year-class abundance, or age determination problems with older fish.

1953-56. Van Cleve and El-Sayed (1969) reported on the instantaneous mortality rates (M and F) for a stock of English sole in northern Puget Sound, in an area newly opened to trawling. Estimates were based on age-frequency (interopercle) samples collected from trawl catches of a research vessel. Their estimates were: Z = 0.57, F = 0.47, and M = 0.10.

Areas 2B-3B

Pikitch and Rogers (1989) cited Demory (1984) for estimates of natural mortality of commercially exploited English sole off the Oregon-Washington coast. The estimates were 0.26 each for males and females.

LENGTH FREQUENCIES

Released *vs* Recovered

The regressions for lengths at release and recovery are presented by sex in Figure 5. In general, smaller fish showed greater incremental growth compared to large fish, and females showed greater incremental growth than males. The largest growth increment for males (Figure 6) was 5 cm for a fish that was 32 cm at the time of release and at large for 2 years. The largest growth increment for females was 12 cm for a fish that was 27 cm at the time of release and at large for just over a year.

Total (Area 5D). Length-frequency distributions differed substantially between releases (N = 4,583), recoveries (223), and samples from commercial landings (5,853) (Table 10; Fig. 7). Modal lengths were 30 cm for releases, 33 cm for recoveries, and 37 cm for the sample from commercial landings. Corresponding mean lengths were 32.7 cm (S.D. = 4.2), 34.5 cm (4.1), and 36.9 cm (4.1). Mean length of recoveries was significantly larger than that of releases (t = -5.920; P < 0.01), but significantly smaller than that of the commercial sample (t = -7.723; P <0.01) (Table 11). After binning tag releases and recoveries within 3-cm length intervals, recovery rates were zero at 22 cm; rose to a peak of 9.3% at 41 cm; declined to 5.8% at 44 cm; and was zero thereafter.   Recovery rates were at least 5.8% from each of the 35 to 44 cm length bins which together encompassed 77% of the numbers in the commercial samples (Table 10).

By Ground (Areas 5D+5C). Length-frequency distributions of releases were multi-modal for all four grounds (Table 12). Principal modes were at 35 cm for Butterworth, 30 cm for White Rocks and Bonilla, and 33 cm for West Horseshoe. Recoveries' distributions were bi-modal for Butterworth and White Rocks, uni-modal for Bonilla, and indeterminate for West Horseshoe (too few recoveries). Principal modes were at 35 and 38 cm for Butterworth, 31 cm for White Rocks, and 33 cm for Bonilla. Mean length of recoveries was significantly larger than releases for Butterworth (37.2 *vs* 35.5 cm), White Rocks (33.8 *vs* 32.3 cm), and Bonilla (34.5 *vs* 32.8 cm) (Table 11). *t* values ranged from -2.228 to -4.111, probabilities were <0.01 to <0.05 (Table 11). Mean lengths for West Horseshoe were not significantly different (34.7 *vs* 34.4 cm; t = 0.176; P >0.50). However, only eight recoveries were reported.

With respect to the commercial samples, mean lengths of recoveries were significantly smaller for White Rocks (33.8 *vs* 36.9 cm) and Bonilla (34.5 *vs* 36.9 cm), but not significantly different for Butterworth (37.2 *vs* 36.9) and West Horseshoe (34.4 *vs* 36.9 cm) (Table 11). Values of *t* were -9.003 (P<0.01) for White Rocks, -3.507 (<0.01) for Bonilla, 0.426 (>0.50) for Butterworth, and -1.723 (>0.05) for West Horseshoe.

Principal middle length of, and recovery rates for, 3-cm length intervals, were 32-41 cm (8.7-17.4%) for Butterworth (Table 12). For the same size range, recovery rates were 6.0-9.3% for White Rocks, 3.0-4.0% for Bonilla, and 0-1.7% for West Horseshoe.

Released *vs* Recovered, by Sex (Area 5D)

 Landings. The 1983-85 length-frequency samples of English sole landed from Area 5D totaled 5,853 specimens—1,493 (26%) males, and 4,360 females (Table 13). Mean lengths were 34.2 and 37.9 cm, respectively, and both distributions were uni-modal— 33 cm for males, and 37 cm for females. Obviously, female mean lengths were significantly larger, based on previous tests. Among years, percent males increased from 13% in 1983 to 34% in 1985,

while mean lengths of males declined from 35.8 cm in 1983 to 33.6 cm in 1985. Female mean lengths also declined, from 39.6 cm in 1983 to 36.2 cm in 1985. Perhaps, one or more strong year classes passed though the fishery.

The 1945-46 length-frequency samples involved English sole landed from three grounds in Area 5D--Triple Island (September 1945, July 1946); Two Peaks (June 1945, January 1946); and Rose Spit (June 1945 and 1946) (Ketchen 1947, 1953). Mean lengths of sampled males from the 1945 and 1946 landings were: 34 and 32 cm at Triple Island; 38 and 31 cm at Two Peaks; and 37 and 34 cm at Rose Spit. Comparable values for females were: 38 and 38 cm; 42 and 34 cm; and 41 and 39 cm. The smaller mean lengths in January 1946 perhaps reflect the southward migration of larger (mature?) members to the spawning ground(s).

Among middle lengths of 3-cm length intervals for 1983-85, percent males rose from 0% at 23 cm to 67.5% at 29 cm, then declined steadily to 0.8% at 44 cm, and to 0% thereafter (Table 13). Among years, percentage males was reasonably consistent--52-56% at 32 cm, 26-34% at 35 cm, 12-19% at 38 cm, 4-7% at 41 cm, and 0-2% at 44 cm. The single exception was at 29 cm, where the values were 25, 69, and 68%, respectively for 1983, 1984, and 1985.

The 1945-46 sex ratios on Triple Island were 11% males in September 1945, and 39% in July 1946 (Ketchen 1947, 1953). Values on Two Peaks were 22% in June 1945, and 41% in January 1946, and on Rose Spit, 19% in June 1945, and 26% in June 1946. The low value in September 1945 might be due to the departure of larger males for spawning, but the high value in January 1946 is not readily explained.

Recoveries. Length-frequencies, by sex, totaled 178—57 (32%) males and 121 females (Table 14). Both length-frequencies were multi-modal. Prominent modes were 30 and 34 cm for males, and 33 cm for females. Mean length of females was significantly larger than that of males (35.6 *vs* 33.0 cm; t = -4.394; P <0.01). Among 3-cm length intervals, the percent males was 33.3 at 26 cm; increased to 66.7 at 29 cm; then declined to 0 at 44 cm.

Releases. Based on the sex ratios among grouped length intervals of the commercial samples, the overall sex ratio was 46.5% males, significantly larger (X^2 = 16.3; P <0.01), than that for recoveries (32.0%) (Table 15). Both length-frequencies were uni-modal, 29cm for males, and 32 cm for females. Mean length of males (30.9 cm) was evidently significantly smaller than that of females (34.2 cm), based on previous tests.

Estimated recovery rate by sex. Overall recovery rates were 2.7% for males, and 4.9% for females (Table 15). Among 3-cm length intervals, male recovery rates increased from 0.6% at 26 cm to 25.0% at 44 cm, but were zero thereafter. The peak rate appeared to be anomalous—3 of 12 released. Female recovery rates increased from 1.7% at 26 cm to 9.8% at 41; declined to 3.5% at

44; and were zero thereafter. Recovery rates were 5% or higher from 35 to 41 cm for males, and from 32 to 41 cm for females.

LOW RECOVERY RATE

Recovery rate was relatively low, compared to other English sole tagging studies off British Columbia, where tagging occurred in all Areas, except 5E (Table 3).   Numbers released ranged from 23 (Area 3D) to 14,100 (4B). Recovery rates ranged from 4.3% for releases in Area 3D (N = 23) to 36.5% for releases in 5D (N = 6,727).

Factors

Seven potential factors were considered which might inhibit recovery rate. They were: (1) relative importance of commercial landings among Areas; (2) numbers released; (3) percent males among releases; (4) proportions of other species in the catches of the tagging vessel; (5) proportions of particular species in the catches; (6) length frequencies of English sole at release; and (7) length frequencies by sex at release.

Commercial Landings

Among areas, recovery rates generally varied directly with commercial landings. During 1983-88, landings of English sole totaled 2,938 t in Area 5D, compared to 300 t in 5C, 135 t in 5B, 80 t in 5A, 43 t in 3D, and 360 t in 3Cn (Table 6). Numbers released in 1983 totaled 4,452 in Area 5D, and 834 in 5C (Table 3). Area 5D accounted for 96.5% of the recoveries released in that Area, and all the recoveries released in 5C. Other proportions of recoveries from 5D-releases were 2.0% in 5C, 1.0% in 5B, 0.5% in 3Cn, and none in 5A or 3D (Table 3).

Within Area 5D, Butterworth accounted for 44% of all recoveries, and 46% of the landings (Tables 7 and 8). However, the same relationship did not apply for the other two principal grounds, Two Peaks and White Rocks. Two Peaks accounted for 19% of the recoveries, but 40% of the landings, while White Rocks accounted for 33% of the recoveries, and 10% of the landings. The Two Peaks "inconsistency" may be due in part to the fishermen "blending" the two adjacent grounds, Dundas and Butterworth. A similar situation is suspected for White Rocks and adjacent Bonilla.

Numbers Released

The 24 hauls which produced releases yielded no significant relationship between recovery rate and numbers released.   Overall, neither the correlation (0.057) nor the slope (-0.001) differed significantly from zero (Fig. 8; Table 16).

Similarly, among release sites, neither correlations (0.625-0.763) nor slopes (-0.011 to +0.049) differed significantly from zero.

Percent Males

The 20 hauls which yielded recoveries yielded no significant relationship between the recovery rate and percent males among recoveries (Fig. 9; Table 16). Overall, neither correlation (0.092) nor slope (-0.011) differed significantly from zero. Similarly, among release sites, neither correlations (0.269-0.968) nor slopes (-0.089 to +0.043) differed significantly from zero.

Percent Principal Species

A limited relationship was noted. Overall, the 24 hauls yielded no significant relationship between recovery rate and percent principal species in the total catch of the tagging vessel (Fig. 10: Table 16). Overall, neither correlation (0.035) nor slope (0.009) differed significantly from zero. However, among release sites, correlations ranged from 0.154 (West Horseshoe) to 0.975 (Butterworth), and the Butterworth correlation differed significantly from zero (P >0.05). Slopes ranged from -0.241 (Butterworth) to +0.013 (West Horseshoe), and only that for Butterworth differed significantly from zero.

Principal Species

A limited relationship was noted. Eight species were designated "principal" in one or more hauls, but only two involved more than three hauls-- arrowtooth flounder (8 hauls) and spiny dogfish (6) (Figs. 11 and 12: Table 16). Neither correlations (0.166 and 0.435) nor slopes (-0.039 and -0.211) differed significantly from zero. Of some interest was the relationship with spiny dogfish on West Horseshoe, particularly Hauls 6 and 7. There, the two recovery rates were zero, and spiny dogfish accounted for 30.8 and 36.0% of the catch, compared to 1.9-13.0% for the remaining four hauls (Table 17).

Length Frequencies

Area 5D. Size composition was an obvious factor affecting recovery rates. Overall, mean lengths of both releases and recoveries (at release) were smaller than those sampled from commercial landings. Modal length was 30 cm for released fish, 33 cm for all recoveries, and 37 cm for samples from commercial landings (Table 10). Corresponding mean lengths were 32.7, 34.5, and 36.9 cm. Both release and recovery values were significantly smaller than those from commercial landings (Table 11).

Among release sites, length-frequencies of releases were consistently, and significantly, smaller than those of recoveries, but only Butterworth recovery length-frequency did not differ significantly from that of the commercial sample

(Tables 10-12). Principal modal lengths of recoveries were 35 cm for Butterworth, 31 and 33 cm for White Rocks, plus 32-33 and 36 for Bonilla. Corresponding mean lengths were 37.2, 33.8, and 34.5 cm. Since most of the recoveries occur in the processing plants, the chances are poor that undersized tagged fish would be recovered at sea before discard. However, even within the major size range of commercial samples (31-42 cm) recovery rates were higher for Butterworth fish (8.7-17.4%) than for White Rocks (6.0-9.3%) or Bonilla (3.0-4.0%).

Area 5C (West Horseshoe). Mean length of releases was 34.7 cm, not significantly different from that for the eight recoveries, at release (33.8 cm), but significantly smaller than that for commercial samples from Area 5D (36.9 cm) (Table 11). Few commercial landings, and associated samples, precluded comparisons with length-frequencies.

Length-Frequencies by Sex

Estimated sex ratio of released fish was 46.5% males, and significantly larger (X^2 = 16.3; P <0.01) than that for recoveries (32.0%), based on numbers of specimens in each category (Table 15). Overall recovery rates were 2.7% for males, and 4.9% for females.

Among 3-cm length intervals, estimated sex ratio of releases increased from 58.2% males at 26 cm to 67.5% at 29 cm; then declined steadily to 0% at 47 and 50 cm (Table 15). Recovery rates of males increased from 0.6% at 26 cm to 25.0% at 41 cm even though only 12 were released; and was zero thereafter. Comparable rates for females increased from 1.7% at 26 cm, to 9.8 at 41 cm; then declined to zero at 47 and 50 cm.

Summary

Five of the seven factors considered to inhibit recovery rate were deemed to be at least partially relevant, *viz.*, commercial landings, percent principal species (Butterworth only), principal species (special case for spiny dogfish in two hauls on West Horseshoe), length-frequencies, and length-frequencies by sex. No relationship was evident for numbers of tagged fish released, or percent males among recoveries.

SUMMARY AND DISCUSSION

During June 9-18, 1983, in Hecate Strait (Areas 5D+5C), 5,433 English sole were tagged, and 5,376 released, on four trawling grounds—three in Area 5D (Butterworth, White Rocks, and Bonilla), and one in Area 5C (West Horseshoe).   The purpose of the project was to validate a new method of age determination. Tagged specimens were injected with oxytetracycline prior to release, to provide a "time mark". Results have been published by Fargo *et al*

(1984). The current report deals with by-products of the tagging study, *viz.*, tagging mortality, recovery rate, migration, and mortality rate, as well as comparisons with comparable studies elsewhere (Table 17).

Tagged specimens were captured by trawl, whose haul duration ranged from 15 to 30 minutes, with a mean of 21 min. (S.E. = 1.2 min.). Each acceptable specimen was tagged, fork length was measured to the nearest centimeter, and the fish was then placed in a holding tank that was hinged to the vessel's rail. Sex was not recorded, nor was an anesthetic applied. Upon completion of tagging, moribund specimens (if any) were removed, and the tank was tilted to discharge its contents into the sea.

Recoveries totaled 227 (4.2%), a relatively low return compared to earlier taggings off British Columbia. Recoveries began in 1983, the last recovery occurred in 1988. No recovery was reported in 1987. Among the four tagging grounds, recovery rates (from known grounds) were 6.3% for Butterworth (301 released), 3.7% for White Rocks (2,770), 1.5% for Bonilla (1,471), and 0.8% for West Horseshoe (834).

During the 1944-60 period, 22,859 English sole were tagged (Petersen disc) and released off British Columbia (Forrester 1967) (Table 3). Through 1964, recovery rate was 26.4%.   Releases in Hecate Strait totaled 8,353, and recovery rate was 31.8%.

Estimated, immediate tagging mortality in the 1983 study was 42%, based on a 24-h hold aboard the tagging vessel. A more elaborate experiment, in 1952, involved tagged (Petersen disc) and untagged specimens held in an outdoor pond for three months. Estimated annual tagging mortalities were 32% for males, and 34% for females.

Migrations from release Areas were extensive, but involved few recoveries in the 1983 study (the annual rate of dispersion was only 0.16%), as well as in others earlier in Area 5D and elsewhere, from British Columbia to California. In the current study, principal quarter-year of recovery in 5D was II (42%), followed by Qtrs IV (21%), III (19%), and I (18%). Comparable values in Area 5C were II (71%) and I (29%). Commercial landings followed a similar pattern.

Within Area 5D, recoveries from the 1983 releases were reported from six grounds, but three accounted for 96% of the recoveries-- Butterworth (44%), White Rocks (33%), and Two Peaks (19%). Principal quarter-years were II for Butterworth, II and III for Two Peaks, and I and IV for White Rocks. These suggested a southward movement in fall, and a northward movement in spring. Similar results were reported for earlier studies in Hecate Strait and off Washington State.

Estimated instantaneous total mortality rate (Z; sexes combined) was 0.41 (or 0.40), based on the linear regression of the natural logarithm of recovered tags per tonne of landing for Qtr IV 1983 through Qtr III 1985 (or Qtr I 1984 through Qtr III 1985). Analysis was limited to releases, and subsequent recoveries in Area 5D, because of negligible recoveries elsewhere. For the same Area, estimates were 0.48-0.51 for males, and 0.32-0.42 for females, based on age compositions (otoliths) of commercial landings during 1945-46. In Puget Sound (4A), estimates of Z were obtained, in the early 1950s, in the north, central and south sectors, based on age-frequencies (interopercles or otoliths) from trawl catches of research vessels. In north Puget Sound, Z was 0.57 (F = 0.47; M = 0.10), in an area newly opened to trawling. In central Puget Sound, on an unfished stock, Z (actually M) was 0.50 for males, and 0.49 for females. In south Puget Sound, also on an unfished stock, Z was 0.75 for males, and 0.56 for females. Off Washington and Oregon, M was estimated to be 0.26 for each sex.

Area-5D length-frequency distributions (sexes combined), differed significantly between releases, recoveries, and samples from commercial landings. Modal lengths were 30 cm for releases, 33 cm for recoveries, and 37 for samples from commercial landings. Mean length of recoveries was significantly larger than that of releases, but significantly smaller than that of commercial samples. Among the three release grounds, mean lengths of recoveries were also significantly larger than those of releases. However, only Butterworth mean length was not significantly different from that of the commercial sample.

Male and female length-frequencies of commercial samples were both uni-modal. Male modal length was smaller, and male mean length was significantly smaller. Overall, sex ratio was 26% males. Among 3-cm intervals, sex ratio peaked at 67.5% (28-30 cm), then declined to zero at 46-56 cm. Similar results were found for samples collected in 1945-46.

Male and female length-frequencies of releases were estimated on the basis of the sex ratio within 3-cm intervals of the commercial samples. Principal male modes were at 30 and 34 cm, and for females, 33 cm. Male mean length was evidently significantly smaller than that of females. Overall sex ratio was 32% males (Table 14). Among intervals, percent males peaked at 28-30 cm (66.7%), then declined to zero at 43-45 cm.

Overall, estimated recovery rate for males was 2.7%, and for females, 4.9% (Table 15). Male rates peaked at 43-45 cm (25.0%), but were zero thereafter. Female rates peaked at 40-42 cm (9.8%), then declined to zero, at 46-51 cm.

Recovery rate was relatively low, compared to other English sole tagging studies off the coast of British Columbia. Seven potential factors were considered which might have inhibited the recovery rate: (1) relative importance

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of commercial landings from Areas; (2) numbers released; (3) percent males among releases; (4) proportions of other species in the catches of the tagging vessel; (5) proportions of particular species in the catches; (6) length-frequencies of English sole at release; and (7) length-frequencies by sex at release.

No relationship was evident for numbers released, percent males among releases, or proportions of other species in the catches. Principal species exhibited a minor, and negative, relationship, involving a relatively high proportion of spiny dogfish in two hauls, which yielded no recoveries. Length-frequencies exhibited a definite relationship overall, and for the three release grounds in Area 5D. Overall, mean lengths of recoveries were significantly larger than those for releases, and both were significantly smaller than those for samples of commercial landings from Area 5D. Within Area 5D, this pattern was evident for White Rocks and Bonilla grounds, but not for Butterworth. In the latter case, mean length of Butterworth recoveries was not significantly different from that of the commercial sample. However, Butterworth recovery rates were even relatively higher within the principal length intervals of the commercial sample. Frequencies by sex, for Area 5D, yielded sex ratios significantly larger for releases than for recoveries, and both were larger than that of the commercial sample. The lower recovery rate for males was due to their slower growth, and resulting lesser numbers achieving commercial size.

The importance of size composition at release is understandable. The original purpose of the tagging study was to validate age determination, and for this purpose a broad size (age) range was essential.

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Table 1. General results of tagging English sole in Hecate Strait, June 9-18, 1983. (Source: Fargo *et al* 1984; Appendix table 1)

Category	Nos.	%
Tagged	5433	
Released[a]	5376	100.0
Total Recoveries[b]	227	4.2
Known Time:		
Year	216	4.0
Month	215	4.0
Known Location;		
Area	205	3.8
Ground	148	2.8
FL at release	205[c]	3.8

[a] The authors reported that an additional 57 died in the recovery tank, prior to release.
[b] Excluding one recovery whose tag number was recorded incorrectly at recovery. See Appendix table
[c] Tag no. 040170 (Haul 8, June 11): FL and sex recorded at recovery, but FL not recorded at release. See Appendix table 1.

Table 2. Numbers of releases and recoveries, by haul, and sex ratio (% males) of recoveries, for English sole tagged in Hecate Strait, June 9-18, 1983. (Fargo *et al* 1984, Appendix table 3; PBS Groundfish database GFBIO; Appendix table 1)

Haul	Dur. (hr)	Area	Grnd[a]	Releases (nos.)	Recoveries (nos.)	(%)	M	M+F	%M
1	0.33	5C	WH	169	5	3.0	0	4	0
2	0.33	5C	WH	142	1	0.7	1	1	100
3	0.30	5C	WH	138	0				
4	0.33	5C	WH	134	0				
5	0.33	5C	WH	57	0				
6	0.50	5C	WH	156	2	1.3	2	2	100
7	0.47	5C	WH	38	0				
8	0.50	5D	Bo	595	22	3.7	8	20	40.0
9	0.50	5D	Bo	576	11	1.9	3	10	30.0
10	0.33	5D	WR	449	26	5.8	8	24	33.0
11	0.33	5D	WR	162	21	13.0	4	19	21.1
12	0.33	5D	WR	236	10	4.2	1	10	10.0
13	0.33	5D	WR	178	16	9.0	3	14	21.4
14	0.33	5D	WR	0					
15	0.33	5D	WR	106	5	4.7	0	4	0
16	0.50	5D	Bu	58	6	10.3	1	4	25.0
17	0.25	5D	Bu	142	21	14.8	9	21	42.9
18	0.25	5D	Bu	15	1	6.7	1	1	100
19	0.25	5D	Bu	86	7	8.1	4	7	57.1
20	0.33	5D	WR	203	3	1.5	1	3	33.3
21	0.33	5D	WR	214	2	0.9	0	2	0
22	0.33	5D	WR	132	5	3.8	1	5	20.0
23	0.33	5D	WR	756	43	5.7	15	40	37.5
24	0.33	5D	WR	334	16	4.8	0	11	0
25	0.33	5D	Bo	300	4	1.3	0	4	0
26	0.42	5D	Bo	0					
Total	24[b]			5376	227	4.2	62	206	30.1
Mean	0.35								
S.D.	0.08								
S.E.	0.02								
Max	**0.50**								
Min	**0.25**								

[a] tagging ground (Bo – Bonilla, Bu – Butterworth, WH – West Horseshoe, WR – White Rocks)
[b] total number of sets where fish were tagged

Table 3. Numbers recovered, by recovery, and tagging, location, of English sole tagged in Hecate Strait (Areas 5D+5C), June 9-18, 1983 (Source: Appendix table 1), and elsewhere on the west coast of North America.

| | Releases | | | | | | | | | Recoveries | | | | | | | | | | | | Total | |
Area	Year	N	6	5D	5C	5B	5A	4B	4A	3D	3Cn	3B	3A	2D	2C	2B	2A	1C	1B	(nos.)	(%)
5D	45-52[a]	6727	1	2437	6	4	6	0	0	1	0	3	0	0	0	0	0	0	0	2458	36.5
	%		0.04	99.1	0.2	0.2	0.2	0	0	0.04	0	0.1	0	0	0	0	0	0	0	100.0	
	1983	4542	0	191	4	2	0	0	0	0	1	0	0	0	0	0	0	0	0	198	4.4
	%		0	96.5	2.0	1.0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	100.0	
5C	1983	834	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.8
	%		0	100.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0	
5B	52-54[b]	1877	0	5	0	167	18	0	0	1	3	5	0	1	0	1	0	1	0	202	10.8
	%		0	2.5	0	82.7	8.9	0	0	0.5	1.5	2.5	0	0.5	0	0.5	0	0.5	0	100.0	
4B	44-60[c]	14100	0	0	0	0	0	3309	103	0	1	6	0	4	0	0	0	1	0	3381	24.0
	%		0	0	0	0	0	97.9	3.0	0	0.03	0.2	0	0.1	0	0	0	0.03	0	100.0	
3D	1945[d]	23	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	4.3
	%		0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100.0	
3Cn	1945[e]	132	0	0	0	0	0	0	0	0	13	13	1	1	1	0	0	0	0	29	22.0
	%		0	0	0	0	0	0	0	0	44.8	44.8	3.4	3.4	3.4	0	0	0	0	100.0	
3B	1956[f]	862	0	0	0	0	0	0	0	0	0	55	3	8	6	2	0	2	0	76	8.8
	%		0	0	0	0	0	0	0	0	0	72.4	3.9	10.5	7.9	2.6	0	2.6	0.0	100.0	
2C	1959[g]	See text																				
1C	38-58[n]	5595	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	727	28	771	13.8
	%		0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	1.7	94.3	3.6	100.0	

Area	Releases Year	N	Recoveries 6	5D	5C	5B	5A	4B	4A	3D	3Cn	3B	3A	2D	2C	2B	2A	1C	1B	Total (nos.)	(%)
1B	38-58[h]	3355	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	35	75	111	3.3
	%		0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	31.5	67.6	100.0	
1A	1963[i]	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	9	7.8
	%		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.1	88.9	100.0	

[a] Forrester 1967 (Fig. 4)
[b] Ibid. (Fig. 5)
[c] Ibid. (Table 2, Fig. 7, and text)
[d] Ibid. (p. 7)
[e] Ibid. (Fig. 6)
[f] Pattie 1969 (Fig. 3)
[g] Ibid. (p. 14)
[h] Jow 1969 (Tables 2-11)
[i] Ibid. (p. 19)

Table 4. Numbers of recoveries, by Area, year, and quarter-year, of tagged English sole released in Areas 5D and 5C (Hecate Strait), June 9-18, 1983. (Source: Appendix table 1)

Year	Quarter	Recovery Area						Total	
		5D	5C	5B	5A	3D	3Cn	(nos)	(%)
1983	II	2	0	0	0	0	0	2	5.3
	III	2	1	0	0	0	0	3	7.9
	IV	33	0	0	0	0	0	33	86.8
	Total	37	1	0	0	0	0	38	100.0
1984	I	27	3	0	0	0	0	30	22.9
	II	62	0	1	0	0	0	63	48.1
	III	31	0	0	0	0	0	31	23.7
	IV	7	0	0	0	0	0	7	5.3
	Total	127	3	1	0	0	0	131	100.0
1985	I	7	0	0	0	0	0	7	26.9
	II	15	0	0	0	0	0	15	57.7
	III	3	0	1	0	0	0	4	15.4
	IV	0	0	0	0	0	0	0	0
	Total	25	0	1	0	0	0	26	100.0
1986	I	0	0	0	0	0	0	0	0
	II	1	0	0	0	0	0	1	100
	III	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0
	Total	1	0	0	0	0	0	1	100.0
1987	I-IV	0	0	0	0	0	0	0	0
1988	I	0	0	0	0	0	0	0	0
	II	1	0	0	0	0	0	1	50.0
	III	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	1	1	50.0
	Total	1	0	0	0	0	1	2	100.0
Total	I	34	3	0	0	0	0	37	18.7
	II	81	0	1	0	0	0	82	41.4
	III	36	1	1	0	0	0	38	19.2
	IV	40	0	0	0	0	1	41	20.7
	Total	191	4	2	0	0	1	198	100.0
	%	96.5	2.0	1.0	0	0	0.5	100.0	
1983	II-IV	0	0	0	0	0	0	0	0
1984	I	2	0	0	0	0	0	2	33.3
	II	4	0	0	0	0	0	4	66.7
	III-IV	0	0	0	0	0	0	0	0

Year	Quarter	Recovery Area						Total	
		5D	5C	5B	5A	3D	3Cn	(nos)	(%)
	Total	6	0	0	0	0	0	6	100.0
1985	I	0	0	0	0	0	0	0	0
	II	1	0	0	0	0	0	1	100.0

Year	Quarter	Recovery Area						Total	
		5D	5C	5B	5A	3D	3Cn	(nos)	(%)
	III-IV	0	0	0	0	0	0	0	0
	Total	1	0	0	0	0	0	1	100.0
1986-88	I-IV	0	0	0	0	0	0	0	0
Total	I	2	0	0	0	0	0	2	28.6
	II	5	0	0	0	0	0	5	71.4
	III	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0
	Total	7	0	0	0	0	0	7	100.0
	%	100	0	0	0	0	0	100	
1983-88	I	36	3	0	0	0	0	39	19.1
	II	86	0	1	0	0	0	87	42.6
	III	36	1	1	0	0	0	38	18.6
	IV	40	0	0	0	0	1	41	20.1
	Total	198	4	2	0	0	1	205	100.0
	%	96.6	2.0	1.0	0	0	0.5	100.0	

Table 5. Distance values used in the estimation of dispersion of English sole from the June 1983 5D+5C tagging areas by ground for 1983-85.

Year	Landings[a]							
	CFS	NWG	WH	Sh	WR	Bu	TP	Du
1983	41	9	23	7	56	116	211	0
1984	82	7	38	3	69	194	296	8
1985	61	17	2	2	29	377	92	3
Total (83-85)	184	33	64	13	154	688	599	11
tags recovered	1	1	1	4	48	64	27	2
distance (km)	756	228	141	257	9	84	72	108
tags/100t)	0.543	3.030	1.563	31.250	31.209	9.306	4.507	17.699
ln(tags/100t)	-0.610	1.109	0.446	3.442	3.441	2.231	1.506	2.874

[a] Ground: Bu = Butterworth (5D); CFS = Cape Flattery Spit (3Cn); Du = Dundas (3D); NWG = Northwest Goose (5B); Sh = Shell (5D); TP = Two Peaks (5D); WH = West Horseshoe (5C); WR = White Rocks (5D)

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Table 6. Landings (t), by year, quarter-year, and Area, of English sole, 1983-88. (Source: PBS Groundfish database PacHarv).

Year	Quarter	Area						Total	
		5D	5C	5B	5A	3D	3Cn	(t)	%
1983	II	210	8	2	2	2	17	241	57.8
	III	48	1	4	6	2	16	77	18.5
	IV	66	20	3	2	0.2	8	99	23.8
	Total	324	29	9	10	4	41	417	100
	%	77.7	7	2.2	2.4	1	9.8	100	
1984	I	113	3	0	0.4	1	5	122	16
	II	261	13	2	4	2	21	303	39.7
	III	178	9	4	3	1	43	238	31.2
	IV	53	28	1	3	2	13	100	13.1
	Total	605	53	7	10	6	82	763	100
	%	79.3	6.9	0.9	1.4	0.8	10.7	100	
1985	I	91	7	0.1	1	2	6	107	15.9
	II	322	4	2	5	2	22	357	53
	III	130	2	9	1	0.03	24	166	24.6
	IV	26	3	6	0.48	0	9	44	6.6
	Total	569	16	17	7	4	61	674	100
	%	84.4	2.4	2.5	1.1	0.6	9.1	100	
1986	I	99	2	0	1	1	1	104	24.4
	II	145	3	9	3	1	34	195	45.7
	III	54	0	5	3	4	14	80	18.7
	IV	22	8	11	2	0.1	5	48	11.3
	Total	320	13	25	9	6	54	427	100
	%	74.9	3	5.9	2.1	1.4	12.6	100	
1987	I	81	17	0.003	1	0.1	1	100	13.6
	II	227	19	12	11	1	30	300	40.9
	III	120	13	9	9	1	24	176	24
	IV	91	53	1	5	1	7	158	21.5
	Total	519	102	22	26	3	62	734	100
	%	70.7	13.9	3	3.5	0.4	8.4	100	
1988	I	168	13	1	2	0.48	8	192	22.9
	II	175	16	12	10	13	19	245	29.2
	III	170	37	27	2	5	23	264	31.5
	IV	88	21	15	3	1	10	138	16.4
	Total	601	87	55	17	19	60	839	100
	%	71.6	10.4	6.6	2	2.3	7.2	100	
								(t)	%
Total	I	552	42	1	5	5	21	626	16.2
	II	1340	63	39	35	21	143	1641	42.6
	III	700	62	58	24	13	144	1001	26
	IV	346	133	37	15	4	52	588	15.2
	Total	2938	300	135	80	43	360	3856	100
	%	76.2	7.8	3.5	2.1	1.1	9.3	100	
1945-64	Mean[a]	1297	25	22	20	3	45	1412	
		91.9	1.8	1.6	1.4	0.2	3.2	100	

[a] 1000s of lbs. Forrester 1967, Table 1

Table 7. Numbers of recoveries, by release and recovery ground, and quarter-year, for tagged English sole released in Hecate Strait, June 9-18, 1983. (Source: Appendix table 1).

Releases Ground	N	Qtr	Total	Du	TP	Bu 5D	WR	Bo	Sh	Total (nos.)	Total (%)	WH 5C	NWG 5B	CFS 3Cn
Butterworth	301	I	2	0	0	2	0	0	0	2	11.1	0	0	0
(Bu)	-5.60%	II	9	0	2	6	1	0	0	9	50	0	0	0
		III	6	0	3	3	0	0	0	6	33.3	0	0	0
		IV	2	0	0	0	1	0	0	1	5.6	0	0	1
		Total	19	0	5	11	2	0	0	18	100	0	0	1
		%	6.3	0	27.8	61.1	11.1	0	0	100				
White Rocks	2770	I	17	0	0	6	11	0	0	17	17	0	0	0
(WR)	-51.50%	II	37	0	10	23	3	0	0	36	36	0	1	0
		III	19	1	9	8	0	0	0	18	18	1	0	0
		IV	29	0	1	3	22	0	3	29	29	0	0	0
		Total	102	1	20	40	36	0	3	100	100	1	1	0
		%	3.7	1	20	40	36	0	3	100				
Bonilla	1471	I	8	1	1	3	2	0	1	8	36.4	0	0	0
(Bo)	-27.40%	II	7	0	0	7	0	0	0	7	31.8	0	0	0
		III	0	0	0	0	0	0	0	0	0	0	0	0
		IV	7	0	0	0	7	0	0	7	31.8	0	0	0
		Total	22	1	1	10	9	0	1	22	100	0	0	0
		%	1.5	4.5	4.5	45.5	40.9	0	4.5	100				
W. Horseshoe	834	I	2	0	0	1	1	0	0	2	40	0	0	0
(WH)	-15.50%	II	3	0	1	2	0	0	0	3	60	0	0	0
		III	0	0	0	0	0	0	0	0	0	0	0	0
		IV	0	0	0	0	0	0	0	0	0	0	0	0
		Total	5	0	1	3	1	0	0	5	100	0	0	0
		%	0.6	0	20	60	20	0	0	100				

Recoveries[a]

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Table 7 (contd.)

Release		Qtr	Total	Du	TP	Bu	WR	Bo	Sh	Total (nos.)	(%)	WH 5C	NWG 5B	CFS 3Cn
							5D							
Total	5376	I	29	1	1	12	14	0	1	29	20	0	0	0
	-													
	100.00%	II	56	0	13	38	4	0	0	55	37.9	0	1	0
		III	25	1	12	11	0	0	0	24	16.6	1	0	0
		IV	38	0	1	3	30	0	3	37	25.5	0	0	1
		Total	148	2	27	64	48	0	4	145	100	1	1	1
		%	2.8	1.4	18.6	44.1	33.1	0	2.8	100				

[a] Ground: Bo = Bonilla (5D); Bu = Butterworth (5D); CFS = Cape Flattery Spit (3Cn); Du = Dundas (3D); NWG = Northwest Goose (5B); Sh = Shell (5D); TP = Two Peaks (5D); WH = West Horseshoe (5C); WR = White Rocks (5D)

Table 8. Landings (t) of English sole, by year, quarter-year, and ground, from Area 5D (Hecate Strait), 1983-85. (Source: PBS Groundfish database PacHarv).

Year	Qtr	Ground[a]									
		Du	TP	Bu	WR	Bo	Sh	Other[b]	Total	%	Unk
1983	I	0	20.7	27.8	18.3	0	0	2.0	68.8	17.3	0
	II	0	129.6	62.8	17.4	0.3	3.0	3.0	216.1	54.4	4.0
	III	0.4	31.4	11.4	1.9	0	0	0.9	46.0	11.6	1.7
	IV	0	29.1	14.4	18.0	0	4.3	0.3	66.1	16.6	0
	T	0.4	210.8	116.4	55.6	0.3	7.3	6.2	397.0	100.0	5.7
	%	0.1	53.1	29.3	14.0	0.1	1.8	1.6	100.0		
1984	I	0	29.1	46.1	27.3	0.1	2.5	1.6	106.7	18.5	6.2
	II	1.6	135.3	95.1	12.5	0	0.6	4.0	249.1	43.1	11.8
	III	6.4	114.9	51.7	4.7	0	0	0.9	178.6	30.9	0
	IV	0	17.0	1.0	24.6	0	0	0.4	43.0	7.4	3.5
	T	8	296.3	193.9	69.1	0.1	3.1	6.9	577.4	100.0	21.5
	%	1.4	51.3	33.6	12.0	0.0	0.5	1.2	100.0		
1985	I	0	24.8	45.5	18.6	0.1	1.0	1.1	91.1	17.9	0
	II	1.2	31.7	257	3.8	0.9	0	0	294.6	57.7	27.5
	III	1.6	24.5	66.7	0.04	0	1.3	4.2	98.34	19.3	31.8
	IV	0.1	11.0	8.2	6.7	0	0.1	0.1	26.2	5.1	0
	T	2.9	92	377.4	29.1	1.0	2.4	5.4	510.2	100.0	59.3
	%	0.6	18.0	74.0	5.7	0.2	0.5	1.1	100.0		
Total	I	0	74.6	119.4	64.2	0.2	3.5	4.7	266.6	18.0	6.2
	II	2.8	296.6	414.9	33.7	1.2	3.6	7.0	759.8	51.2	43.3
	III	8.4	170.8	129.8	6.64	0	1.3	6.0	322.9	21.8	33.5
	IV	0.1	57.1	23.6	49.3	0	4.4	0.8	135.3	9.1	3.5
	T	11.3	599.1	687.7	153.8	1.4	12.8	18.5	1484.6	100.0	86.5
	%	0.8	40.4	46.3	10.4	0.1	0.9	1.2	100.0		

[a] Ground: Bo = Bonilla; Bu = Butterworth; Du = Dundas; Sh = Shell; TP = Two Peaks
[b] Other: Fingers; McIntyre Bay; Oval Hill; West Masset; Zayas Island

Table 9. Recovery numbers, landings, plus recovery rates (recoveries per 100 tonnes landed) by year, quarter-year, and Area, of tagged English sole released in Area 5D, June 9-18, 1983. Recoveries span 1983-88, with no recoveries in Areas 5A and 3D (Source: Tables 4 and 5).

Year	Qtr	Area 5D (rec)(R)	5D (land)(t)	5D (R/100t)	5C (rec)(R)	5C (land)(t)	5C (R/100t)	5B (rec)(R)	5B (land)(t)	5B (R/100t)	5A (land)(t)	3D (land)(t)	3Cn (rec)(R)	3Cn (land)(t)	3Cn (R/100t)
1983	II	2	210	1.0	0	8	0		2		2	2		17	
	III	2	48	4.2	1	1	100.0		4		6	2		16	
	IV	33	66	50.0	0	20	0		3		2	0.2		8	
	Total	37	324	11.4	1	29	3.4	0	9	0	10	4	0	41	0
1984	I	27	113	23.9	3	3	100.0	0	0	0	0.4	1		5	
	II	62	261	23.8	0	13	0	1	2	50.0	4	2		21	
	III	31	178	17.4	0	9	0	0	4	0	3	1		43	
	IV	7	53	13.2	0	28	0	0	1	0	3	2		13	
	Total	127	605	21.0	3	53	5.7	1	7	14.3	10	6	0	82	0
1985	I	7	91	7.7		7		0	0.1	0	1	2		6	
	II	15	322	4.7		4		0	2	0	5	2		22	
	III	3	130	2.3		2		1	9	11.1	1	0.03		24	
	IV	0	26	0		3		0	6	0	0.48	0		9	
	Total	25	569	4.4	0	16	0	1	17	5.8	7	4	0	61	0
1986	I	0	99	0		2			0		1	1		1	
	II	1	145	0.7		3			9		3	1		34	
	III	0	54	0		0			5		3	4		14	
	IV	0	22	0		8			11		2	0.1		5	
	Total	1	320	0.3	0	13	0	0	25	0	9	6	0	54	0
1987	I		81			17			0.00		1	0.1		1	
	II		227			19			12		11	1		30	
	III		120			13			9		9	1		24	
	IV		91			53			1		5	1		7	
	Total	0	519	0	0	102	0	0	22	0	26	3	0	62	0

Table 9 (contd.)

Year	Qtr	5D (rec) (R)	5D (land) (t)	5D (R/100t)	5C (rec) (R)	5C (land) (t)	5C (R/100t)	5B (rec) (R)	5B (land) (t)	5B (R/100t)	5A (land) (t)	3D (land) (t)	3Cn (rec) (R)	3Cn (land) (t)	3Cn (R/100t)
1988	I	0	168	0		13			1		2	0.48	0	8	0
	II	1	175	0.6		16			12		10	13	0	19	0
	III	0	170	0		37			27		2	5	0	23	0
	IV	0	88	0		21			15		3	1	1	10	10.0
	Total	1	601	0.2	0	87	0	0	55	0	17	19	1	60	1.7
Total	I	35	552	6.3	3	42	7.1	0	1	0.0	5	5	0	21	0
	II	80	1340	6.0	0	63	0.0	1	39	2.6	35	21	0	143	0.0
	III	36	700	5.1	1	62	1.6	1	58	1.7	24	13	0	144	0.0
	IV	38	346	11.0	0	133	0.0	0	37	0.0	15	4	1	52	1.9
	Total	189	2939	6.4	4	300	1.3	2	135	1.5	80	43	1	360	0.3

Table 10. Length-frequencies of English sole in Area 5D: releases, recoveries, and samples from commercial landings, 1983-85. (Source: Fargo *et al* 1984, Appendix table 4; Appendix tables 1-4)

Fork length (cm)	Releases (nos.)	(%)	Recoveries (nos.)	(%)	% rec	Landings (nos.)	(%)
22	…	…	…	…		1	0.0
23	…	…	…	…	0	3	0.1
24	1	0.0	…	…		0	0
25	20	0.4	…	…		3	0.1
26	71	1.5	2	0.9	1.4	2	0.0
27	188	4.1	2	0.9		7	0.1
28	334	7.3	5	2.2		10	0.2
29	417	9.1	10	4.5	2.1	31	0.5
30	<u>577</u>	<u>12.6</u>	13	5.8		125	2.1
31	530	11.6	22	9.9		204	3.5
32	446	9.7	22	9.9	5.3	357	6.1
33	392	8.6	<u>28</u>	12.6		443	7.6
34	307	6.7	19	8.5		552	9.4
35	270	5.9	20	9.0	7.1	565	9.7
36	228	5.0	18	8.1		563	9.6
37	202	4.4	14	6.3		<u>589</u>	<u>10.1</u>
38	161	3.5	13	5.8	7.8	525	9.0
39	86	1.9	8	3.6		449	7.7
40	102	2.2	9	4.0		418	7.1
41	75	1.6	5	2.2	9.7	267	4.6
42	49	1.1	8	3.6		196	3.3
43	41	0.9	3	1.3		152	2.6
44	27	0.6	1	0.4	5.8	138	2.4
45	18	0.4	1	0.4		74	1.3
46	12	0.3	…	…		58	1.0
47	7	0.2	…	…	0	44	0.8
48	13	0.3	…	…		21	0.4
49	5	0.1	…	…		18	0.3
50	4	0.1	…	…	0	17	0.3
51	…	…	…	…		10	0.2
52-56	…	…	…	…		11	0.2
Total	4583	100.0	223	100.0	4.9	5853	100.0
Mean	32.7		34.5			36.9	
S.D.	4.2		4.1			4.1	
S.E.	0.06		0.32			0.67	

Table 11. *t* tests of mean-length differences for length-frequencies of English sole in Hecate Strait: releases vs recoveries; recoveries vs commercial samples. (Source: Tables 9 and 11; Dixon & Massey 1969, p. 116)

Param.	Rel	Rec	Rec	Com
		All Release Grounds		
N	4583	223	223	5853
Mean	32.7	34.4	34.4	36.9
S.D.	4.2	3.9	3.9	4.1
t	-5.92		-7.723	
Df	4804		6016	
P	<0.01		<0.01	
		Butterworth		
N	346	34	34	5853
Mean	35.5	37.2	37.2	36.9
S.D.	4.3	3.5	3.5	4.1
t	-2.228		0.426	
Df	378		5885	
P	<0.05		>0.50	
		White Rocks		
N	2767	145	145	5853
Mean	32.3	33.8	33.8	36.9
S.D.	4.3	3.9	3.9	4.1
t	-4.111		-9.003	
Df	2910		5996	
P	<0.01		<0.01	
		Bonilla		
N	1470	36	36	5853
Mean	32.8	34.5	34.5	36.9
S.D.	3.7	2.7	2.7	4.1
t	-2.737		-3.507	
Df	1504		5887	
P	<0.01		<0.01	
		West Horseshoe		
N	834	8	8	5853
Mean	34.7	34.4	34.4	36.9
S.D.	4.8	3.9	3.9	4.1
t	0.176		-1.723	
Df	840		5859	
P	>0.50		>0.05	

Table 12. Length-frequencies (nos.), by ground, of releases and recoveries (length at release), for tagged English sole in the Hecate Strait study, 1983-88. (Sources: Fargo *et al* 1984, Appendix table 4; Appendix table 1)

Fork length (cm)	Butterworth			White Rocks			Bonilla			West Horseshoe		
	rel	rec	%rec	rel	rec	%rec	rel	rec	%rec	Rel	rec	%rec
24	…	…		…	…		1	…	0	…	…	0
25	…	…		15	…		5	…		1	…	
26	2	…	0	62	2	1.4	7	…	0	9	…	0
27	7	…		139	2		42	…		25	…	
28	10	…		257	5		67	…		25	…	
29	7	…	0	293	9	2.8	117	…	0.3	49	1	0.7
30	17	…		369	12		191	1		67	0	
31	20	1		331	17		179	3		66	1	
32	25	2	8.7	261	13	6.0	160	6	3.0	65	1	1.5
33	24	3		210	18		158	6		72	1	
34	35	2		156	13		116	2		56	2	
35	42	5	9.3	120	10	8.3	108	4	4.0	65	1	1.7
36	20	2		108	9		100	7		57	0	
37	32	3		94	8		76	3		55	0	
38	26	4	12.3	92	7	8.6	43	2	3.8	50	0	0
39	15	2		57	6		14	0		32	0	
40	21	2		58	6		23	1		40	0	
41	17	3	17.4	39	2	9.3	19	0	3.2	23	0	1.3
42	8	3		21	3		20	1		13	1	
43	7	2		25	1		9	…		15	…	
44	3	…	20.0	20	1	20.0	4	…	0.0	13	…	0
45	0	…		15	1		3	…		14	…	
46	2	…		9	…		1	…		9	…	
47	1	…	0	3	…	0	3	…	0	7	…	0
48	4	…		6	…		3	…		4	…	
49	1	…		4	…		0	…		0	…	
50	…	…	0	3	…	0	1	…	0	0	…	0
51	…	…		…	…		…	…		2	…	
Total	346	34	9.8	2767	145	5.2	1470	36	2.4	834	8	1.0
Mean	35.5	37.2		32.3	33.8		32.8	34.5		34.7	34.4	
S.D.	4.3	3.5		4.3	3.9		3.7	2.7		4.8	3.4	

Table 13. Length-frequencies (nos.), by year and sex, of English sole in commercial trawl-landing samples from Area 5D, 1983-85. (Source: Appendix tables 2-4)

Fork length (cm)	1983 M	1983 F	1983 %M	1984 M	1984 F	1984 %M	1985 M	1985 F	1985 %M	Total M	Total F	Total %M
22	...	...		...	...		...	1		0	1	
23	...	...	0	...	...	0	...	3	0	0	3	0
24	...	...		...	...		...	0		0	0	
25	...	...		...	...		1	2		1	2	
26	...	...	0	...	...	0	0	2	58.3	0	2	58.3
27	...	...		...	...		6	1		6	1	
28	0	1		0	0		5	4		5	5	
29	0	0	25.0	4	1	69.2	14	12	68.4	18	13	67.5
30	1	2		14	7		74	27		89	36	
31	6	4		25	10		79	80		110	94	
32	13	16	54.8	54	34	56.5	140	100	51.7	207	150	53.2
33	27	18		69	70		121	138		217	226	
34	27	51		57	97		128	192		212	340	
35	23	78	26.0	65	113	32.7	102	184	34.1	190	375	32.2
36	28	93		44	132		67	199		139	424	
37	22	138		42	147		60	180		124	465	
38	20	130	12.2	21	158	16.3	31	165	19.2	72	453	16.1
39	16	151		23	138		16	105		55	394	
40	10	158		10	142		8	90		28	390	
41	3	108	4.1	3	93	5.1	2	58	7.1	8	259	5.1
42	2	88		3	64		4	35		9	187	
43	3	73		0	50		0	26		3	149	
44	0	74	1.6	0	45	0.0	0	19	0.0	0	138	0.8
45	0	32		0	24		0	18		0	74	
46	...	35		...	15		...	8		...	58	
47	...	21	0	...	14	0	...	9	0	...	44	0
48	...	11		...	8		...	2		...	21	
49	...	11		...	4		...	3		...	18	
50	...	8	0	...	2	0	...	7	0	...	17	0
51	...	5		...	5		...	0		...	10	
52	...	3		...	1		...	2		...	6	
53	...	1	0	...	2	0	...	...	0	...	3	0
54	...	0		...	...		...	...		...	0	
55	...	1		...	...		...	...		...	1	
56	...	1	0	...	...	0	...	...	0	...	1	0
Total	201	1312	13.3	434	1376	24.0	858	1672	33.9	1493	4360	25.5
Mean	35.8	39.6		34.6	38.2		33.6	36.2		34.2	37.9	
S.D.	2.7	3.8		2.6	3.7		2.6	3.7		2.7	4.0	
.E.	0.19	0.11		0.32	0.37		0.09	0.09		0.07	0.06	

Table 14. Length-frequencies (nos.) of recoveries (length at release), by sex, for tagged English sole released and recovered in Area 5D (Hecate Strait), June 11-18, 1983.

Fork length (cm)	Males	Females	Total	% males
26	1		1	33.3
27	0	2	2	
28	0	1	1	
29	4	3	7	66.7
30	8	2	10	
31	7	12	19	
32	7	5	12	39.6
33	7	15	22	
34	8	11	19	
35	6	13	19	30.8
36	2	12	14	
37	2	7	9	
38	0	4	4	16.0
39	2	10	12	
40	3	10	13	
41	0	4	4	12.5
42	0	7	7	
43	0	1	1	
44	0	1	1	0
45	0	1	1	
Total	57	121	178	32.0
Mean	33.0	35.6		
S.D.	3.1	3.9		
S.E.	0.54	0.65		
t [a]		-4.394		
Df		176		
P		<0.01		

[a] Dixon and Massey (1969, p. 116)

Table 15. Estimated length-frequencies, by sex, of 5D releases, and length-frequencies, by sex, of resulting 5D recoveries, for English sole in the Hecate Strait study, June 11-18, 1983. (Sources listed below).

Fork length[a] (cm)	Total[b]	M/T[c]	Released M	F	%M		Recovered Numbers[d] M	F	Percent M	F
26	280	0.583	163	117	58.2		1	2	0.6	1.7
29	1328	0.675	896	432	67.5		12	6	1.3	1.4
32	1368	0.532	728	640	53.2		21	32	2.9	5
35	805	0.322	259	546	32.2		16	36	6.2	6.6
38	449	0.161	72	377	16		4	21	5.5	5.6
41	226	0.051	12	214	5.3		3	21	25	9.8
44	86	0.008	1	85	1.2		0	3	0	3.5
47	32	0	0	32	0		0	0	nil	0
50	9	0	0	9	0		0	0	nil	0
Total	4583		2131	2452	46.5	Obs	57	121	2.7	4.9
%M			46.5				32			
Mean			30.9	34.2	34.2	Exp	82.4	95.6		
S.D.			2.9	4.7	4.7					
						$X^{2\,e}$		16.3		
						Df		1		
						P		<0.01		

[a] Mid-lengths of 3-cm intervals: 26 = 25-27, etc.
[b] Source: Table 9
[c] Source: Table 12
[d] Source: Table 13
[e] Dixon & Massey (1969, p. 238)

Table 16. Parameters for correlations, and regressions, of percent recoveries on selected factors, by ground or principal species, for English sole tagged and released in Hecate Strait, June 9-18, 1983. (Source: Tables 2 and 17).

Relationship	Parameters					
	N	r	P[a]	a	b	b$_{.95}$
% Recovered on Nos. released						
All	24	0.057	<0.01	4.695	-0.001	-0.011/+0.008
Butterworth	4	0.763	<0.01	6.541	0.049	-0.078/+0.176
White Rocks	7	0.642	<0.01	9.525	-0.011	-0.025/+0.004
Bonilla	6	0.654	<0.01	1.097	0.006	-0.004/+0.015
W. Horseshoe	7	0.625	<0.01	-0.926	0.014	-0.006/+0.033
% Recovered on % Males						
All	20	0.092	<0.01	5.658	-0.011	-0.070/+0.048
Butterwotth	4	0.883	<0.01	15.022	-0.089	-0.234/+0.055
White Rocks	7	0.269	<0.01	7.308	-0.063	-0.325/+0/198
Bonilla	6	0.379	<0.01	2.343	0.043	-0.104/+0.191
W. Horseshoe	3	0.968	<0.01	3.000	-0.020	-0.086/+0.046
% Recovered on % Principal Species						
All	24	0.035	<0.01	4.288	0.009	-0.099/+0.117
Butterwotth	4	0.975	>0.05	19.004	-0.241	-0.409/-0.074
White Rocks	7	0.294	<0.01	7.099	-0.059	-0.241/+0.214
Bonilla	6	0.307	<0.01	4.000	-0.123	-0.218/+0.108
W. Horseshoe	7	0.154	<0.01	0.988	0.013	-0.083/+0.109
% Recovered on Principal Species						
Arrowtooth flounder	8	0.166	<0.01	7.612	-0.039	-0.270/+0.192
Pacific cod	1	nil		nil	nil	
Pacific halibut	2	nil		nil	nil	
Pacific sanddab	2	nil		nil	nil	
Rex sole	3	nil		nil	nil	
Skates	1	nil		nil	nil	
Speckled sanddab	1	nil		nil	nil	
Spiny dogfish	6	0.435	<0.01	8.738	-0.211	-0.816/+0.394

[a] Snedecor (1946, Table 7.3). Df = N - 2.

Table 17. R/V G.B. REED catch data, and tagging results, by haul and ground, for the English sole tagging study in Hecate Strait, June 9-18, 1983. (Source: Fargo *et al* 1984, Appendix tables 1 and 3; Appendix table 1).

Haul	Grnd[a]	Catch (kg)						Tagging (nos.)		
		Total	English		Principal species[c]			rel	rec	% rec
		(kg)	(kg)	(%T)	Species[d]	(kg)	(%T)			
16	Bu	1205	409	33.9	Arrowtooth flounder	409	33.9	58	6	10.3
17	Bu	194	55	28.4	Skates	36	18.6	142	21	14.8
18	Bu	476	Tr	0.0	Arrowtooth flounder	228	47.9	15	1	6.7
19	Bu	222	9	4.1	Arrowtooth flounder	109	49.1	86	7	8.1
4		2097	473	22.6		782	37.3	301	35	11.6
10	WR	448	228	50.9	Spiny dogfish	68	15.2	449	26	5.8
11	WR	308	127	41.2	Spiny dogfish	64	20.8	162	21	13.0
12	WR	441	102	23.1	Pacific halibut	271	61.5	236	10	4.2
13	WR	250	75	30.0	Arrowtooth flounder[e]	75	30.0	178	16	9.0
15	WR	199	18	9.0	Arrowtooth flounder	91	45.7	106	5	4.7
20	WR	259	68	26.3	Pacific halibut	55	21.2	203	3	1.5
21	WR	331	89	26.9	Arrowtooth flounder	148	44.7	214	2	0.9
22	WR	286	55	19.2	Arrowtooth flounder	109	38.1	132	5	3.8
23	WR	635	445	70.1	Arrowtooth flounder[f]	64	10.1	756	43	5.7
24	WR	331	223	67.4	Spiny dogfish	32	9.7	334	16	4.8
10		3488	1430	41.0		977	28.0	2770	147	5.3
8	Bo	469	364	77.6	Rex sole	46	9.8	595	22	3.7
9	Bo	381	232	60.9	Spiny dogfish	58	15.2	576	11	1.9
25	Bo	231	136	58.9	Speckled sandab	23	10.0	300	4	1.3
3		1081	732	67.7		127	11.7	1471	37	2.5
1	WH	143	109	76.2	Pacific sandab[g]	9	6.3	169	5	3.0
2	WH	272	191	70.2	Pacific sandab[f]	27	9.9	142	1	0.7
3	WH	178	91	51.1	Rex sole	36	20.2	138	2	1.4
4	WH	163	95	58.3	Rex sole	48	29.4	134	0	0
5	WH	227	45	19.8	Pacific cod	132	58.1	57	2	3.5
6	WH	266	82	30.8	Spiny dogfish	82	30.8	156	0	0
7	WH	189	45	23.8	Spiny dogfish	68	36.0	38	0	0
7		1438	658	45.8		402	28.0	834	10	1.2

Table 17 (contd.)

Haul	Grnd[a]	Catch (kg)						Tagging (nos.)		
		Total	English		Principal species[c]			rel	rec	% rec
		(kg)	(kg)	(%T)	Species[d]	(kg)	(%T)			
24		8104	3293	40.6		2288	28.2	5376	229	4.3
14	WR	588	Tr	0.0	Pacific halibut	225	38.3	0		nil
26	Bo	1392	546	39.2	Arrowtooth flounder	409	29.4	0		nil

[a] Ground: Bo = Bonilla; Bu = Butterworth; WH = West Horseshoe; WR = White Rocks
[b] Beginning and ending of haul.
[c] Most important, or second to English sole. If more than one species, see footnote.
[d] Species: (in parentheses, as listed in tagging report): Arrowtooth flounder, *Atheresthes stomias* (turbot); Pacific cod, *Gadus macrocephalus*; Pacific halibut, *Hippoglossus stenolepis* (halibut); Pacific sanddab, *Citharichthys sordidus* (dab (Pacific)); Rex sole, *Glyptocephalus zachirus*; Skates, Rajidae; Speckled sanddab, *C. stigmaeus* (dab (speckled)); Spiny dogfish, *Squalus acanthias* (dogfish).
[e] Also spiny dogfish
[f] Also walleye pollock (*Theragra chalcogramma*) and rex sole
[g] Also Pacific cod
[h] Also flathead sole (*Hippoglossoides elassodon*) and rex sole

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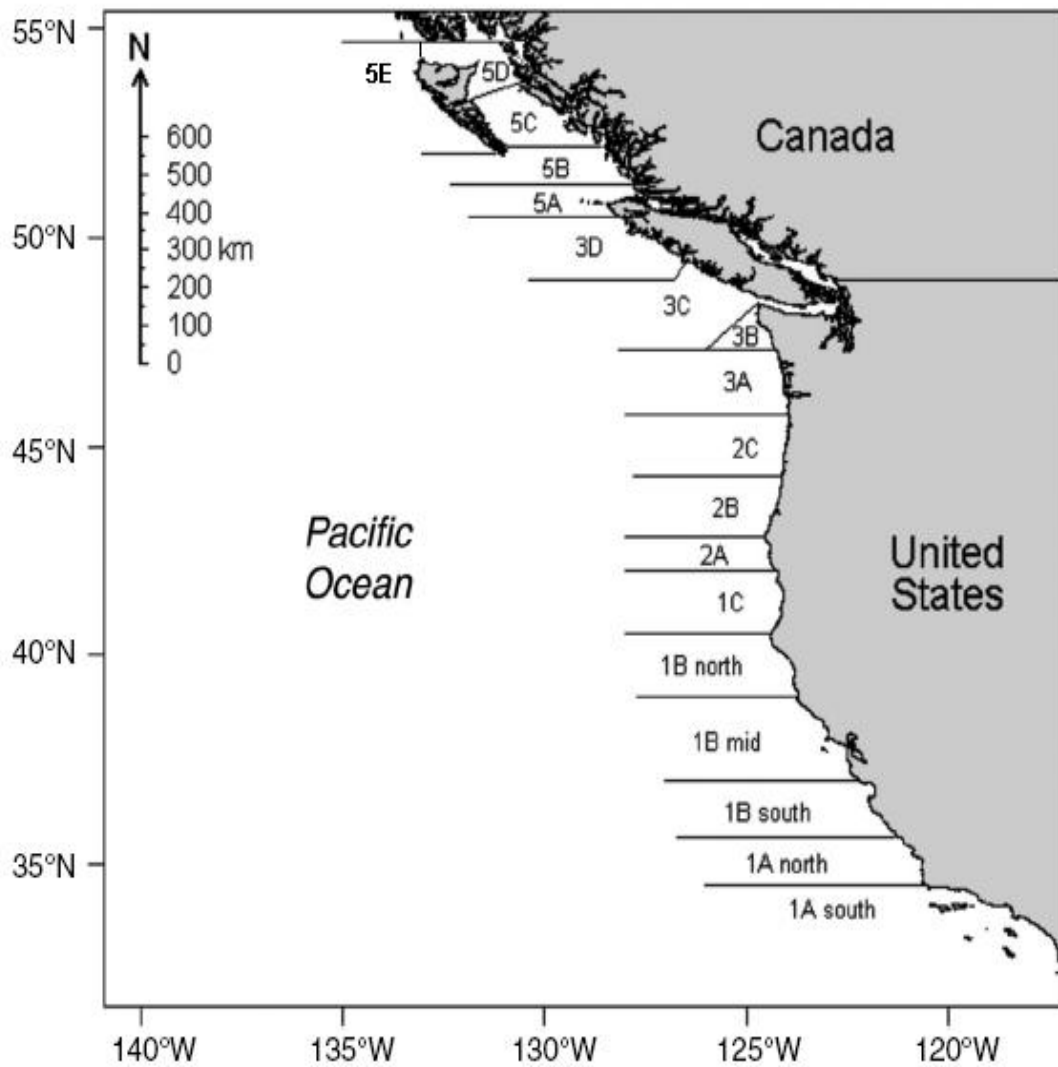
Figure 1. International groundfish statistical areas, British Columbia to California
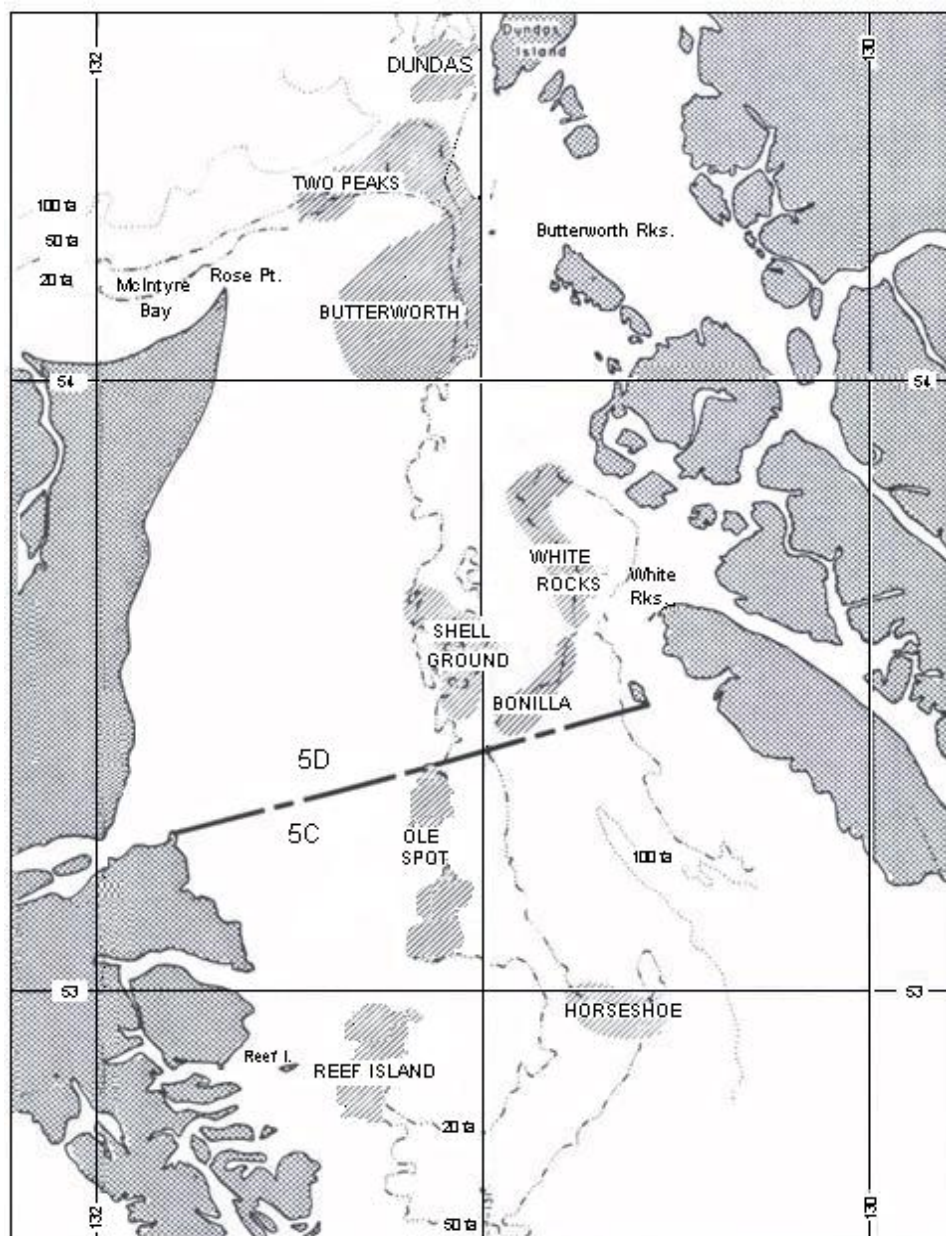
Figure 2. Principal trawling grounds in Hecate Strait (Areas 5C+5D)
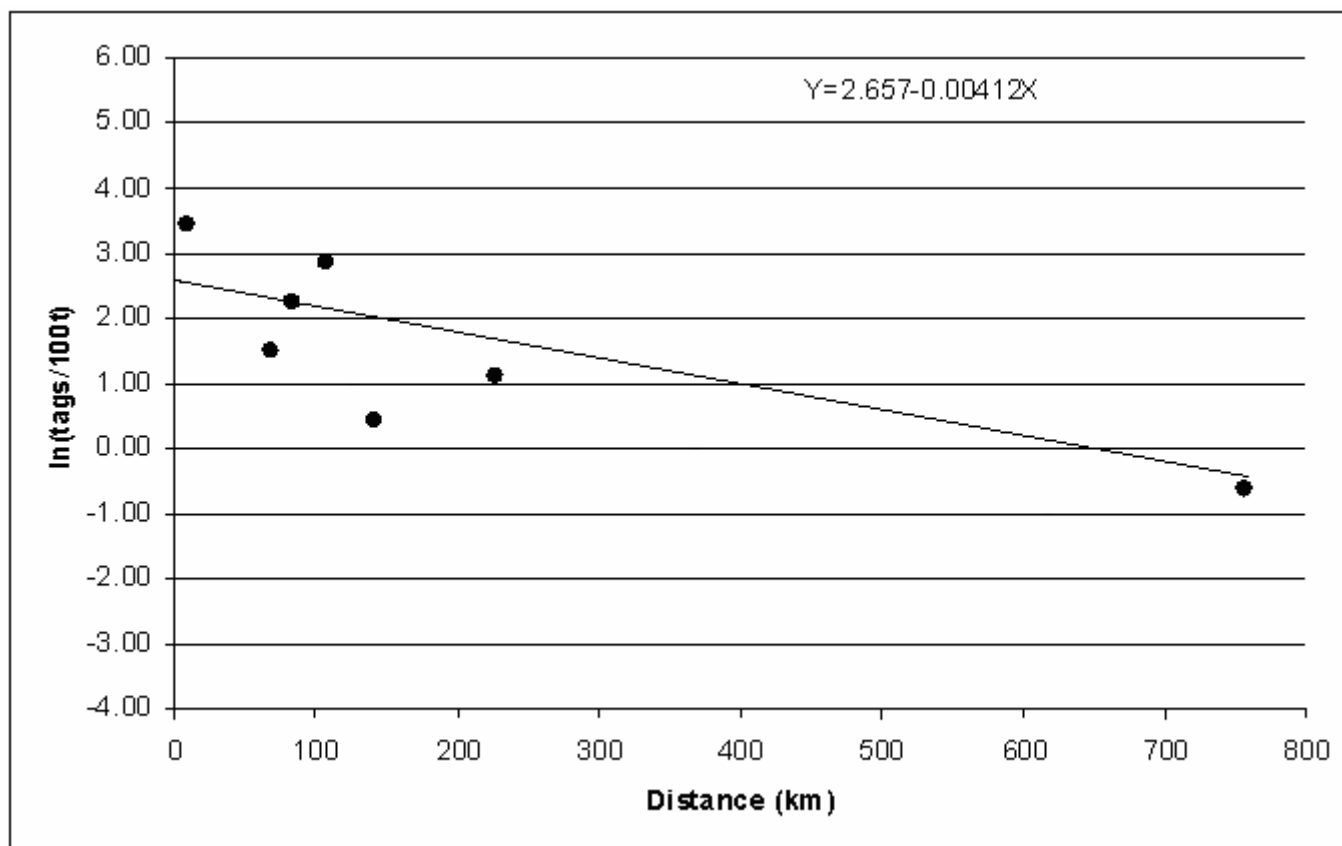
Figure 3. Regression of ln(tags/100t) on distance (km) from the tagging location for English sole captured during 1983-85.

$Y_{IV-III} = 4.276 - 0.406$
$r = 0.981$

$Y_{I-III} = 4.293 - 0.396$
$r = 0.967$

Year	Qtr	T/100t	Ln T/100t
1983	IV	50.0	3.912
1984	I	23.9	3.174
	II	23.8	3.168
	III	17.4	2.857
	IV	13.2	2.581
1985	I	7.7	2.040
	II	4.7	1.539
	III	2.3	0.836

y-axis: ln(tags recovered per 100 tonnes of landings)

x-axis (Year quarter): IV I II III IV I II III
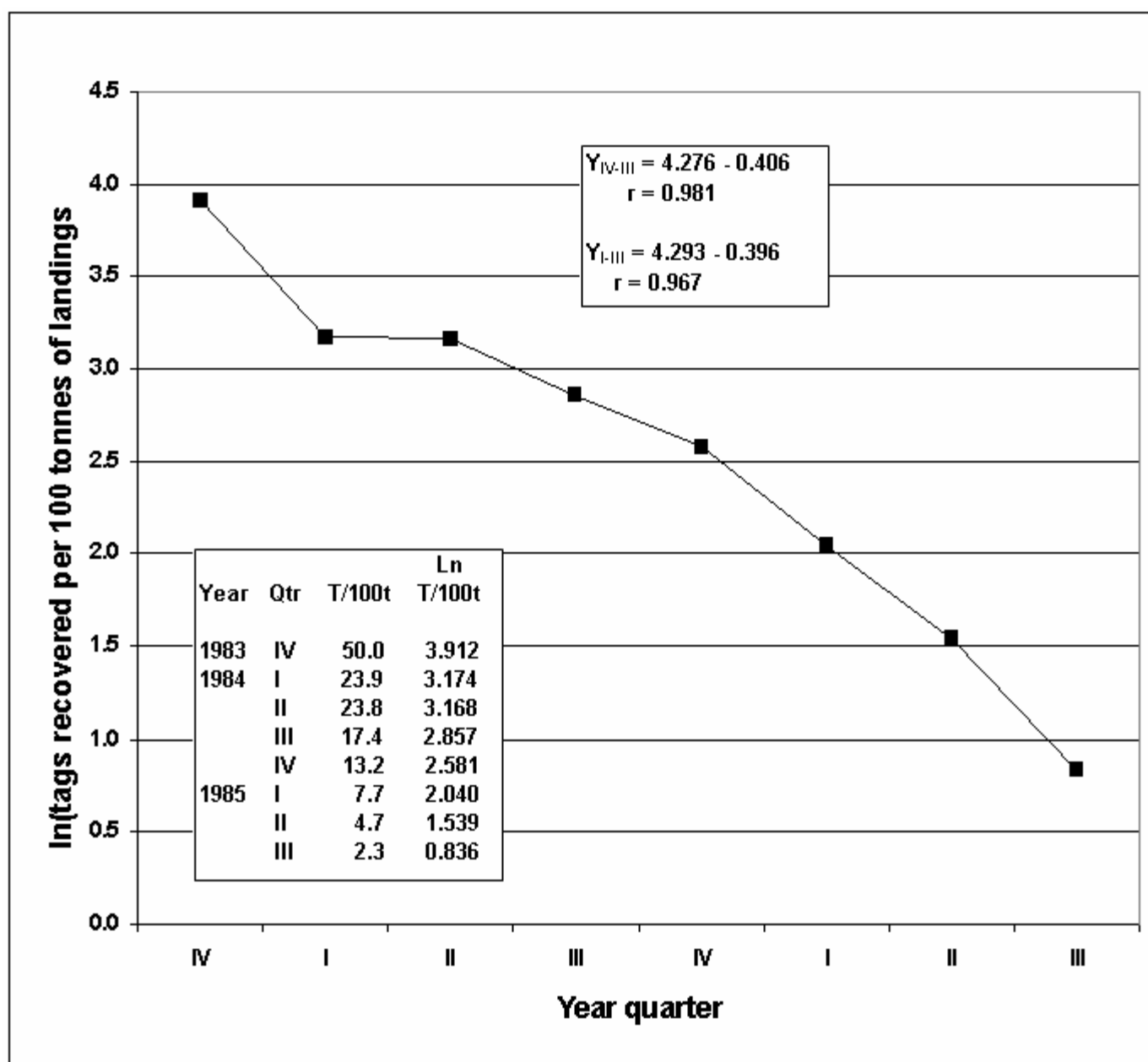
Figure 4. Logarithms of recoveries (T) per 100 tonnes (t) of landing, by quarter-year, for tagged English sole released and recovered in Area 5D, 1983-88. (Source: Tables 4, 6).
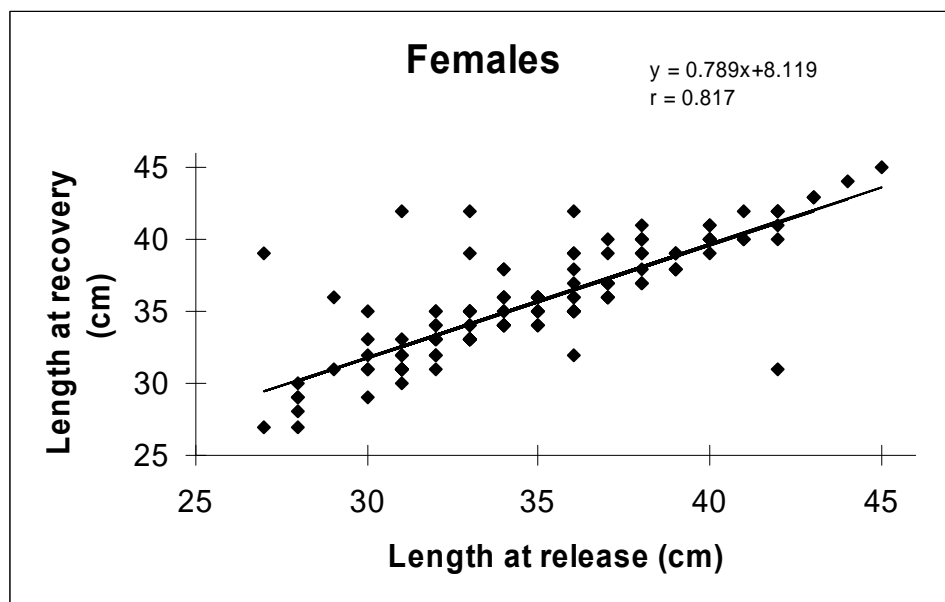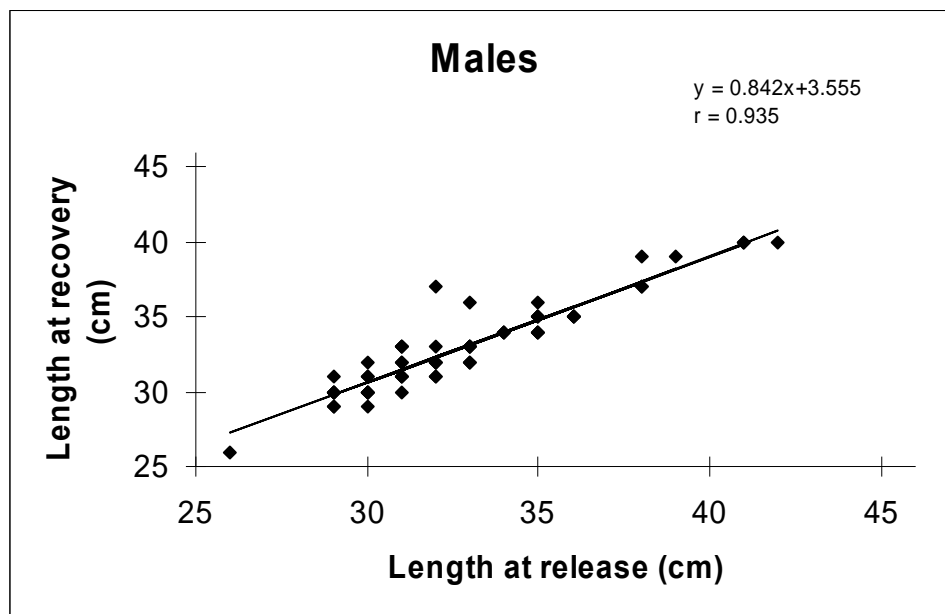
Figure 5. Length at release and recovery by sex for English sole recovered from the Hecate Strait tagging study conducted in 1983.
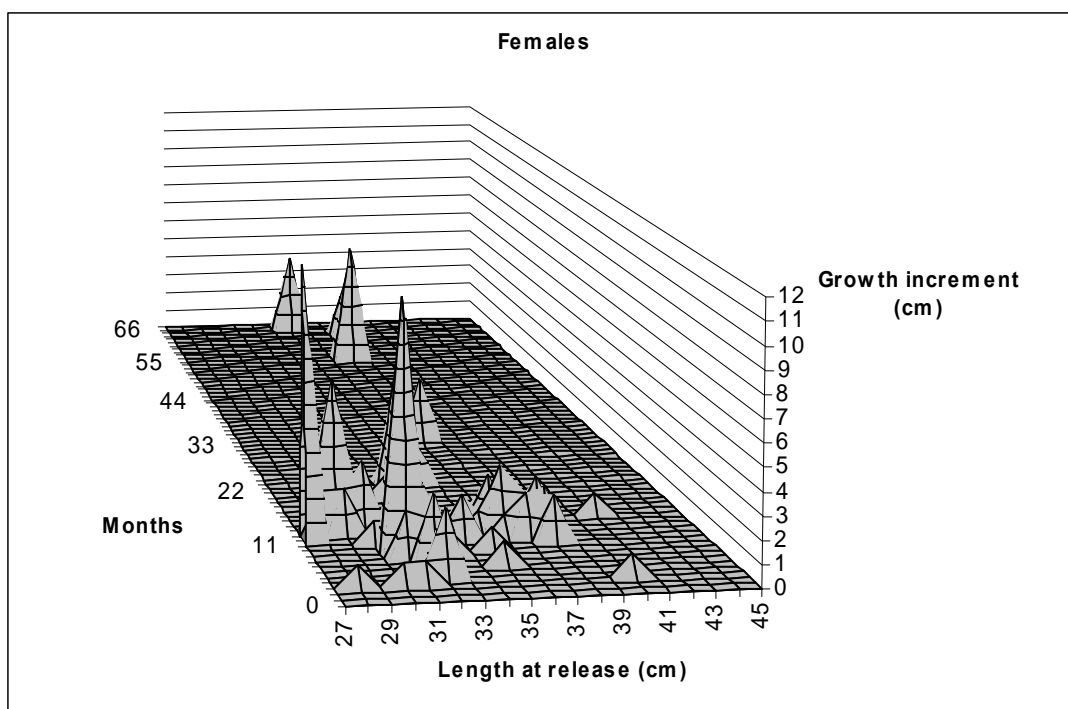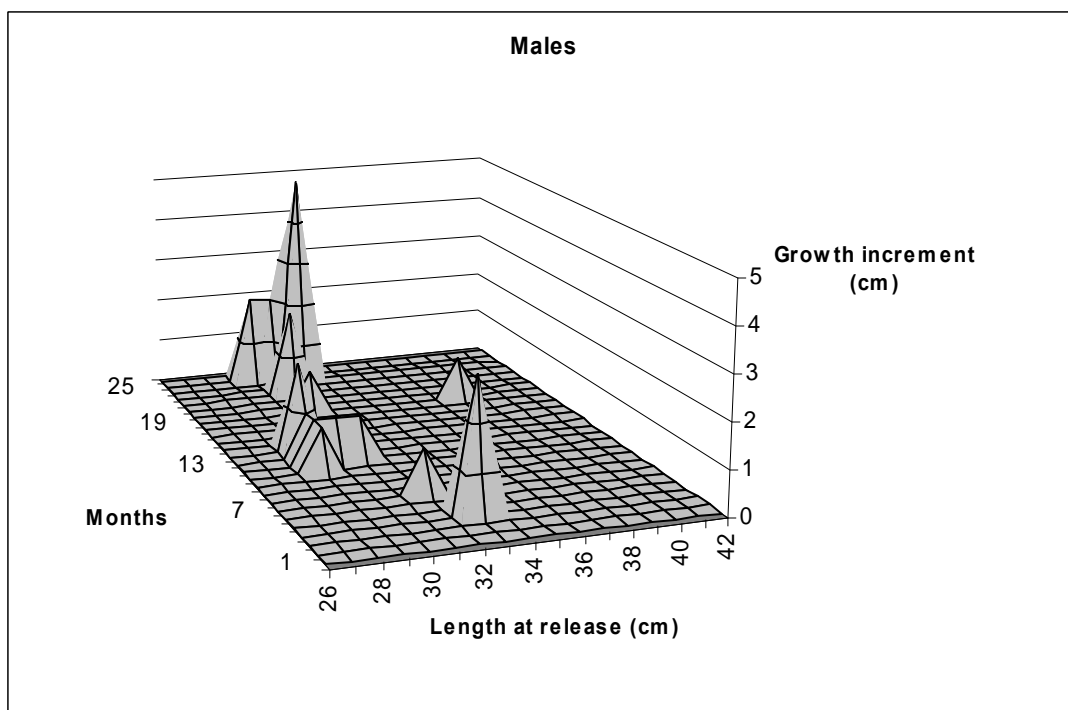
Figure 6. Incremental growth given time at liberty and length at release for English sole recovered from the 1983 tagging experiment in Hecate Strait.

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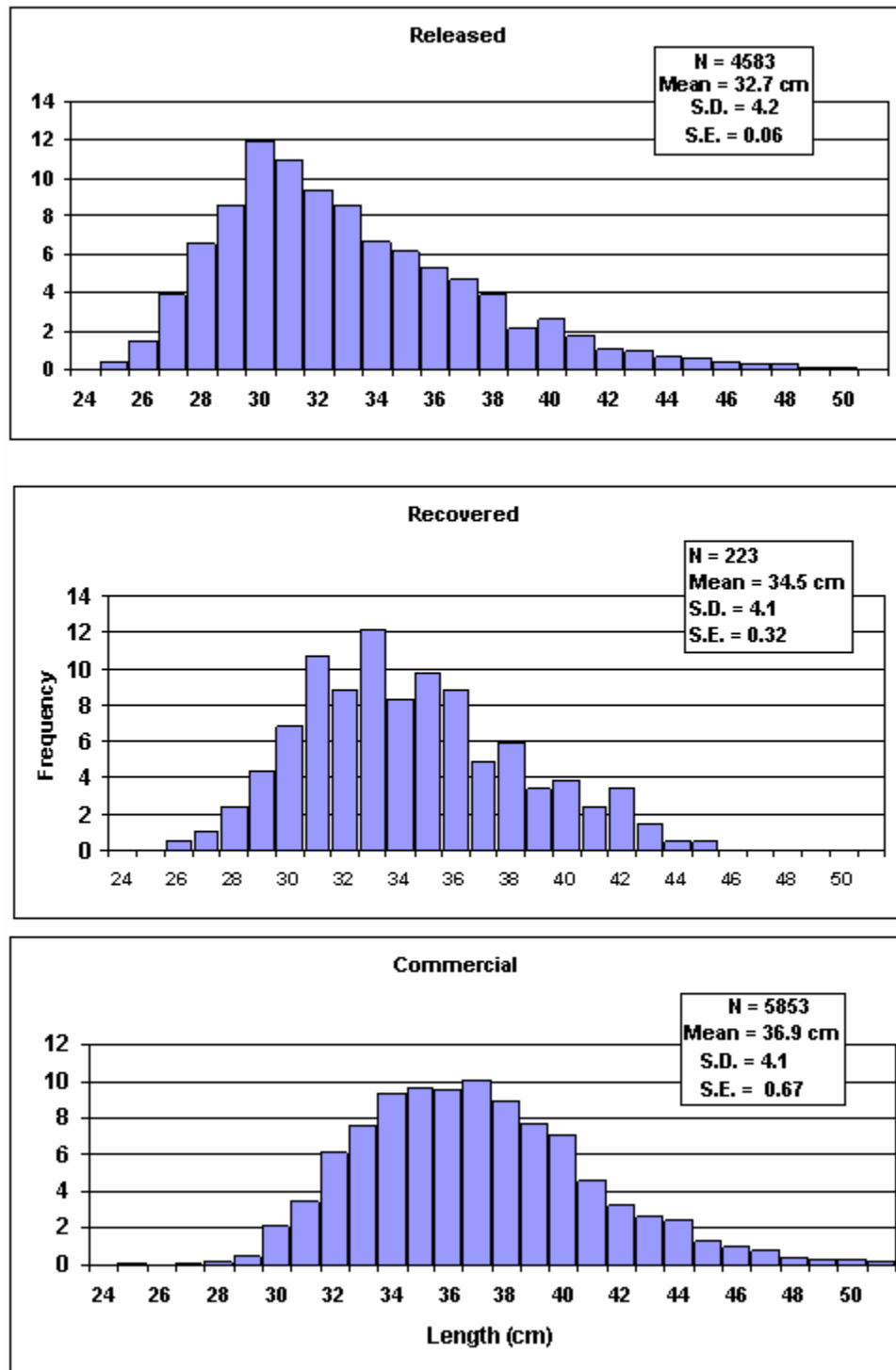
Figure 7. Length-frequencies (%) of releases, recoveries, and commercial samples, for English sole in Hecate Strait, June 1983. (Source: Table 9)
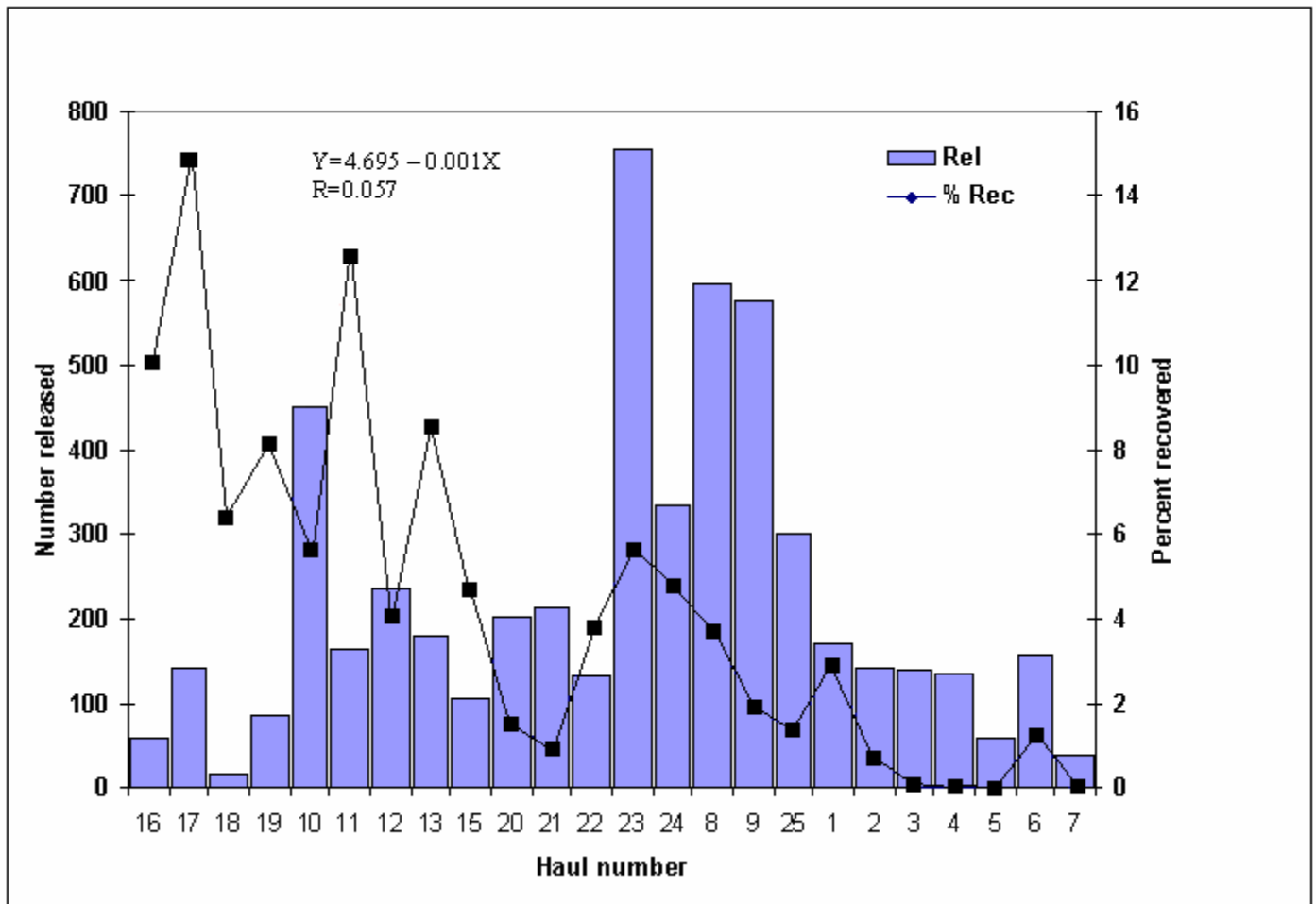
Figure 8. Recovery rate (%) versus numbers released, by haul, of tagged English sole released in Hecate Strait, June 9-18, 1983. Hauls 16-19 on Butterworth (5D); hauls 10-13, 15, and 20-24 on White Rocks (5D); hauls 8, 9, and 25 on Bonilla (5D); hauls 1-7 on West Horseshoe (5C). No tagging from hauls 14 and 26. (Source: Table 2).
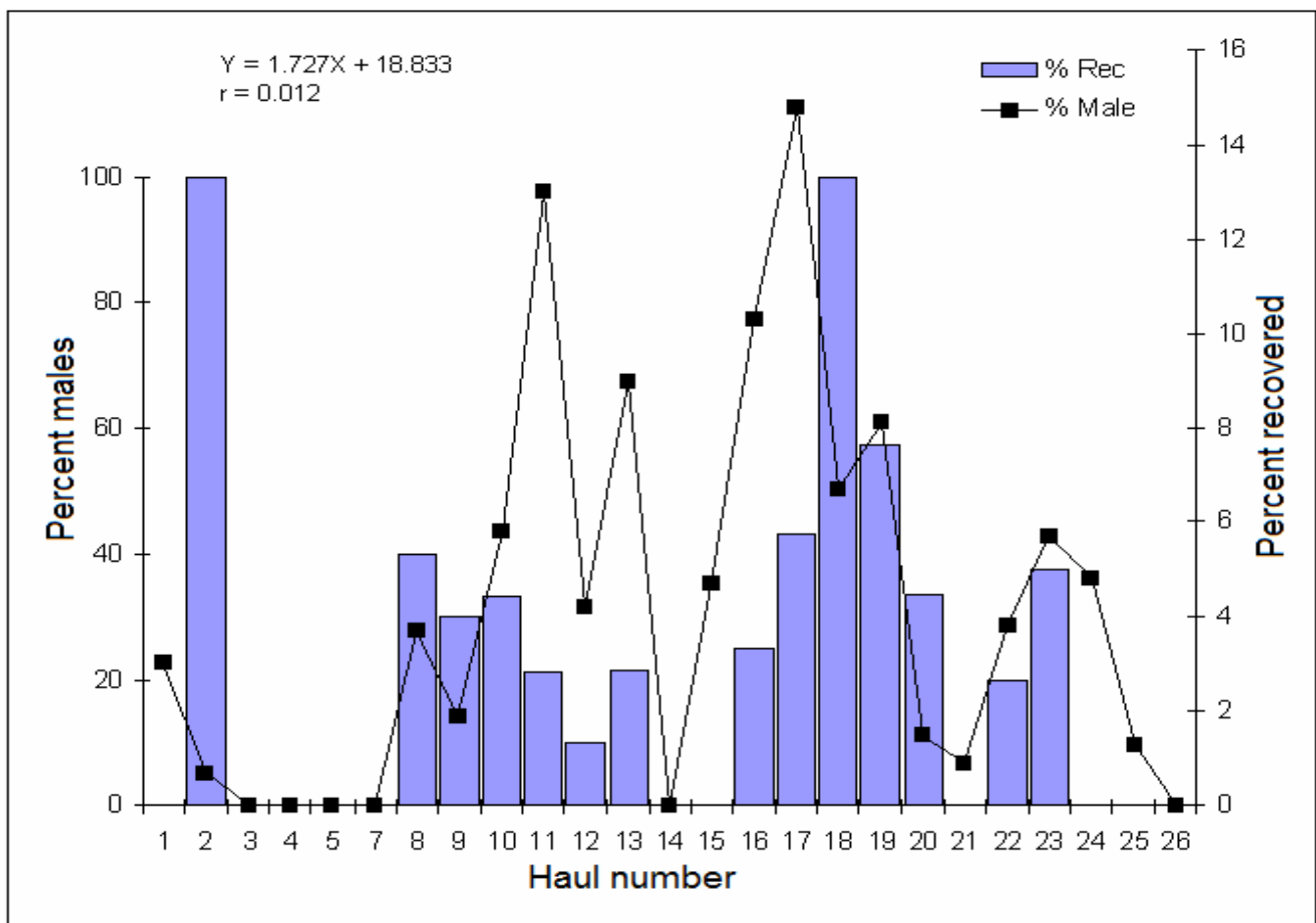
Figure 9. Recovery rate (%) versus percent males among recoveries, by haul, of tagged English sole released in Hecate Strait, June 9-18, 1983. Hauls 16-19 on Butterworth (5D); hauls 10-13, 15, and 20-24 on White Rocks (5D); hauls 8, 9, and 25 on Bonilla (5D); hauls 1-7 on West Horseshoe (5C), No tagging from hauls 14 and 26. (Source: Table 2)
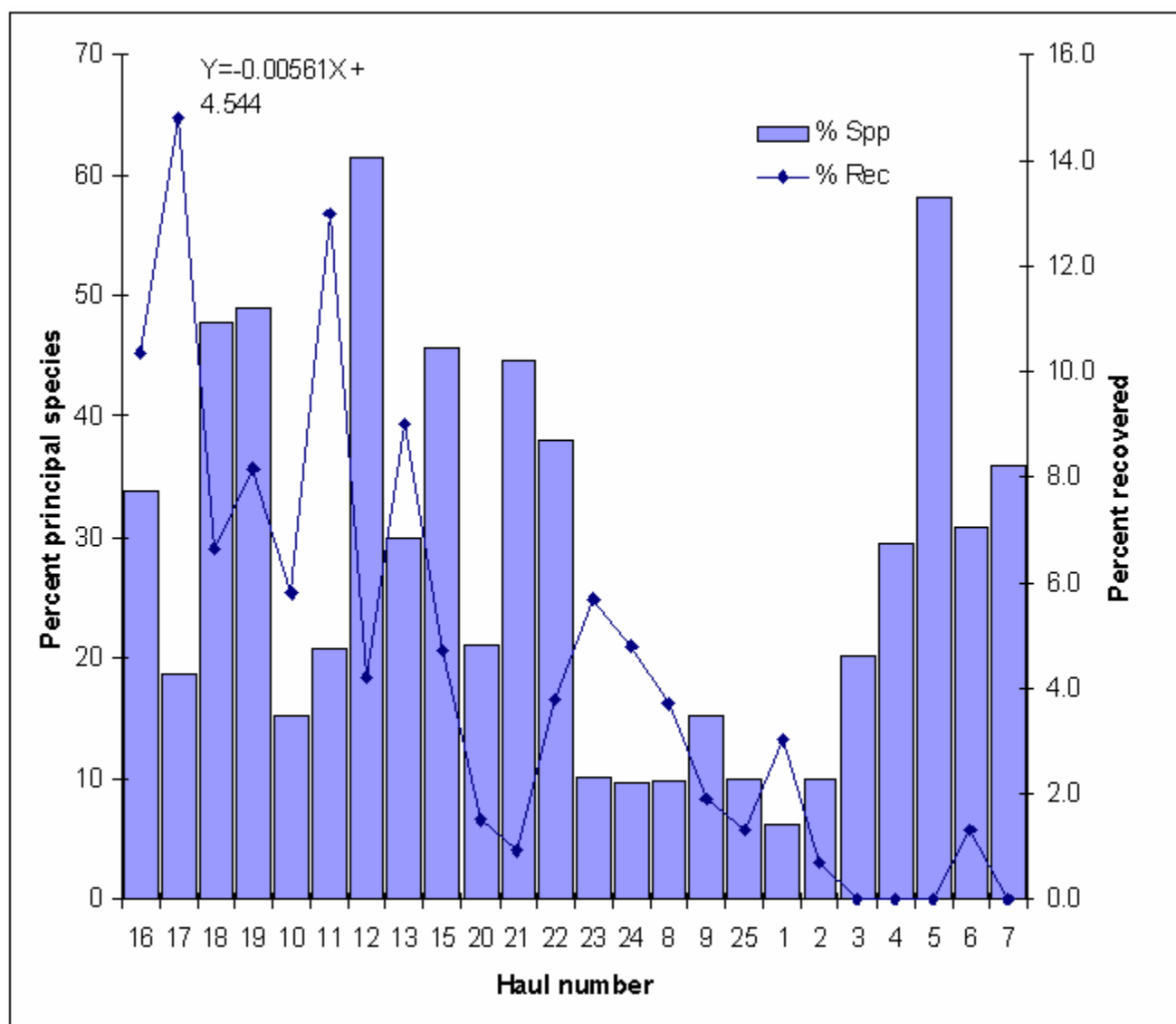
Figure 10. Recovery rate (%) versus percent principal species, among hauls of English sole tagged in Hecate Strait, June 9-18, 1983. Hauls 16-19 on Butterworth (5D); hauls 10-13, 15, and 20-24 on White Rocks (5D); hauls 8, 9, and 25 on Bonilla (5D); hauls 1-7 on West Horseshoe (5C), No tagging from hauls 14 and 26. (Source: Table 17).

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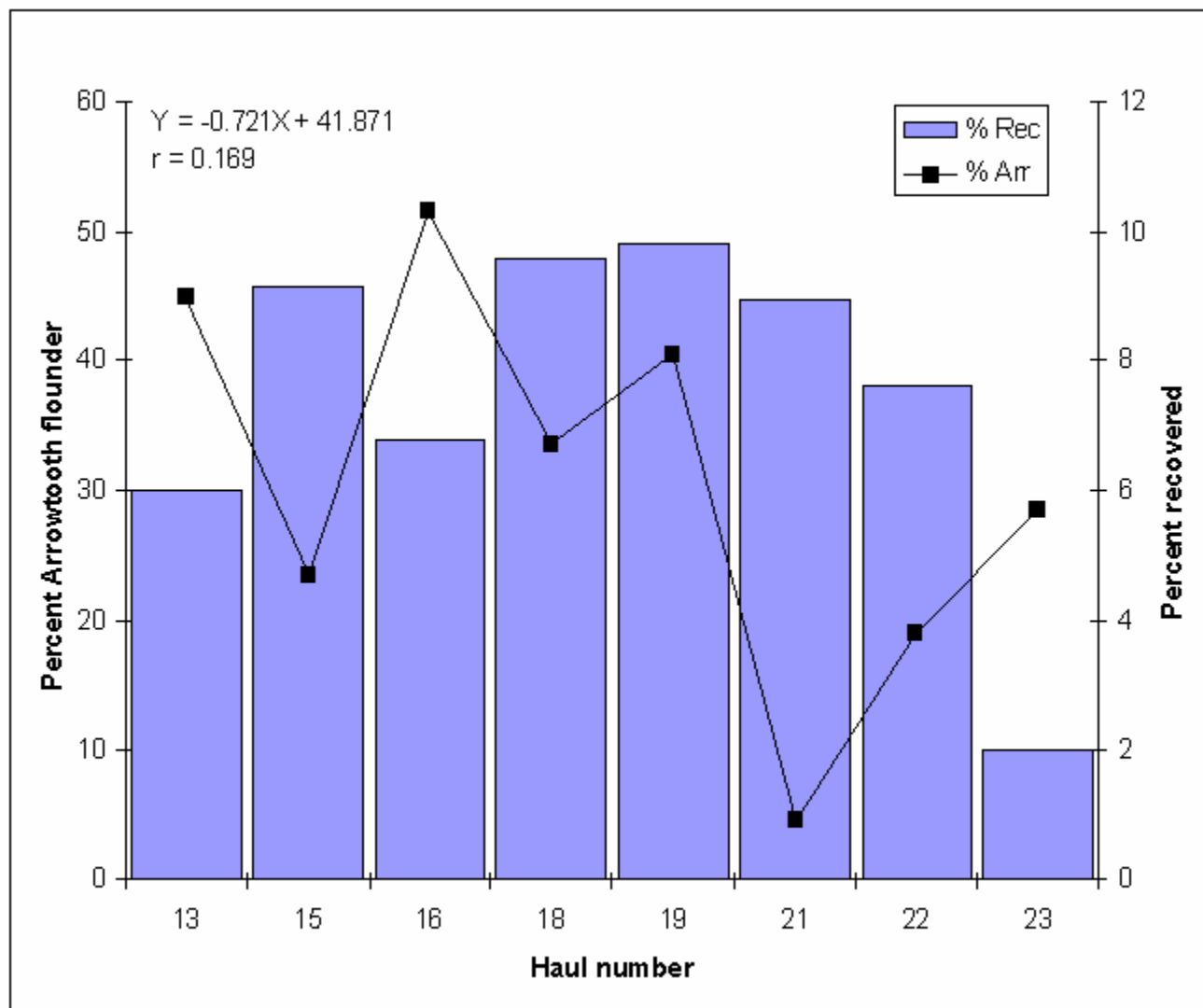
Figure 11. Recovery rate of released English sole versus percent arrowtooth flounder in the catch of the tagging vessel, by haul, 1983-88. Hauls 16, 18, and 19 on Butterworth; hauls 13, 15, and 21-23 on White Rocks. (Source: Table 17).
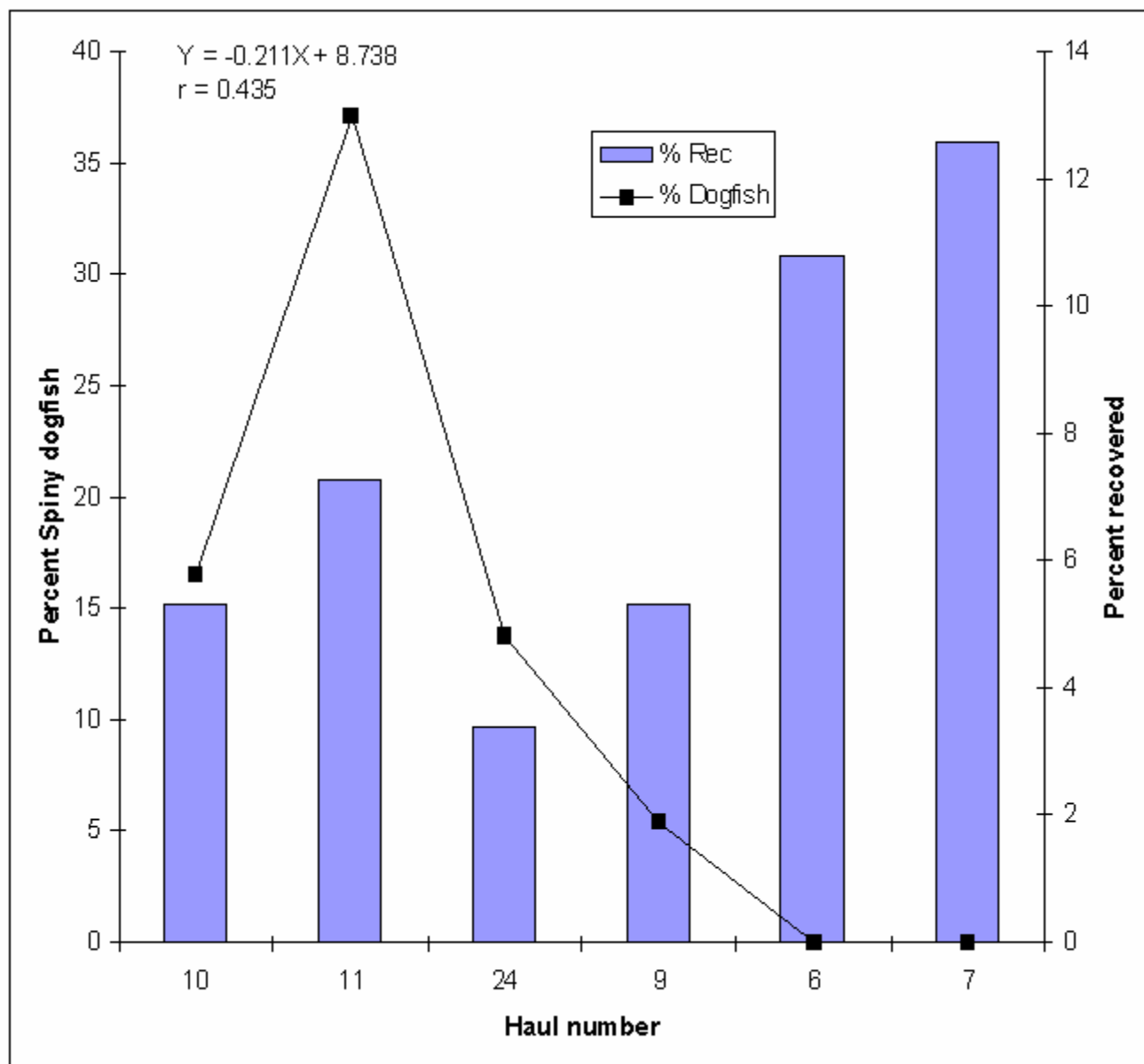
Figure 12. Percent recovery rate of released English sole versus percentage spiny dogfish in the catch of the tagging vessel, by haul, 1983-88. Hauls 10, 11, and 24 on White Rocks; haul 9 on Bonilla; hauls 6 and 7 on West Horseshoe. (Source: Table 17)

Appendix table 1. Detailed records of English sole recovered from the tagging study in Hecate Strait, June 9-18, 1983. (Source: PBS Groundfish database GFBIO; also three tags were recovered with no information).

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
39258	1	9	2	84	5C	WH	5D	WR	34	34	F
39270	1	9	5	84	5C	WH	5D		35	35	F
39411	1	9	6	84	5C	WH	5D		34	36	F
39259	1	9	7	84	5C	WH			42		
39298	1	9	6	85	5C	WH	5D	Bu	33	35	F
39525	2	9	2	84	5C	WH	5D	Bu	31	31	M
39965	6	10	5	84	5C	WH	5D	TP	29	30	M
40008	6	10	5	84	5C	WH	5D	Bu	32	32	M
40536	8	11	10	83	5D	Bo	5D	Sh	33	36	M
40213	8	11	11	83	5D	Bo	5D	WR	37	36	F
40256	8	11	11	83	5D	Bo	5D	WR	40	41	F
40672	8	11	1	84	5D	Bo			36	35	F
40682	8	11	1	84	5D	Bo			32		
40253	8	11	3	84	5D	Bo	5D		32	32	M
40170	8	11	5	84	5D	Bo	5D			29	M
40675	8	11	5	84	5D	Bo	5D	Bu	35	36	F
40457	8	11	6	84	5D	Bo	5D	Bu	34	35	F
40574	8	11	7	84	5D	Bo	5D	TP	30	30	M
40272	8	11	8	84	5D	Bo	5D	Du	35	34	M
40296	8	11	10	84	5D	Bo			38	39	F
40664	8	11	11	84	5D	Bo	5D	WR	36	35	F
40607	8	11	1	85	5D	Bo	5D	Bu	33	32	M
40138	8	11	3	85	5D	Bo	5D	WR	36	32	F
40398	8	11	3	85	5D	Bo	5D		32	33	F
40107	8	11	4	85	5D	Bo	5D	Bu	33	33	M
40316	8	11	5	85	5D	Bo	5D		33	35	F
40442	8	11	5	85	5D	Bo	5D	Bu	36	35	M
40645	8	11	6	85	5D	Bo			37		
40549	8	11	2	88	5D	Bo	5D	WR	36	42	F
40361	8	11			5D	Bo	5D		35	34	F
40844	9	11	11	83	5D	Bo	5D	WR	33	33	F
40750	9	11	12	83	5D	Bo	5D	WR	33	33	F
40813	9	11	2	84	5D	Bo	5D	Bu	42	40	F
41235	9	11	2	84	5D	Bo	5D		32	33	M
40894	9	11	4	84	5D	Bo	5D	Bu	31	31	F
40767	9	11	5	84	5D	Bo	5D		38	37	F
40789	9	11	6	84	5D	Bo	5D	Bu	31	33	M
40867	9	11	8	84	5D	Bo	5D		35	36	F
41256	9	11	8	84	5D	Bo	5D		36	35	F
41299	9	11	7	85	5D	Bo	5D		31	33	M
41273	9	11			5D	Bo	5D	Bu	34		

Appendix Table 1 (contd.)

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
41702	10	12	8	83	5D	WR	5C	WH	31	31	F
41434	10	12	11	83	5D	WR	5D	WR	37	37	F
41560	10	12	11	83	5D	WR	5D	Bu	35	34	F
41680	10	12	11	83	5D	WR	5D	WR	31	30	F
41549	10	12	1	84	5D	WR	5D		35	35	F
41583	10	12	1	84	5D	WR	5D	WR	40		
41391	10	12	2	84	5D	WR	5D	Bu	30	30	M
41712	10	12	2	84	5D	WR	5D	WR	39	39	F
41751	10	12	2	84	5D	WR	5D	WR	40	40	F
41647	10	12	3	84	5D	WR	5D		33	33	M
41701	10	12	3	84	5D	WR	5D		36	36	F
41416	10	12	4	84	5D	WR	5D	TP	37	36	F
41420	10	12	4	84	5D	WR	5D	Bu	30	31	M
41510	10	12	4	84	5D	WR	5D	Bu	33	32	M
41578	10	12	4	84	5D	WR	5D	TP	31	30	M
41334	10	12	5	84	5D	WR	5D		31	31	F
41721	10	12	5	84	5D	WR	5D		33	33	F
41529	10	12	6	84	5D	WR	5D	Bu	34	34	M
41558	10	12	6	84	5D	WR	5D	Bu	31	32	M
41801	10	12	6	84	5D	WR	5D		34	35	F
41747	10	12	9	84	5D	WR	5D	Bu	28	29	F
41445	10	12	1	85	5D	WR	5D		33	35	F
41733	10	12	4	85	5D	WR	5D		29	36	
41588	10	12	7	85	5D	WR	5D	Bu	30	32	M
41740	10	12	12	88	5D	WR			34	38	F
41504	10	12			5D	WR			41	40	F
41972	11	12	10	83	5D	WR	5D	Sh	37	37	F
41828	11	12	11	83	5D	WR	5D	WR	42	42	F
41862	11	12	11	83	5D	WR	5D	WR	33	33	F
41901	11	12	11	83	5D	WR	5D	WR	36	35	F
41907	11	12	11	83	5D	WR	5D	WR	42	42	F
41933	11	12	11	83	5D	WR	5D	WR	34	34	F
41924	11	12	1	84	5D	WR	5C		35	36	F
41787	11	12	3	84	5D	WR	5D	WR	32		
41826	11	12	5	84	5D	WR	5D		41	40	F
41899	11	12	5	84	5D	WR	5D		37	36	F
41940	11	12	5	84	5D	WR	5D		31	31	M
41789	11	12	6	84	5D	WR	5D	Bu	33	33	F
41887	11	12	6	84	5D	WR	5D	Bu	30	31	M
41796	11	12	7	84	5D	WR	5D	Bu	30	30	M
41857	11	12	8	84	5D	WR	5D	TP	38	41	F
41891	11	12	8	84	5D	WR	5D	TP	38	38	F

Appendix Table 1 (contd.)

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
41784	11	12	1	85	5D	WR	5D	Bu	31	32	M
41929	11	12	4	85	5D	WR			35	35	F
41872	11	12	6	85	5D	WR	5D	Bu	34	38	F
97010	12	12	11	83	5D	WR	5D	WR	40	39	F
97169	12	12	11	83	5D	WR	5D	WR	39	38	F
41958	12	12	11	83	5D	WR	5D	WR	40	41	F
97082	12	12	3	84	5D	WR	5D		38	37	M
41980	12	12	4	84	5D	WR	5D	TP	40	40	F
97016	12	12	4	84	5D	WR	5D	WR	31	31	F
41995	12	12	5	84	5D	WR	5D		34	34	F
97102	12	12	6	84	5D	WR	5D		31	32	F
41951	12	12	8	84	5D	WR	5D	Bu	26		
97179	12	12	10	84	5D	WR	5D	WR	31	31	F
97083	12	12	4	85	5D	WR	5D	Bu	42	31	F
97115	12	12			5D	WR			43	43	F
97240	13	12	6	83	5D	WR	5D	WR	32		
97219	13	12	11	83	5D	WR	5D	WR	37	37	F
97200	13	12	12	83	5D	WR	5D	TP	33	33	F
97245	13	12	1	84	5D	WR			35	34	F
97348	13	12	2	84	5D	WR	5D	WR	32	32	M
97272	13	12	4	84	5D	WR	5D	TP	38	40	F
97214	13	12	5	84	5D	WR	5D	Bu	29	30	M
97231	13	12	6	84	5D	WR	5D	TP	30	32	F
97267	13	12	6	84	5D	WR	5D	Bu	29	30	M
97325	13	12	6	84	5D	WR	5D		37	36	F
97355	13	12	6	84	5D	WR	5D	TP	32	34	F
97375	13	12	6	84	5D	WR	5D		32	34	F
97228	13	12	9	84	5D	WR	5D	TP	38	40	F
97330	13	12	5	85	5D	WR	5D	TP	33	42	F
97199	13	12	6	85	5D	WR	5D	TP	34	36	F
97352	13	12			5D	WR			33		
97490	15	13	11	83	5D	WR	5D		32	31	F
97439	15	13	4	84	5D	WR	5D	Bu	36	35	F
97484	15	13	4	84	5D	WR	5D	Bu	32	33	F
97399	15	13	5	85	5D	WR	5D	Bu	37		
97408	15	13	6	85	5D	WR	5D	TP	44	44	F
97519	16	15	6	83	5D	Bu	5D	TP	42	42	F
97536	16	15	5	84	5D	Bu	5D	Bu	32		
97546	16	15	5	84	5D	Bu	5D	Bu	34	34	M
97567	16	15	7	84	5D	Bu	5D		38	39	F
97592	16	15	7	84	5D	Bu	5D	TP	35	34	M
97557	16	15	7	85	5D	Bu			33		

Appendix Table 1 (contd.)

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
97527	16	15			5D	Bu			33	33	F
97617	17	15	11	83	5D	Bu	5D	WR	34	34	M
97649	17	15	1	84	5D	Bu	5C		40	40	F
97672	17	15	1	84	5D	Bu	5C		43	43	F
97678	17	15	3	84	5D	Bu	5D	Bu	43	43	F
97609	17	15	4	84	5D	Bu	5D	WR	40	40	F
97607	17	15	5	84	5D	Bu	5D		39	39	F
97637	17	15	5	84	5D	Bu	5D		36	35	M
97679	17	15	5	84	5D	Bu	5D		41	40	M
97615	17	15	6	84	5D	Bu	5D	TP	37		M
97645	17	15	6	84	5D	Bu	5D		38	40	F
97654	17	15	6	84	5D	Bu	5D		37	39	F
97569	17	15	7	84	5D	Bu	5D	Bu	42	40	M
97703	17	15	7	84	5D	Bu	5D		41	40	M
97737	17	15	7	84	5D	Bu	5D		38	40	F
97602	17	15	8	84	5D	Bu	5D	Bu	35	35	F
97702	17	15	9	84	5D	Bu	5D	TP	42	41	F
97663	17	15	11	84	5D	Bu	5D		41	42	F
97651	17	15	6	85	5D	Bu	5D	Bu	35	35	M
97682	17	15	10	88	5D	Bu	3Cn	CFS	37	40	F
97750	18	15	7	84	5D	Bu	5D	Bu	39	39	M
97844	19	15	8	83	5D	Bu	5D	TP	33	33	F
97783	19	15	1	84	5D	Bu	5D		35	35	M
97776	19	15	4	84	5D	Bu	5D	Bu	35	34	M
97793	19	15	4	84	5D	Bu	5D	Bu	32	31	M
97833	19	15	4	84	5D	Bu	5D	Bu	31	33	F
97779	19	15	8	84	5D	Bu	5D		36	39	F
97785	19	15	1	85	5D	Bu	5D	Bu	38	39	M
97917	20	17	2	84	5D	WR	5D	Bu	26	26	M
97959	20	17	5	84	5D	WR	5D	WR	40	40	F
97915	20	17	7	84	5D	WR	5D	TP	28	28	F
98155	21	17	4	84	5D	WR	5D	Bu	33	34	F
98139	21	17	7	84	5D	WR	5D		27	39	F
98342	22	17	11	83	5D	WR	5D	WR	33	33	F
98309	22	17	3	84	5D	WR	5D	WR	28	27	F
98274	22	17	4	84	5D	WR	5D		39	39	F
98303	22	17	4	85	5D	WR			33	35	F
98336	22	17	4	85	5D	WR	5D	Bu	31	33	M
98866	23	17	10	83	5D	WR	5D	Sh	30	30	M
99042	23	17	10	83	5D	WR	5D	Bu	31	32	F
98537	23	17	11	83	5D	WR	5D	WR	34		F
98606	23	17	11	83	5D	WR	5D	WR	31	31	M

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
98630	23	17	11	83	5D	WR	5D	WR	39	38	F
98788	23	17	11	83	5D	WR	5D	WR	28	29	F
98979	23	17	11	83	5D	WR	5D	Bu	32	35	F
99126	23	17	11	83	5D	WR	5D	WR	45	45	F
98595	23	17	2	84	5D	WR	5D	WR	35	35	M
99123	23	17	2	84	5D	WR	5D	Bu	29	29	M
99145	23	17	2	84	5D	WR	5D	WR	29		
98711	23	17	3	84	5D	WR	5D	WR	32	32	F
98909	23	17	3	84	5D	WR	5D		34	34	F
98998	23	17	3	84	5D	WR	5D		35	36	M
98440	23	17	4	84	5D	WR	5D		36	35	M
98503	23	17	4	84	5D	WR	5D	Bu	30	29	M
98546	23	17	4	84	5D	WR	5D	Bu	29	29	M
98976	23	17	4	84	5D	WR	5D	Bu	35	36	F
98460	23	17	5	84	5D	WR	5D	Bu	32	31	M
99071	23	17	5	84	5D	WR	5D		33	34	F
98857	23	17	6	84	5D	WR	5D		36	35	F
99016	23	17	6	84	5D	WR	5D	Bu	30	31	F
99082	23	17	6	84	5D	WR	5D	TP	33	33	M
98492	23	17	7	84	5D	WR	5D	TP	32	33	F
98835	23	17	7	84	5D	WR	5D	TP	29	30	M
99151	23	17	7	84	5D	WR	5D	TP	35	36	F
98539	23	17	8	84	5D	WR	5D	Du	33	33	F
98732	23	17	8	84	5D	WR	5D	Bu	28	30	F
98943	23	17	8	84	5D	WR	5D	Bu	29	31	M
98946	23	17	9	84	5D	WR	5D	TP	30	33	F
98989	23	17	10	84	5D	WR			36	38	F
99040	23	17	10	84	5D	WR	5D	WR	33	33	M
98459	23	17	11	84	5D	WR	5D	WR	34	34	F
98692	23	17		84	5D	WR			38		
98475	23	17	1	85	5D	WR	5D	Bu	36	35	M
98718	23	17	6	85	5D	WR	5D		33	39	F
98787	23	17	6	85	5D	WR	5D		32	37	M
99109	23	17	7	85	5D	WR	5D		34	34	F
98700	23	17	4	86	5D	WR	5D	WR	36	39	F
98487	23	17			5D	WR	5D		34	34	F
98605	23	17			5D	WR			39	38	F
99154	23	17			5D	WR			37		
99317	24	17	1	84	5D	WR	5D		30		
99395	24	17	2	84	5D	WR	5D	WR	38	37	F
99484	24	17	2	84	5D	WR	5D	WR	27	27	F
99219	24	17	4	84	5D	WR	5B	NWG	35	36	F

Appendix Table 1 (contd.)

Tag no.	Haul	Time			Location[a]				FL (cm)		Sex
F82-		rel.	rec.		release		recovery		rel.	rec.	
		DD	MM	YY	Area	grnd	Area	grnd			
99357	24	17	4	84	5D	WR	5D	Bu	31	31	F
99464	24	17	4	84	5D	WR	5D	Bu	31	42	F
99191	24	17	6	84	5D	WR	5D		39		
99377	24	17	6	84	5D	WR	5D	Bu	34	36	F
99393	24	17	7	84	5D	WR	5D	Bu	31	31	
99488	24	17	7	84	5D	WR	5D	TP	36	37	F
99386	24	17	8	84	5D	WR	5D		31	31	F
99426	24	17	8	84	5D	WR	5D	Bu	29	31	F
99360	24	17	7	85	5D	WR	5B		30	35	F
99354	24	17			5D	WR			33		
99388	24	17			5D	WR			32	32	F
99730	25	18	11	83	5D	Bo	5D	WR	36	36	F
99625	25	18	10	84	5D	Bo	5D	WR	32	33	F
99664	25	18	2	84	5D	Bo	5D	Bu	32	35	F
99677	25	18	6	85	5D	Bo	5D	Bu	37	37	F
N	12	227	215	216					226	206	206
F824 042			4	84			5D	Bu		36	

[a] Location: Area = major area, see Figure 1; grnd = Ground (see Figure 2): Bo = Bonilla (5D); Bu = Butterworth (5D); CFS = Cape Flattery Spit (3Cn); Du = Dundas (5D); NWG = Northwest Goose (5B); Sh = Shell (5D); TP = Two Peaks (5D); WH = West Horseshoe (5C); WR = White Rocks (5D).

Appendix table 2. Length-frequencies (nos.), by month and sex, of trawl-caught English sole landed from Area 5D, 1983. (Source:PBS Groundfish database GFBIO).

Fork length (cm)	May M	May F	Jun M	Jun F	July M	July F	November M	November F	Total M	Total F
28	...	...	...	...	...	...	...	1	...	1
29	...	...	...	...	...	...	...	0	...	0
30	...	...	...	1	...	...	1	1	1	2
31	3	...	...	1	...	...	3	3	6	4
32	9	9	2	3	...	1	2	3	13	16
33	15	7	3	5	2	2	7	4	27	18
34	13	21	6	8	1	4	7	18	27	51
35	16	36	1	18	0	10	6	14	23	78
36	12	44	3	20	2	9	11	20	28	93
37	12	54	4	37	2	22	4	25	22	138
38	10	54	1	26	3	25	6	25	20	130
39	5	59	6	36	3	31	2	25	16	151
40	...	61	2	35	1	42	7	20	10	158
41	...	27	0	29	1	33	2	19	3	108
42	...	30	1	13	1	29	0	16	2	88
43	...	31	...	19	1	17	2	6	3	73
44	...	29	...	10	...	23	...	12	...	74
45	...	14	...	5	...	9	...	4	...	32
46	...	10	...	9	...	10	...	6	...	35
47	...	5	...	3	...	6	...	7	...	21
48	...	4	...	1	...	3	...	3	...	11
49	...	3	...	4	...	1	...	3	...	11
50	...	4	...	1	...	1	...	2	...	8
51	...	3	...	...	...	2	...	0	...	5
52	...	...	...	...	...	1	...	2	...	3
53	...	...	...	...	...	1	...	0	...	1
54	...	...	...	...	...	0	...	0	...	0
55	...	...	...	...	...	0	...	1	...	1
56	...	...	...	...	...	1	...	...	...	1
Total	95	505	29	284	17	283	60	240	201	1312
%M	16		9		6		20		13	
Mean	35.0	39.3	36.3	39.3	37.8	40.7	36.1	39.3	35.8	39.6
S.D.	2.1	3.7	2.8	3.5	2.9	3.6	3.0	4.4	2.7	3.8
S.E.	0.22	0.16	0.51	0.21	0.70	0.21	0.39	0.28	0.19	0.11

Appendix table 3. Length-frequencies, by month and sex, of trawl-caught English sole landed from Area 5D, 1984. (Source: PBS Groundfish database GFBIO).

Fork length (cm)	March M	March F	April M	April F	May M	May F	June M	June F	July M	July F	August M	August F	Total M	Total F
29	1	1	...	...	...	...	3	...	...	...	...	...	4	1
30	2	1	5	3	2	...	5	3	...	...	...	...	14	7
31	8	4	2	2	4	...	10	3	1	...	...	1	25	10
32	18	8	2	5	10	1	16	10	1	4	7	6	54	34
33	16	19	12	18	18	2	13	8	3	6	7	17	69	70
34	15	26	10	17	14	9	8	20	4	8	6	17	57	97
35	16	31	11	15	12	8	11	24	5	16	10	19	65	113
36	10	26	12	23	6	10	8	24	5	20	3	29	44	132
37	5	22	10	31	4	19	11	14	6	25	6	36	42	147
38	4	19	2	27	2	28	7	23	3	33	3	28	21	158
39	4	7	4	21	1	44	5	16	1	22	8	28	23	138
40	1	19	4	18	1	31	2	19	0	34	2	21	10	142
41	...	7	0	13	...	27	2	12	1	22	...	12	3	93
42	...	4	2	11	...	19	1	10	...	14	...	6	3	64
43	...	1	...	6	...	11	...	6	...	16	...	10	...	50
44	...	2	...	7	...	8	...	4	...	18	...	6	...	45
45	...	0	...	1	...	6	...	3	...	8	...	6	...	24
46	...	1	...	0	...	3	...	3	...	6	...	2	...	15
47	...	1	...	2	...	1	...	2	...	7	...	1	...	14
48	...	0	...	3	...	1	...	0	...	3	...	1	...	8
49	...	0	...	0	...	0	...	2	...	2	...	0	...	4
50	...	0	...	0	...	1	...	...	...	0	...	1	...	2
51	...	1	...	1	...	...	...	...	...	3	...	...	...	5
52	...	...	...	...	...	...	...	...	...	1	...	...	...	1
53	...	...	...	...	...	...	...	...	...	2	...	...	...	2
Total	100	200	76	224	74	229	102	206	30	270	52	247	434	1376
%M	33		25		24		33		10		17		24	
Mean	34	36.4	35.2	37.7	34	39.5	34.4	37.6	35.6	39.9	35.4	37.8	34.6	38.2
S.D.	2.3	3.2	2.7	3.6	3.6	2	3	3.8	2.2	4	2.4	3.3	2.6	3.7
S.E.	0.23	0.22	0.31	0.24	0.23	0.19	0.3	0.28	0.4	0.25	0.33	0.21	0.32	0.37

Appendix table 4. Length-frequencies (nos.), by month and sex, of trawl-caught English sole landed from Area 5D, 1985. (Source: PBS Groundfish database GFBIO) Appendix table 4. Length-frequencies (nos.), by month and sex, of trawl-caught English sole landed from Area 5D, 1985. (Source: PBS Groundfish database GFBIO)

Fork length (cm)	April M	April F	May M	May F	June M	June F	July M	July F	Total M	Total F
22	...	1	...	...	...	...	...	...	...	1
23	...	1	...	...	...	1	...	1	...	3
24	...	0	...	...	...	0	...	0	...	0
25	...	0	...	...	...	1	1	1	1	2
26	...	0	...	...	...	2	0	0	0	2
27	3	0	...	...	1	1	2	0	6	1
28	2	2	...	...	2	0	1	2	5	4
29	2	0	...	...	3	7	9	5	14	12
30	15	1	14	4	15	6	30	16	74	27
31	14	7	12	14	24	15	29	44	79	80
32	21	15	37	25	34	17	48	43	140	100
33	10	27	33	30	27	31	51	50	121	138
34	11	22	24	53	32	48	61	69	128	192
35	14	22	26	47	31	47	31	68	102	184
36	7	20	15	60	18	48	27	71	67	199
37	8	18	17	61	16	42	19	59	60	180
38	4	14	8	42	6	48	13	61	31	165
39	2	7	4	26	6	37	4	35	16	105
40	...	13	1	26	1	22	6	29	8	90
41	...	7	...	14	1	16	1	21	2	58
42	...	2	...	8	...	11	4	14	4	35
43	...	2	...	3	...	7	...	14	...	26
44	...	2	...	6	...	5	...	6	...	19
45	...	1	...	6	...	8	...	4	...	19
46	...	2	...	1	...	4	...	1	...	8
47	...	0	...	4	...	3	...	2	...	9
48	...	0	...	0	...	2	...	0	...	2
49	...	0	...	1	...	1	...	1	...	3
50	...	1	...	...	...	...	...	6	...	7
51	...	...	...	...	...	...	...	0	...	0
52	...	...	...	...	...	...	...	1	...	1
Total	113	187	191	431	217	430	337	624	858	1672
%M	38		31		34		35		34	
Mean	32.9	35.7	33.8	36.5	33.6	36.6	33.6	36.0	33.6	36.2
S.D.	2.7	3.7	2.3	3..3	2.5	3.9	2.7	3.9	2.6	3.7
S.E.	0.26	0.27	0.17	0.16	0.17	0.19	0.15	0.15	0.09	0.09