A Comparison of the Results of the 1998 Georgia Strait Creel Survey with an Independent Observer Program

R.E. Diewert, D.A. Nagtegaal, and K. Hein

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

2005

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2716

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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

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

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

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

Rapport manuscrit canadien des sciences halieutiques et aquatiques

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

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

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

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

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2716

2005

A COMPARISON OF THE RESULTS OF THE 1998 GEORGIA STRAIT CREEL SURVEY WITH AN INDEPENDENT OBSERVER PROGRAM

by

R.E. Diewert[1], D.A. Nagtegaal, and K. Hein

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, B.C. V9T 6N7

[1]Diewert Consulting Services, Site 152, Compartment 90, RR #1, Bowser, B.C. V0R 1G0

Cat. No. Fs 97-4/2716E ISSN 0706-6473

Correct citation for this publication:

Diewert, R.E., Nagtegaal, D.A., and Hein, K. 2005. A comparison of the results of the 1998 Georgia Strait creel survey with an independent observer program. Can. Manuscr. Rep. Fish. Aquat. Sci. 2716: vii + 39 p.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDECES

ABSTRACT

Diewert, R.E., Nagtegaal, D.A., and Hein, K. 2005. A comparison of the results of the 1998 Georgia Strait creel survey with an independent observer program. Can. Manuscr. Rep. Fish. Aquat. Sci. 2716: vii + 39 p.

The Georgia Strait creel survey monitors recreational fishing activity throughout Georgia Strait and the Canadian portion of Juan de Fuca Strait. In 1998, an independent observer program was implemented to assess non-sampling errors that may bias the catch and release estimates generated by the survey. Between July and September, on-board observers monitored a total of 191 sport fishing trips in DFO Statistical Areas 18, 19 and 20 located in the southern portion of Georgia Strait. Differences were noted in the species composition of the catch based on creel survey interviews versus the independent observer data. While the difference was not statistically significant for kept fish it was highly significant for released fish. Total encounter rates were also compared and it was found that encounter frequency distributions based on the two data sets were not different for any of the kept species or species groups; however, encounter frequencies were significantly higher for released chinook salmon (*Oncorhynchus. tshawytscha*), coho salmon (*O. kisutch*) and rockfish (*Sebastes spp*) based on the independent observer data. An analysis of fishing success rates found similar results. In the final assessment, total catch was estimated using the creel survey interview responses and the independent observer data following the standard creel survey methodology. A consistent trend emerged with higher estimated releases of chinook and coho salmon based on the independent observer data. These results suggest that a bias may exist in the creel survey resulting in an underestimate of the number of chinook and coho salmon that are released by recreational anglers.

RÉSUMÉ

Diewert, R.E., D.A. Nagtegaal, and K. Hein. 2005. A comparison of the results of the 1998 Georgia Strait creel survey with an independent observer program. Can. Manuscr. Rep. Fish. Aquat. Sci. 2716: vii + 39 p.

L'enquête sur les prises récréatives dans le détroit de Georgia permet de contrôler les activités de pêche récréative menées dans ce bassin et dans les eaux canadiennes du détroit de Juan de Fuca. En 1998, un programme des observateurs indépendant a été mis en oeuvre afin d'évaluer l'ampleur de l'erreur non liée à l'échantillonnage, qui peut biaiser les estimations des prises remises à l'eau reposant sur les données d'enquête. De juillet à septembre, des observateurs à bord ont contrôlé un total de 191 sorties de pêche récréative effectuées dans les zones statistiques 18, 19 et 20 du MPO, situées dans la partie sud du détroit de Georgia. Nous avons relevé des différences dans la composition des prises par espèces établie par entrevues des pêcheurs et d'après les données des observateurs. Bien que la différence ne soit pas statistiquement significative dans le cas des prises retenues, elle était hautement significative dans le cas des prises remises à l'eau. Nous avons aussi comparé les taux totaux de rencontre et nous avons constaté que les distributions de la fréquence de rencontre reposant sur les deux séries de données n'étaient pas différentes pour aucune des espèces et aucun des groupes d'espèces retenus; par contre, les fréquences de rencontre étaient significativement plus élevées dans le cas du saumon quinnat (*Oncorhynchus tshawytscha*), du saumon coho (*O. kisutch*) et du sébaste (*Sebastes* sp.) remis à l'eau, d'après les données des observateurs. L'analyse des taux de succès de la pêche a donné des résultats semblables. Nous avons enfin estimé les prises totales d'après les réponses de l'enquête sur les prises récréatives et les données des observateurs en nous servant de la méthode normalisée d'enquête sur ces prises. Une tendance persistante s'est dessinée : le nombre estimatif de quinnats et de cohos remis à l'eau était plus élevé d'après les données des observateurs. Ces résultats donnent à penser qu'un biais peut exister dans l'enquête sur les prises récréatives, donnant lieu à une sous-estimation du nombre de quinnats et de cohos remis à l'eau par les pêcheurs récréatifs.

INTRODUCTION

The Georgia Strait sport fishery is the largest recreational fishery on Canada's Pacific coast. This fishery is open year round and is readily accessible to many anglers who catch a wide variety of salmon (*Oncorhynchus spp*) groundfish and rockfish (*Sebastes spp*) species. Annual fishing effort has ranged from over 660,000 boat trips in 1988 when coho salmon (*O. kisutch*) catch exceeded one million fish, to a low of 174,000 boat trips in 1998 when the coho salmon fishery was closed and chinook salmon (*O. tshawytscha*) catch rates were low (English 2001). Since 1998, angler effort has varied annually, exhibiting a general increasing trend.

The Georgia Strait creel survey has monitored recreational fishing activity throughout Georgia Strait and the Canadian portion of Juan de Fuca Strait since 1980. The survey provides monthly catch estimates for chinook and coho salmon and annual catch estimates for all species harvested in the sport fishery. The program involves stationing observers at the major landing sites across Georgia Strait to collect catch information. Aerial surveys provide counts of sport fishing boats and activity profiles are developed for each group of landing sites (Hardie *et al.* 2001). The catch per trip data generated from landing site interviews are then combined with the boat counts and activity profile information to determine total catch and release estimates, by species and DFO Statistical Area, for each month of the survey.

In 1998, an independent observer program was implemented to assess non-sampling errors that may bias the results of the Georgia Strait creel survey. Such errors include recall bias, non-response or refusal to answer interview questions and the truthfulness of answers given to creel survey interviewers. The study involved placing observers on-board recreational fishing vessels to record catch information. The results of the independent observer program were then compared to data collected by creel survey interviewers in order to assess potential biases. The primary objective of the study was to provide an independent audit of the release estimates generated by the creel survey, although both catch and release estimates were examined. There has been considerable discussion concerning the accuracy of the release estimates since they are based on an interview process that takes place after the fishing has occurred. It has been suggested that there is a strong likelihood that recall bias may significantly influence the data collected (Pollock *et al.* 1994). Some contend that the recall bias would likely cause an overestimation of releases in the creel survey since it is presumed that fishers tend to exaggerate the numbers of fish that were released.

The need for accurate catch and particularly release information has become increasingly important with the advent of two new management initiatives effecting chinook and coho salmon stocks. First, the Pacific Salmon Treaty now requires both Canada and the USA to provide a measure of total mortality for chinook salmon in sport fisheries. Second, due to coho conservation concerns, selective hatchery mark only coho recreational fisheries have been recently implemented in many areas. The intent of this management initiative is to allow the harvest of hatchery stocks while attempting to minimize exploitation on natural populations. In both these instances, there is an essential need for accurate release information since these data are used to determine total mortality and exploitation. Inaccurate release information could have

significant impacts on both chinook and coho stocks since management actions based on these data may not meet the precautionary approach required to reduce overall exploitation.

METHODOLOGY

CREEL SURVEY

The Georgia Strait creel survey has two independent components: angler interviews and aerial overflights. Landing site interviews provide data on sport fishing catch/release per boat trip along with daily fishing activity patterns. Aerial boat counts provide estimates of the total sport fishing effort in the study area at the time of the aerial survey. The point estimate of effort from the aerial survey is combined with the activity profile and expanded to total fishing effort. In its simplest form, the estimated total catch and release values are calculated by multiplying the estimated total effort by catch/release per boat trip (Hardie *et al.* 2001). For a full description of the Georgia Strait creel survey methodology see Hardie *et al.* 2003 e.g.

INDEPENDENT OBSERVER PROGRAM

Between July and September 1998, observers were randomly placed aboard recreational fishing vessels operating in the southern portion of Georgia Strait (Figure 1). As anglers were leaving launch ramps and marinas to fish, they were approached by fisheries staff and asked if an observer could be placed on board to record data associated with the days fishing activity. If an observer was accepted, they remained with the vessel until it returned to the launch site at the end of the fishing trip. In order to appropriately represent the fishing fleet in each area effort was made to place observers using the same stratification levels as in the creel survey (weekend vs. weekday), on all types of vessels (large and small, guided and non-guided) and with fishers of all different levels of experience. All data associated with each fishing trip were recorded in a manner similar to a creel survey interview. These included the DFO Statistical Area where the fishing occurred, species hooked, whether the fish was kept or released, and whether the fish was legal for retention. At the completion of the program, all data collected were entered into a relational database for analysis.

DATA COMPARISON

In order to compare the results of the creel survey and independent observer programs two general assessments were conducted. First, the raw data collected by creel survey interviewers were compared to the same data complied by the independent observers. This included a comparison of species catch composition, species specific encounter rates and angler success rates. In the second assessment, the raw data collected by creel survey interviewers and independent observers were used to generate species specific catch and release estimates following the standard creel survey methodology. These estimates were then compared for each area and month during which the study was conducted. The overall intent of the data comparison

was to first determine if both creel survey and the independent observer data were sampled from the same population, and then to assess whether there were any significant differences between the samples.

Catch Composition

The species composition of the recorded catch for both kept and released fish was determined based on creel survey interviews and on the independent observer data. Catch data were stratified into six species or species group categories that included chinook salmon, coho salmon, other salmon, groundfish, rockfish and all others species combined. These were the actual raw data as directly recorded by creel survey interviewers and independent observers. Results were compared graphically and statistically using the Chi-square test of proportions for kept fish, released fish and for all fish combined.

Encounter Rates

Total Encounters: Total encounter rates were determined for each of the six species or species groups. The total encounter rate was the total number of fish captured divided by the total number of fishing trips. Total encounters were first determined for all fish captured and then separately for kept and released fish only. For the creel survey, each interview counted as one fishing trip. In the independent observer data set, each observed outing counted as one fishing trip. Results based on creel survey interviews and on the independent observer data were compared graphically. The species specific encounter frequency distributions were then compared statistically using the Mann-Whitney U test. This non-parametric test was utilized as the encounter frequencies were highly skewed thus violating the assumption of normality required by comparable parametric tests (Zar 1996).

Angler Success: Encounter rates were further examined by determining the number and percentage of trips where at least one fish of each species or species groups was captured. This angler success rate (either a fish from the particular species or species group was encountered or it was not) was first determined for all fish captured and then separately for kept and released fish only. Results based on creel survey interviews and on the independent observer data were compared graphically and statistically assessed using the Chi-square test.

Total Catch Estimates

The final data comparison involved generating and comparing separate catch and release estimates for each species or species group using creel survey interview results and the independent observer data for each month and area. Error bounds were calculated around each estimate to allow for statistical comparisons. All calculations were carried out using the standard creel survey methodology (e.g. Hardie *et al.* 2003).

RESULTS

Between July and September 1998, on-board observers monitored a total of 191 sport fishing trips in DFO Statistical Areas 18, 19 and 20 located in the lower portion of Georgia Strait (Figure 1). The number of observer trips ranged from 18 in July to 99 in August (Table 1). A total of 141 observer trips occurred on weekdays (day type 1) while the remaining 50 observer trips occurred on weekend days (day type 2). Only two observer trips took place in DFO Statistical Area 18 while 98 and 91 trips occurred in DFO Statistical Areas 19 and 20, respectively. Over the same period and areas, a total of 1,076 creel survey interviews were conducted (Table 1). The number of creel survey interviews ranged from 275 in September to 473 in July. A total of 469 interviews occurred on weekdays while 607 were conducted weekend days. Anglers fishing in DFO Statistical Areas 18, 19 and 20 accounted for 55, 562 and 459 of the creel survey interviews, respectively (Table 1).

CATCH / RELEASE COMPOSITION

The species composition of the July to September recreational fishery catch from DFO Statistical Areas 18, 19 and 20 was determined using creel survey interviews and the independent observer data. All numbers presented are the actual recorded catch values, which have not been expanded in any way. The total catch was grouped into six categories made up of either individual species (chinook and coho salmon) or species groups (other salmon, groundfish, rockfish and other). Results indicated a higher proportion of chinook salmon, coho salmon and rockfish in the total reported independent observer catch while the catch determined by creel survey interviews showed a higher proportion of other salmon, groundfish and other species (Table 2; Figure 2). A Chi-square test of proportions revealed that the difference in species catch composition between the two samples was statistically significant (Chi-square = 179.897; $p = 0.05$). When kept and released fish were examined separately, it was revealed that there was no significant difference in species composition between the creel survey and independent observer samples for kept fish (Chi-square = 8.787; $p = 0.05$) (Table 2; Figure 3); however, released fish exhibited a highly significant difference (Chi-square = 207.862; $p = 0.05$) (Table 2; Figure 4).

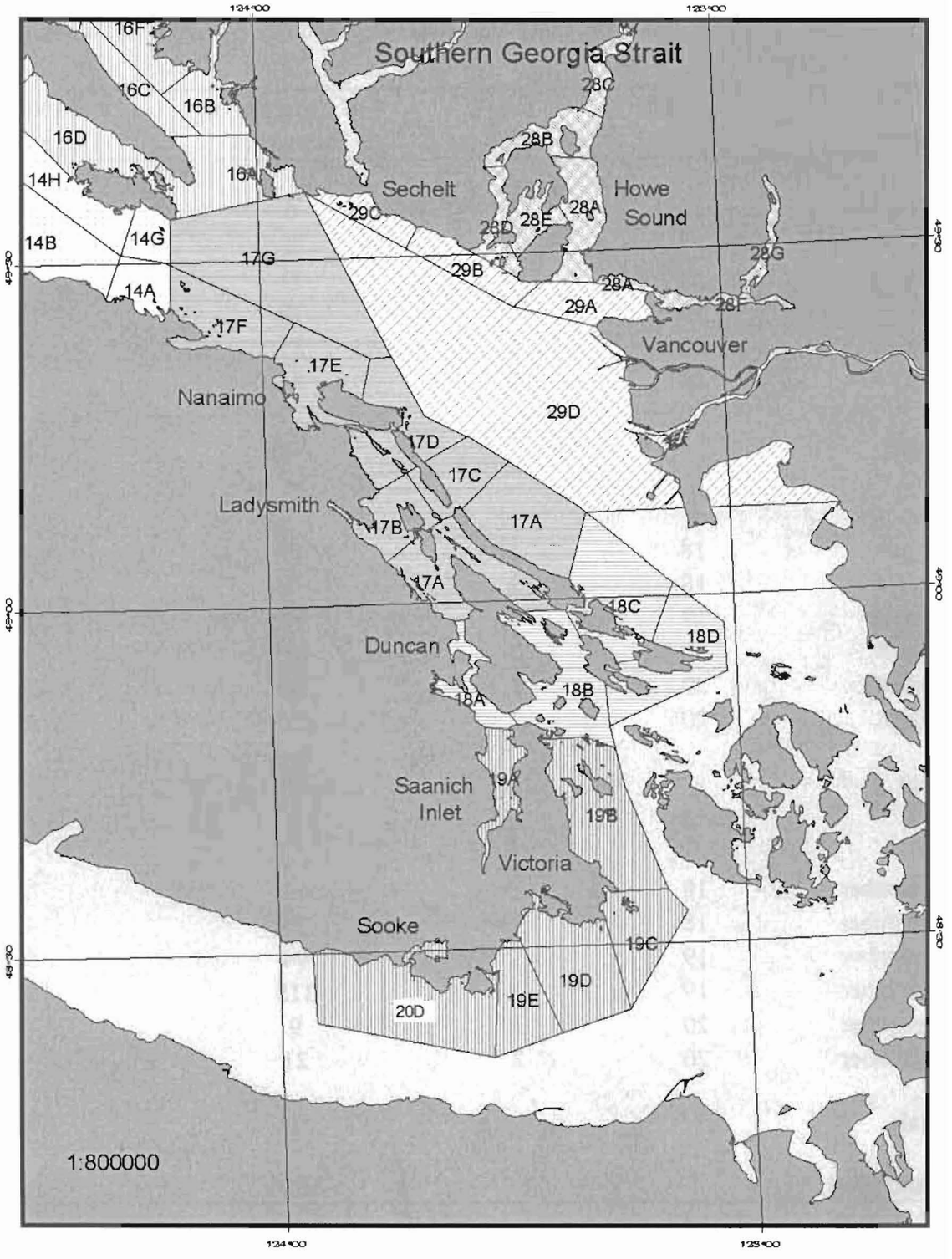

Figure 1. DFO Statistical Areas in the southern portion of Georgia Strait where the 1998 study was conducted.

Table 1. Number of creel survey interviews and independent observer trips completed during the 1998 program, by month, DFO Statistical Area, and day type (1 = weekday; 2 = weekend).

Month	Statistical Area	Day Type	# of Creel Survey Interviews	# of Independent Observer Trips
July	18	1	6	0
July	18	2	3	0
July	19	1	71	5
July	19	2	79	0
July	20	1	85	10
July	20	2	84	3
Total			328	18
August	18	1	6	0
August	18	2	4	0
August	19	1	98	17
August	19	2	105	4
August	20	1	88	57
August	20	2	172	21
Total			473	99
September	18	1	12	2
September	18	2	24	0
September	19	1	94	50
September	19	2	115	22
September	20	1	9	0
September	20	2	21	0
Total			275	74
Grand Total			1076	191

Table 2. Species composition, by encounter type, in the Georgia Strait recreational fishery from DFO Statistical Areas 18, 19 and 20 between July and September 1998, based on creel survey interviews and on independent observer data.

	Creel Survey			Independent Observer			Total		
Species	Kept	Released	Total	Kept	Released	Total	Kept	Released	Total
Chinook	149	285	434	33	105	138	182	390	572
Coho	1	215	216	0	89	89	1	304	305
Other Sal.	122	157	279	26	8	34	148	165	313
Groundfish	118	1267	1385	9	123	132	127	1390	1517
Rockfish	406	453	859	77	117	194	483	570	1053
Other	420	1160	1580	73	113	186	493	1273	1766
Total	1216	3537	4753	218	555	773	1434	4092	5526

Chi-Square Test Result	
All kept and released fish:	179.897
Kept fish only:	8.787
Released fish only:	207.862
Critical Chi-Square (df = 5; p = 0.05)	11.070

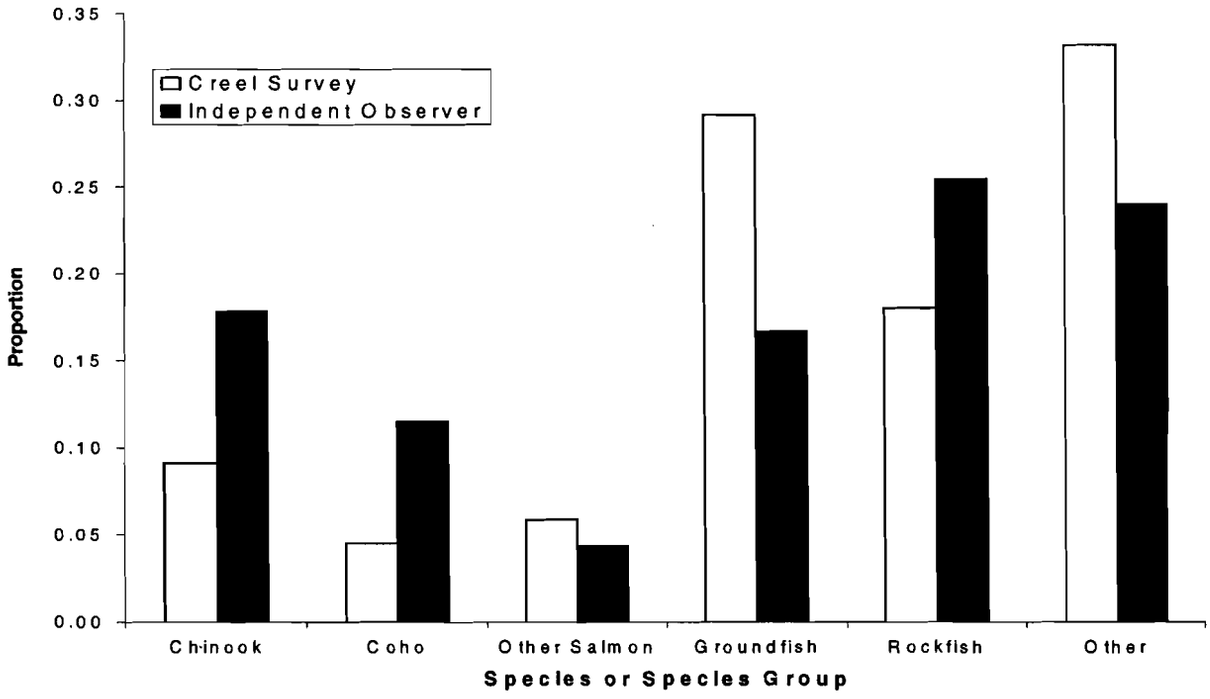

Figure 2. Composition of both kept and released fish combined from the Georgia Strait recreational fishery operating in DFO Statistical Areas 18, 19 and 20 between July and September 1998, based on creel survey interviews and on independent observer data.

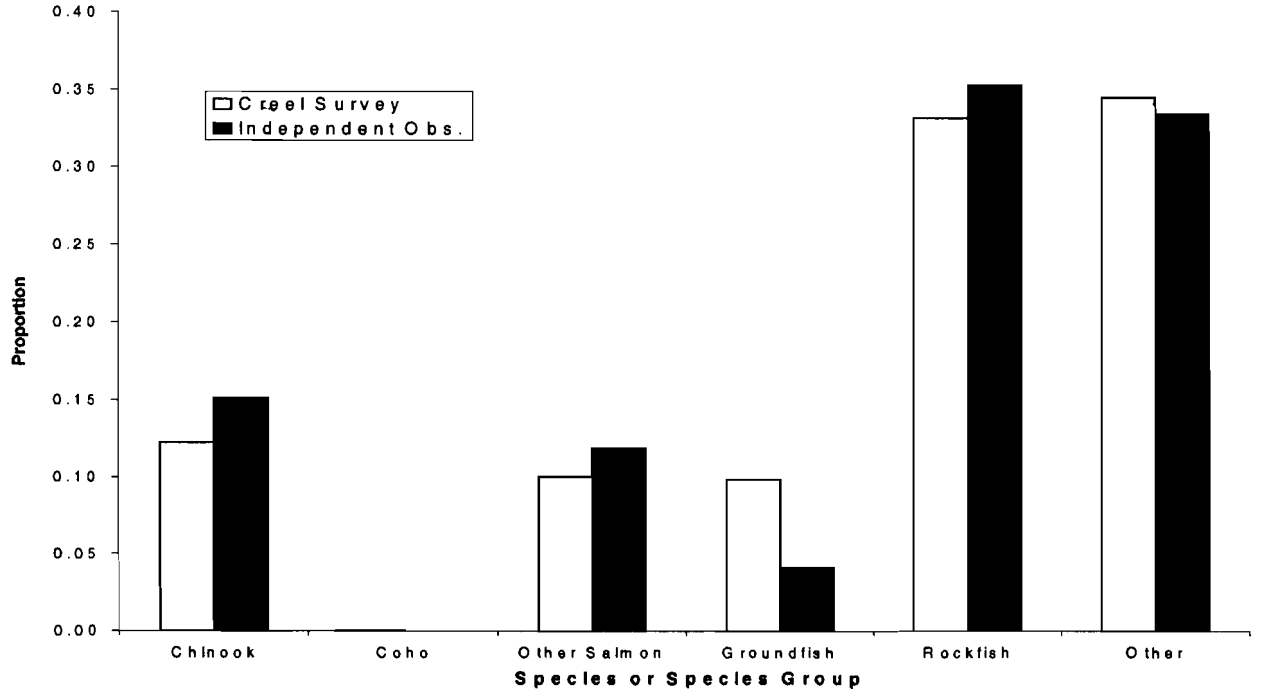

Figure 3. Composition of kept fish only from the Georgia Strait recreational fishery operating in DFO Statistical Areas 18, 19 and 20 between July and September 1998, based on creel survey interviews and on independent observer data.

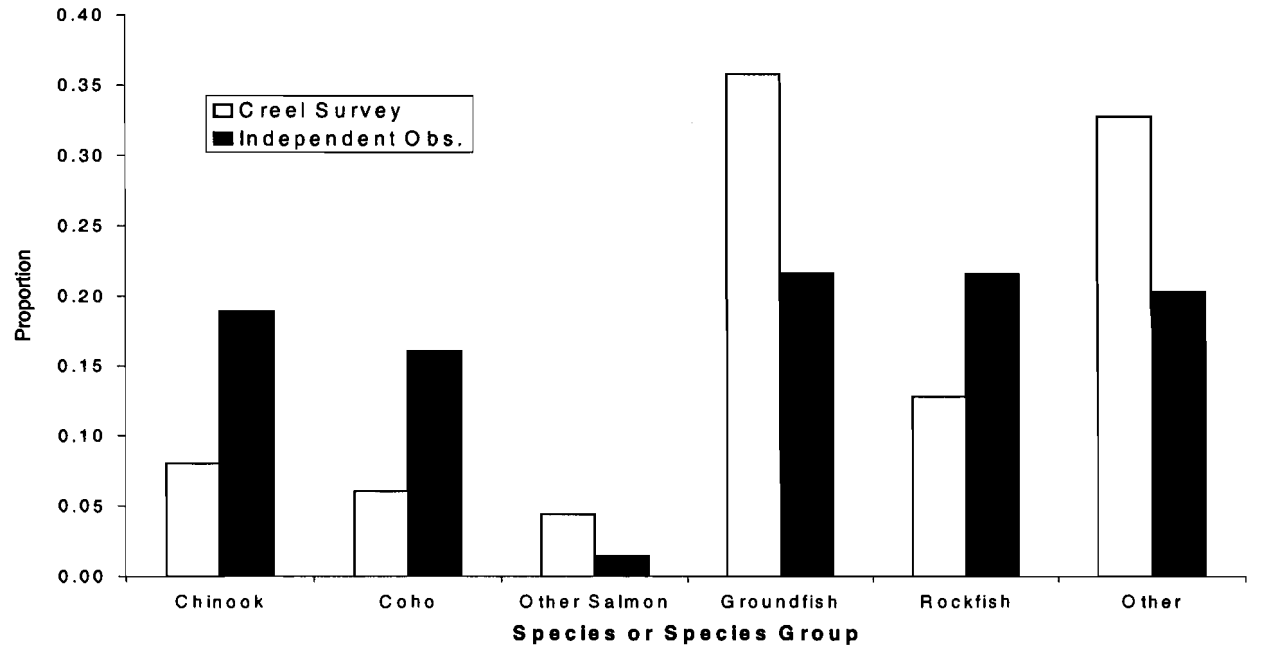

Figure 4. Composition of released fish only from the Georgia Strait recreational fishery operating in DFO Statistical Areas 18, 19 and 20 between July and September 1998, based on creel survey interviews and on independent observer data.

ENCOUNTER RATE

Total Encounters

The total encounter rates for kept and released fish combined over all areas and months were determined for each of the six species or species groups based on creel survey interviews and on the independent observer data. Total encounter rates were higher for chinook salmon, coho salmon and rockfish based on the independent observer data while groundfish, other salmon and other species encounters were higher based on creel survey interviews (Table 3; Figure 5). Chinook salmon, coho salmon, groundfish and rockfish encounter rates were further examined by comparing encounter frequency distributions using the Mann-Whitney U test (Appendix 1). Results revealed statistically significant differences between encounter frequency distributions based on creel survey interviews and independent observer data for both chinook and coho salmon. A much higher proportion of creel survey interviews reported zero chinook salmon encounters while a lower proportion reported one or more chinook salmon encounters when compared with the independent observer data (Appendix 2). A similar pattern occurred for coho salmon encounters (Appendix 2). Groundfish and rockfish total encounter rate frequency distributions based on creel survey interviews and on the independent observer data were not significantly different (Appendix 1, 2).

Table 3. Total encounter rates for all fish, kept fish only and released fish only, by species or species group, based on creel survey interviews and on the independent observer data.

	Creel Survey			Independent Observer		
Species Or Group	All Fish	Kept Only	Released Only	All Fish	Kept Only	Released Only
Chinook	0.403	0.138	0.265	0.723	0.173	0.550
Coho	0.201	0.001	0.200	0.466	0.000	0.466
Other Salmon	0.259	0.113	0.146	0.178	0.136	0.042
Groundfish	1.287	0.110	1.178	0.691	0.047	0.644
Rockfish	0.798	0.377	0.421	1.016	0.403	0.613
Other	1.468	0.390	1.078	0.974	0.382	0.592
Total	4.417	1.130	3.287	4.047	1.141	2.906

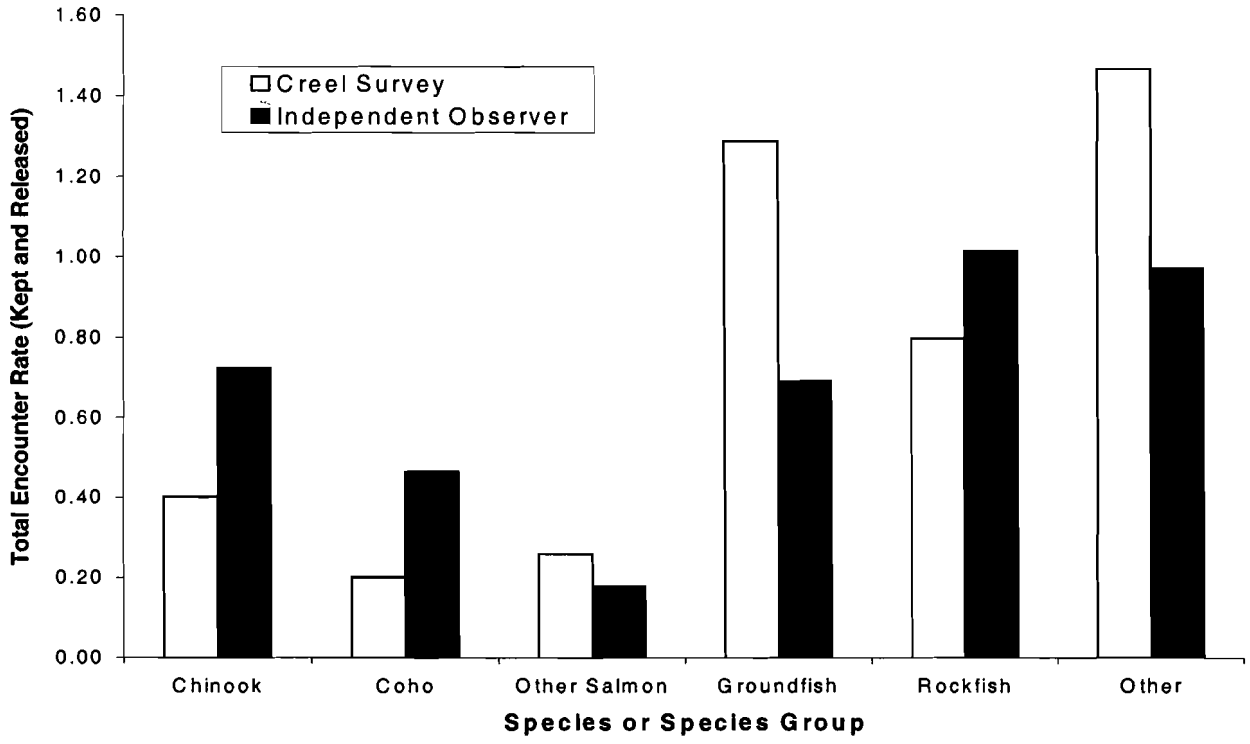

Figure 5. Total encounter rate for all kept and released fish combined, by species or species group, based on creel survey interviews and on the independent observer data.

The total encounter rates for kept fish only over all areas and months combined were determined for each species or species groups based on creel survey interviews and on the independent observer data. Since the fishery was closed to the retention of coho salmon, this species was omitted from the assessment. Total encounter rates were slightly higher for chinook salmon, other salmon and rockfish based on the independent observer data while groundfish encounters were higher based on creel survey interviews (Table 3; Figure 6). The total encounter rates for the "other species" group were very similar based on the two data sets (Figure 6). Chinook salmon, groundfish and rockfish encounter rates for kept fish only were further examined by comparing encounter frequency distributions using the Mann-Whitney U test (Appendix 3). Results revealed no statistically significant differences between encounter frequency distributions based on creel survey interviews and independent observer data for kept chinook salmon, groundfish or rockfish (Appendix 3, 4).

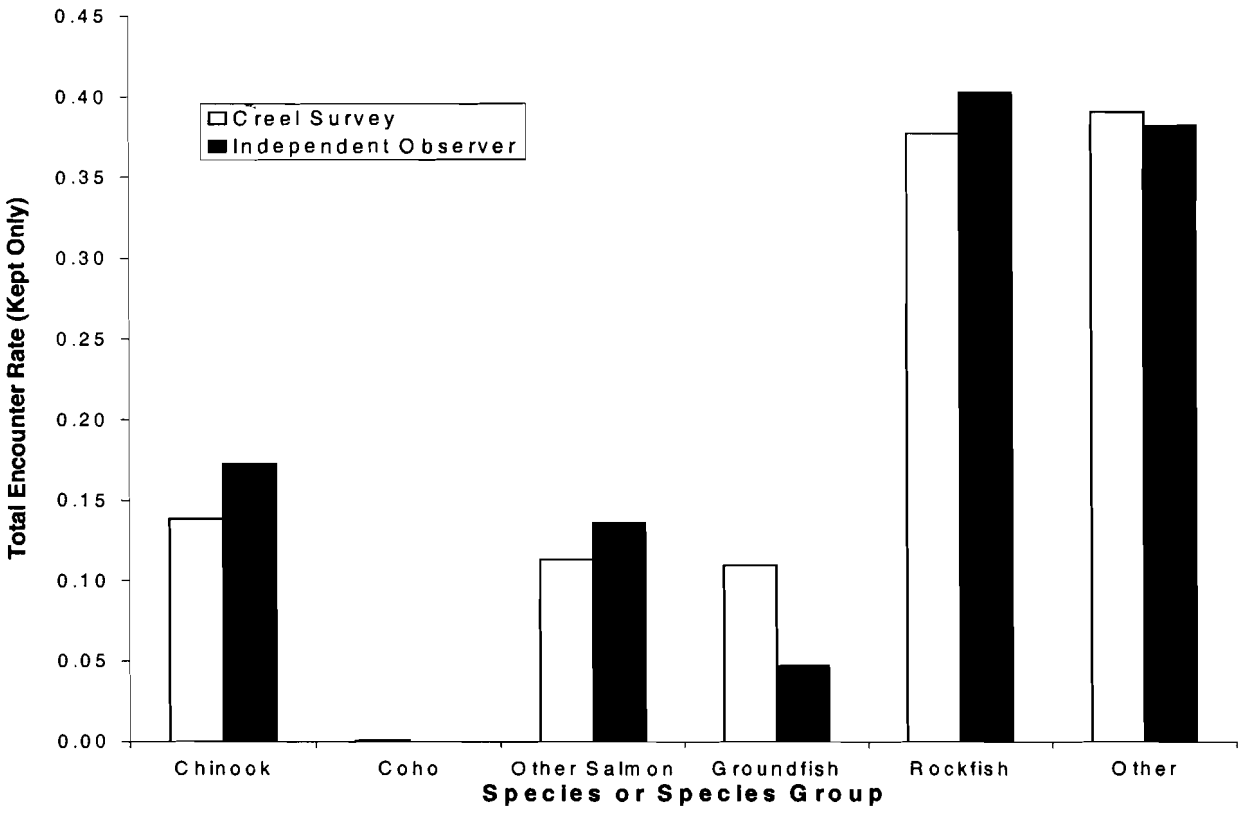

Figure 6. Total encounter rate for kept fish only, by species or species group, based on creel survey interviews and on the independent observer data.

The total encounter rates for released fish only over all areas and months combined were determined for each of the six species or species groups based on creel survey interviews and on the independent observer data. Total encounter rates were higher for chinook salmon, coho salmon and rockfish based on the independent observer data while groundfish, other salmon and other species encounters were higher based on creel survey interviews (Table 3; Figure 7). Chinook salmon, coho salmon, groundfish and rockfish encounter rates were further examined by comparing encounter frequency distributions using the Mann-Whitney U test. Results revealed statistically significant differences between encounter frequency distributions for released fish only based on creel survey interviews and independent observer data for chinook and coho salmon and for rockfish (Appendix 5). In each case, a higher proportion of creel survey interviews reported zero releases while a lower proportion reported one or more releases when compared with the independent observer data (Appendix 6). Groundfish release distributions based on creel survey interviews and on the independent observer data were not significantly different (Appendix 5, 6).

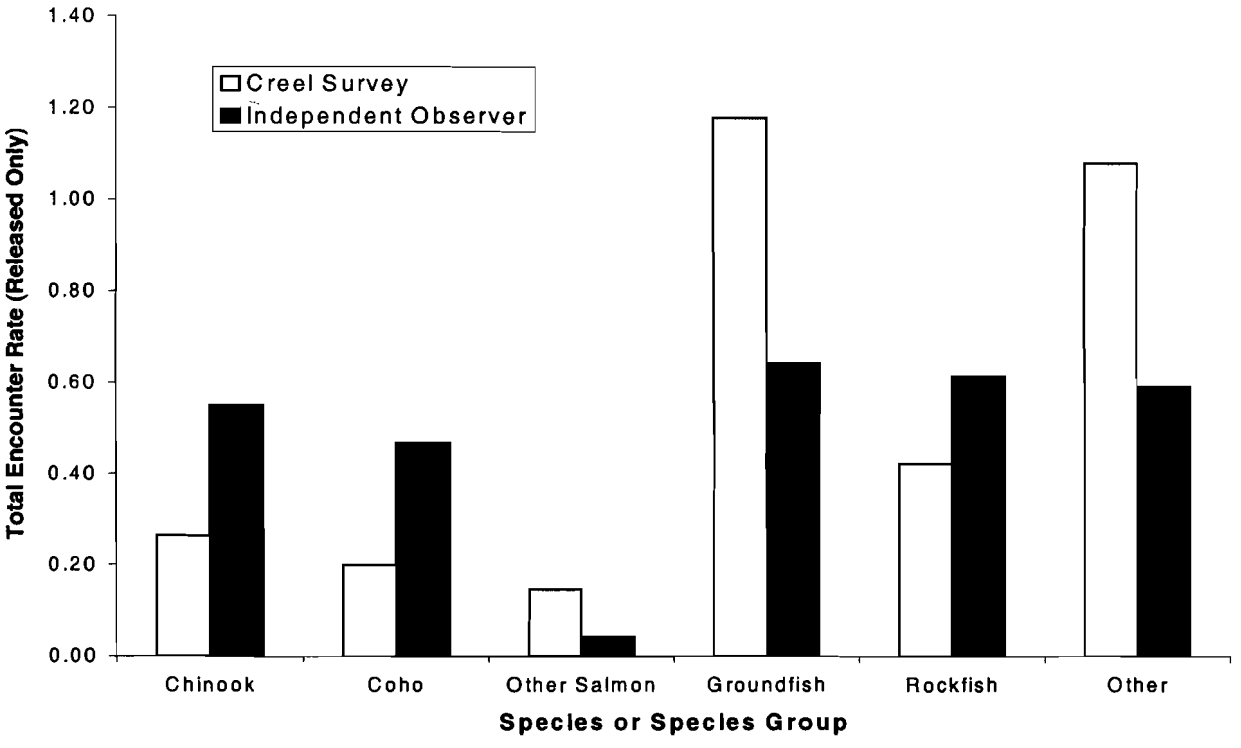

Figure 7. Total encounter rate for released fish only, by species or species group, based on creel survey interviews and on the independent observer data.

Angler Success

Encounters were further examined by determining the number and percentage of trips where at least one fish was encountered for each species or species group based on creel survey interviews and on the independent observer data. This measure of angler success removes extreme values from the data set and simply determines if a trip resulted in the angler hooking at least one fish. In the first analysis, all encounters were included regardless of whether the fish was kept or released. Results indicated that a higher percentage of independent observer trips reported at least one chinook salmon, coho salmon, groundfish, rockfish or other species encountered when compared to creel survey interviews (Figure 8; Table 4). Chi-square test results revealed that the differences were statistically significant for chinook and coho salmon (Table 4).

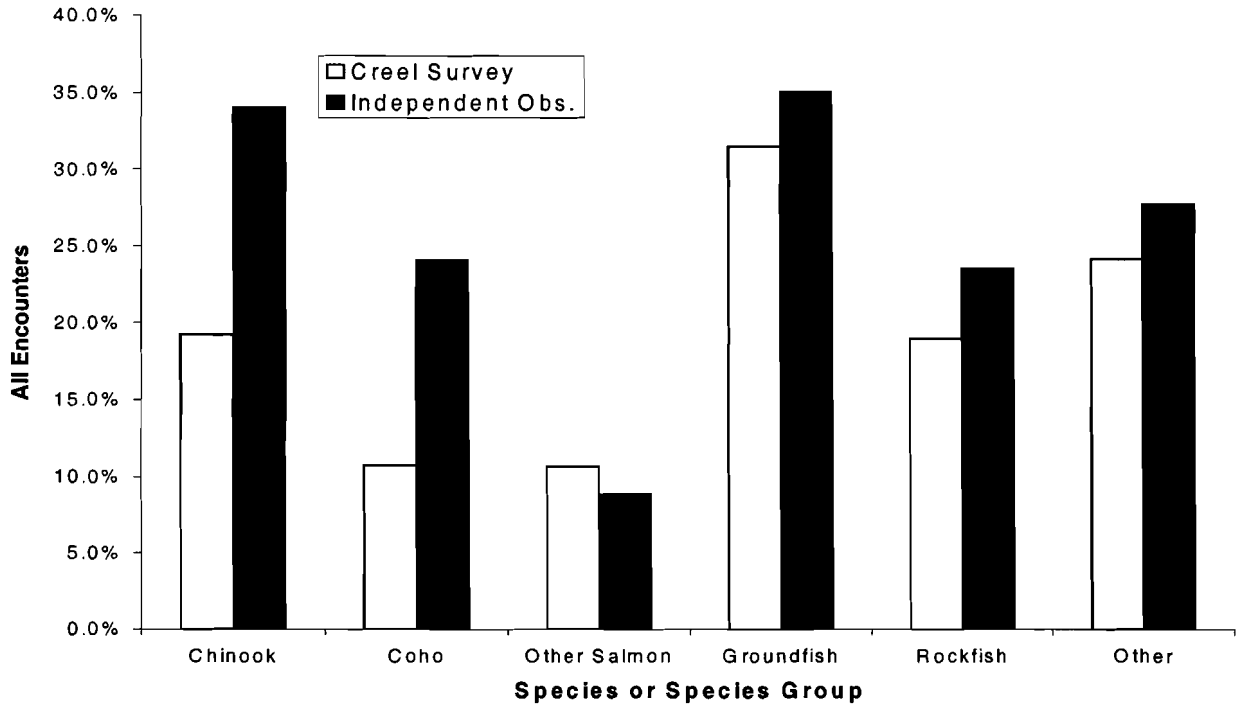

Figure 8. Percentage of trips reporting at least one fish encountered (kept or released), by species or species group, based on creel survey interviews and on the independent observer data.

The number and percentage of fishing trips where at least one fish was encountered and kept was determined based on creel survey interviews and on the independent observer data. Results indicated that a higher percentage of independent observer trips reported at least one chinook salmon, other salmon or other species encountered and kept when compared to creel survey interviews (Figure 9; Table 5). However, Chi-square test results revealed that the differences were not statistically significant for any of the species or species groups (Table 5).

The number and percentage of fishing trips where at least one fish was encountered and released was determined based on creel survey interviews and on the independent observer data. Results indicated that a higher percentage of independent observer trips reported at least one chinook salmon, coho salmon, groundfish, rockfish and other species encountered and released when compared to creel survey interviews (Figure 10; Table 6). A higher percentage of creel survey interviews reported at least one other salmon encountered and released (Figure 10). Chi-square test results revealed that the differences were statistically significant for chinook salmon, coho salmon, other salmon, and rockfish (Table 6).

Table 4. Number and percentage of trips where at least one fish was encountered, by species or species group, based on creel survey interview responses and on the independent observer data. Chi-square test results are presented.

	Fishing Trips					
	Creel Survey		Independent Observer		Total	
	#	%	#	%	#	%
Chinook						
At Least One Fish Kept or Rel.	207	19.2%	65	34.0%	272	21.5%
No Fish Encountered	869	80.8%	126	66.0%	995	78.5%
Chi-Square Test Result:						**20.187**
Coho						
At Least One Fish Kept or Rel.	116	10.8%	46	24.1%	162	12.8%
No Fish Encountered	960	89.2%	145	75.9%	1105	87.2%
Chi-Square Test Result:						**24.563**
Other Salmon						
At Least One Fish Kept or Rel.	115	10.7%	17	8.9%	132	10.4%
No Fish Encountered	981	91.2%	174	91.1%	1155	91.2%
Chi-Square Test Result:						0.292
Groundfish						
At Least One Fish Kept or Rel.	339	31.5%	67	35.1%	406	32.0%
No Fish Encountered	737	68.5%	124	64.9%	861	68.0%
Chi-Square Test Result:						0.794
Rockfish						
At Least One Fish Kept or Rel.	204	19.0%	45	23.6%	249	19.7%
No Fish Encountered	872	81.0%	146	76.4%	1018	80.3%
Chi-Square Test Result:						1.893
Other						
At Least One Fish Kept or Rel.	260	24.2%	53	27.7%	313	24.7%
No Fish Encountered	816	75.8%	138	72.3%	954	75.3%
Chi-Square Test Result:						0.936
Critical Chi-Square for all test results (P = 0.05)						3.841

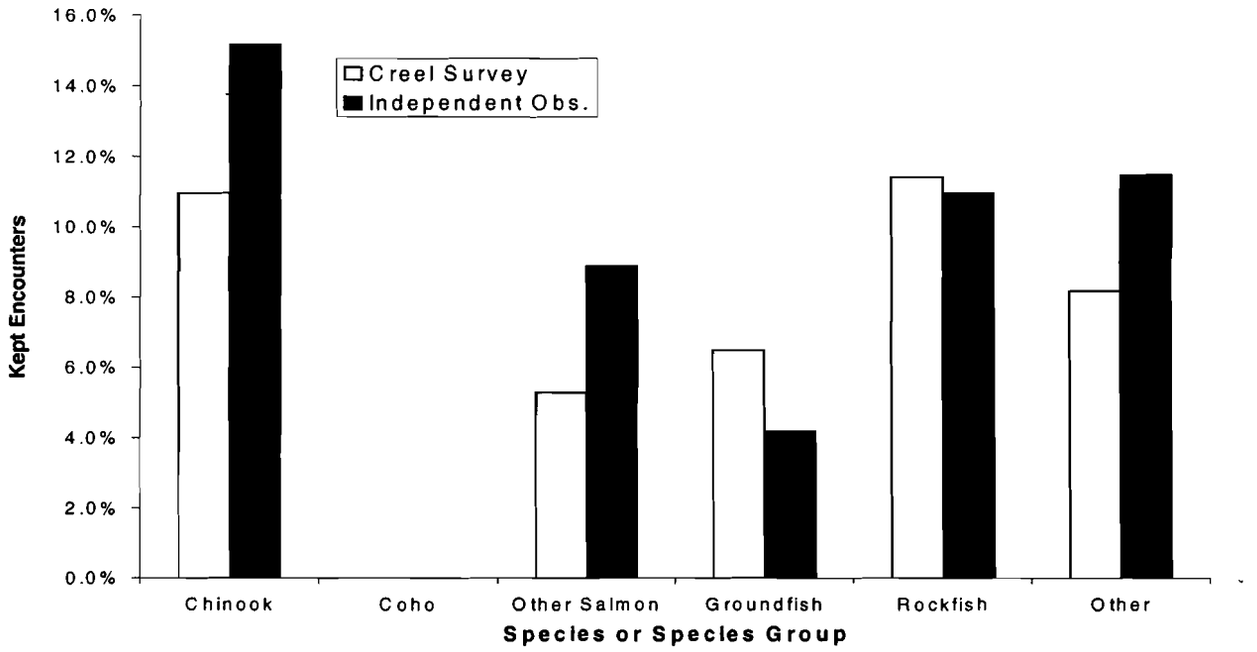

Figure 9. Percentage of trips reporting at least one fish encountered and kept, by species or species group, based on creel survey interviews and on the independent observer data.

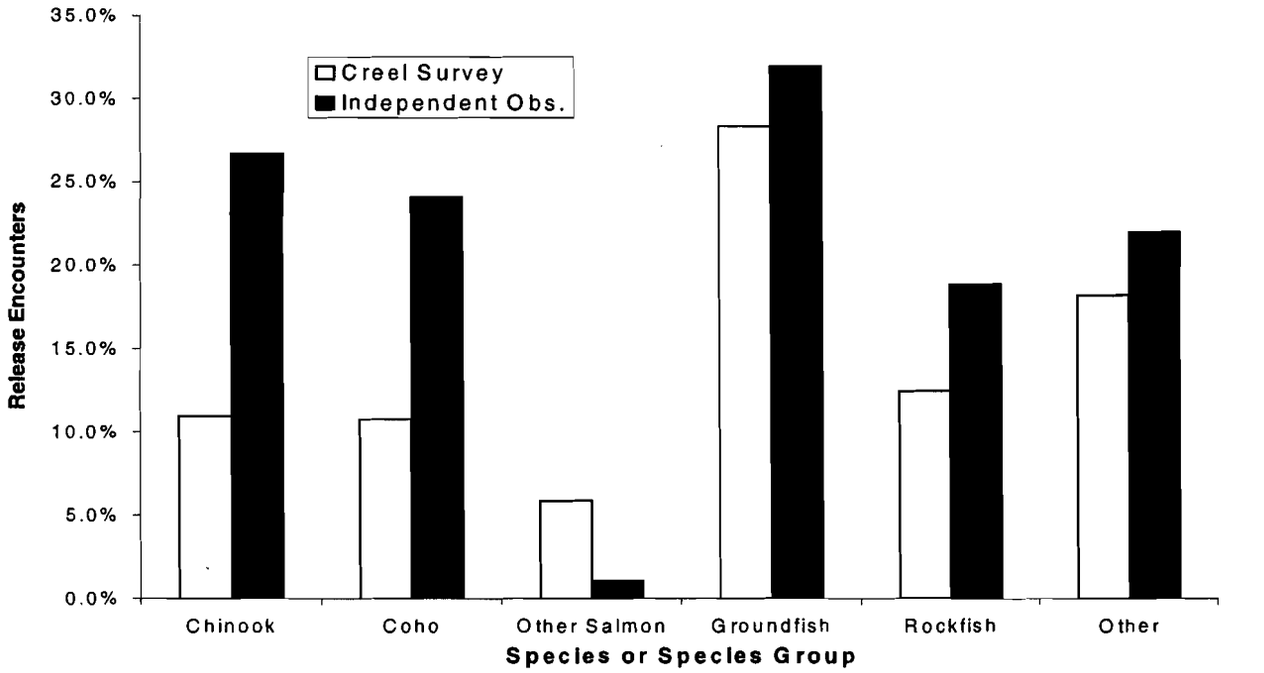

Figure 10. Percentage of trips reporting at least one fish encountered and released, by species or species group, based on creel survey interviews and on the independent observer data.

Table 5. Number and percentage of trips where at least one fish was encountered and kept, by species or species group, based on creel survey interview responses and on the independent observer data. Chi-square test results are presented.

	Fishing Trips					
	Creel Survey		Independent Observer		Total	
	#	%	#	%	#	%
Chinook						
At Least One Fish Kept	118	11.0%	29	15.2%	147	11.6%
No Fish Encountered and Kept	958	89.0%	162	84.8%	1120	88.4%
Chi-Square Test Result:						2.416
Other Salmon						
At Least One Fish Kept	57	5.3%	17	8.9%	74	5.8%
No Fish Encountered and Kept	1019	94.7%	174	91.1%	1193	94.2%
Chi-Square Test Result:						3.202
Groundfish						
At Least One Fish Kept	70	6.5%	8	4.2%	78	6.2%
No Fish Encountered and Kept	1006	93.5%	183	95.8%	1189	93.8%
Chi-Square Test Result:						1.133
Rockfish						
At Least One Fish Kept	123	11.4%	21	11.0%	144	11.4%
No Fish Encountered and Kept	953	88.6%	170	89.0%	1123	88.6%
Chi-Square Test Result:						0.003
Other						
At Least One Fish Kept	88	8.2%	22	11.5%	110	8.7%
No Fish Encountered and Kept	988	91.8%	169	88.5%	1157	91.3%
Chi-Square Test Result:						1.880
Critical Chi-Square for all test results (P = 0.05)						3.841

Table 6. Number and percentage of trips where at least one fish was encountered and released, by species or species group, based on creel survey interview responses and on the independent observer data. Chi-square test results are presented.

	Fishing Trips					
	Creel Survey		Independent Observer		Total	
	#	%	#	%	#	%
Chinook						
At Least One Fish Released	118	11.0%	51	26.7%	169	13.3%
No Fish Encountered and Rel.	958	89.0%	140	73.3%	1098	86.7%
Chi-Square Test Result:						**33.395**
Coho						
At Least One Fish Released	116	10.8%	46	24.1%	162	12.8%
No Fish Encountered and Rel.	960	89.2%	145	75.9%	1105	87.2%
Chi-Square Test Result:						**24.563**
Other Salmon						
At Least One Fish Released	63	5.9%	2	1.0%	65	5.1%
No Fish Encountered and Rel.	1013	94.1%	189	99.0%	1202	94.9%
Chi-Square Test Result:						**6.748**
Groundfish						
At Least One Fish Released	305	28.3%	61	31.9%	366	28.9%
No Fish Encountered and Rel.	771	71.7%	130	68.1%	901	71.1%
Chi-Square Test Result:						0.851
Rockfish						
At Least One Fish Released	134	12.5%	36	18.8%	170	13.4%
No Fish Encountered and Rel.	942	87.5%	155	81.2%	1097	86.6%
Chi-Square Test Result:						**5.172**
Other						
At Least One Fish Released	196	18.2%	42	22.0%	238	18.8%
No Fish Encountered and Rel.	880	81.8%	149	78.0%	1029	81.2%
Chi-Square Test Result:						1.277
Critical Chi-Square for all test results (P = 0.05)						3.841

CATCH/RELEASE ESTIMATES

The total number of chinook salmon that were kept and released by the recreational fishery operating in DFO Statistical Areas 19 and 20 between July and September was estimated separately based on creel survey interviews and the independent observer data. All estimates and error bounds were determined using the standard Georgia Strait creel survey methodology (e.g. Hardie *et al.* 2003). Estimates of the total number of chinook salmon kept by anglers were higher based on creel survey interviews in three of the month and area strata while the remaining two catch estimates were higher based on the independent observer data (Table 7, Figure 11). When the estimated numbers of chinook salmon kept by anglers were summed across all areas and months, the total based on the creel survey interviews was 3,819 chinook while the total based on the independent observer data was 3,356 chinook.

Estimates of the total number of chinook salmon released by anglers based on the independent observer data were higher than estimates based on creel survey interviews in four of the five month/area strata. In two of these cases, the independent observer point estimate was above the upper error bound of the creel survey estimate and in one case, the error bounds did not overlap (Table 7; Figure 12). This last scenario occurred during August in DFO Statistical Area 20 when the highest number of chinook salmon encounters were recorded. When estimated chinook salmon releases were summed across areas and month, the total based on the creel survey interviews was 6,681 chinook while the total based on the independent observer data was 11,242 chinook.

Since the fishery was closed to the retention of coho salmon, no estimates were made of the total number of coho kept by anglers. Estimates of the total number of coho salmon released by anglers were higher based on the independent observer data in all five of the month and area strata (Table 8; Figure 13). In four of the five cases, the independent observer point estimate was above the upper error bound of the creel survey estimate and in two of these cases, the error bounds did not overlap (Table 8; Figure 13). When estimated coho salmon releases were summed across areas and month, the total based on the creel survey interviews was 7,383 coho while the total based on the independent observer data was 12,361 coho.

Table 7. Monthly estimates of kept and released chinook salmon and associated error values for DFO Statistical Areas 19 and 20 based on creel survey interviews and on the independent observer data.

Area 19

	Chinook Kept							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	154	82	236	72	130	79	209	51
Aug	286	87	373	199	152	93	245	59
Sep	281	104	385	177	446	233	679	213

	Chinook Released							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	311	182	493	129	325	232	557	93
Aug	634	265	899	369	837	253	1090	584
Sep	968	302	1270	666	704	363	1067	341

Area 20

	Chinook Kept							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	1460	379	1839	1081	965	537	1502	428
Aug	1638	259	1897	1379	1663	683	2346	980

	Chinook Released							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	1348	625	1973	723	2572	1824	4396	748
Aug	3420	632	4052	2788	6804	1523	8327	5281

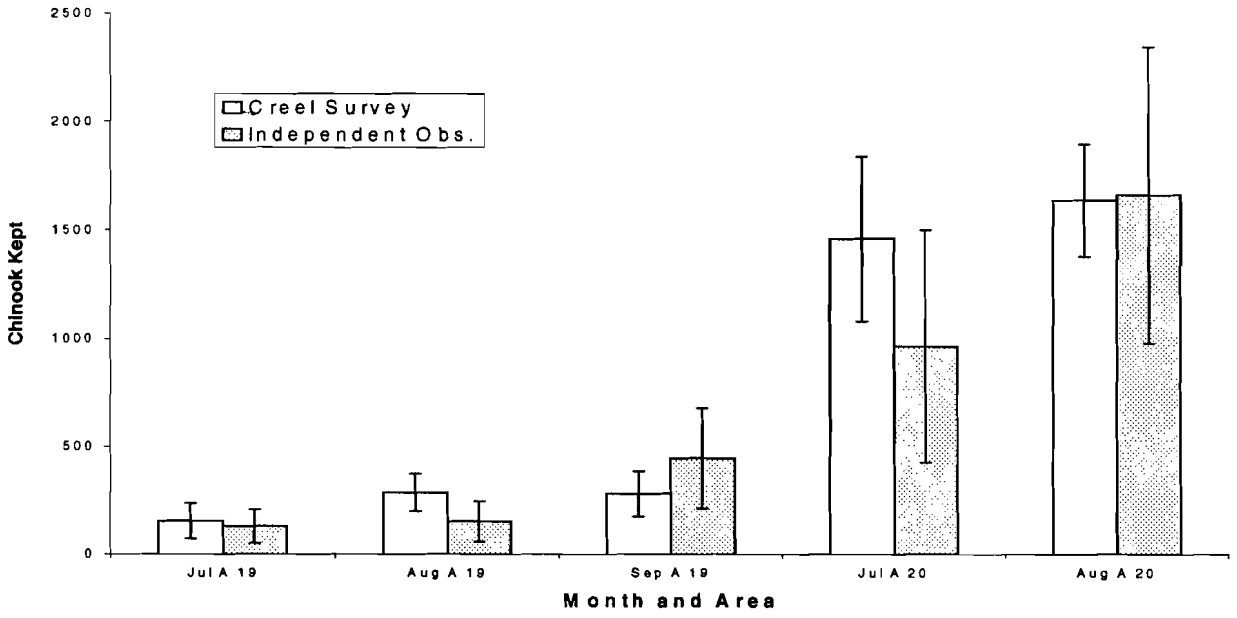

Figure 11. Monthly estimates and associated error values for kept chinook salmon from DFO Statistical Areas 19 and 20 based on creel survey interviews and on the independent observer data.

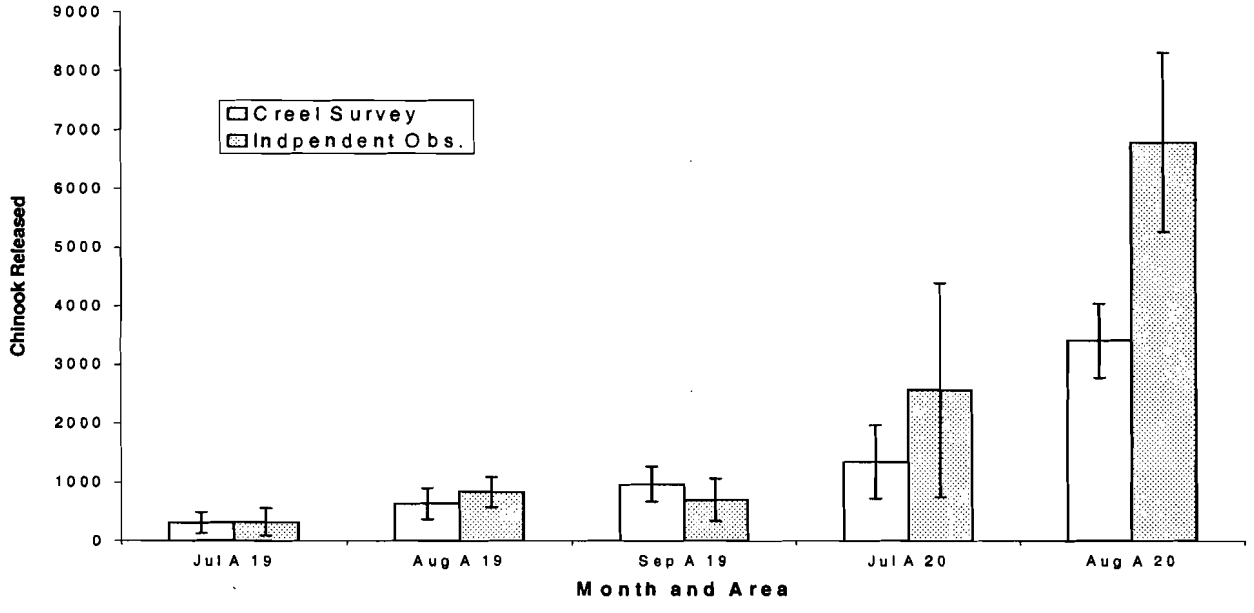

Figure 12. Monthly estimates and associated error values for released chinook salmon from DFO Statistical Areas 19 and 20 based on creel survey interviews and on the independent observer data.

Table 8. Monthly estimates of released coho salmon and associated error values for DFO Statistical Areas 19 and 20 based on creel survey interviews and on the independent observer data.

Area 19

	Coho Released							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	221	94	315	127	726	291	1017	435
Aug	241	143	384	99	580	261	840	319
Sep	649	197	846	451	779	336	1115	443

Area 20

	Coho Released							
	Creel Survey				Independent Obs.			
Month	Est.	Err.	High	Low	Est.	Err.	High	Low
Jul	3465	973	4438	2492	5150	1767	6918	3383
Aug	2807	503	3311	2304	5126	1745	6871	3381

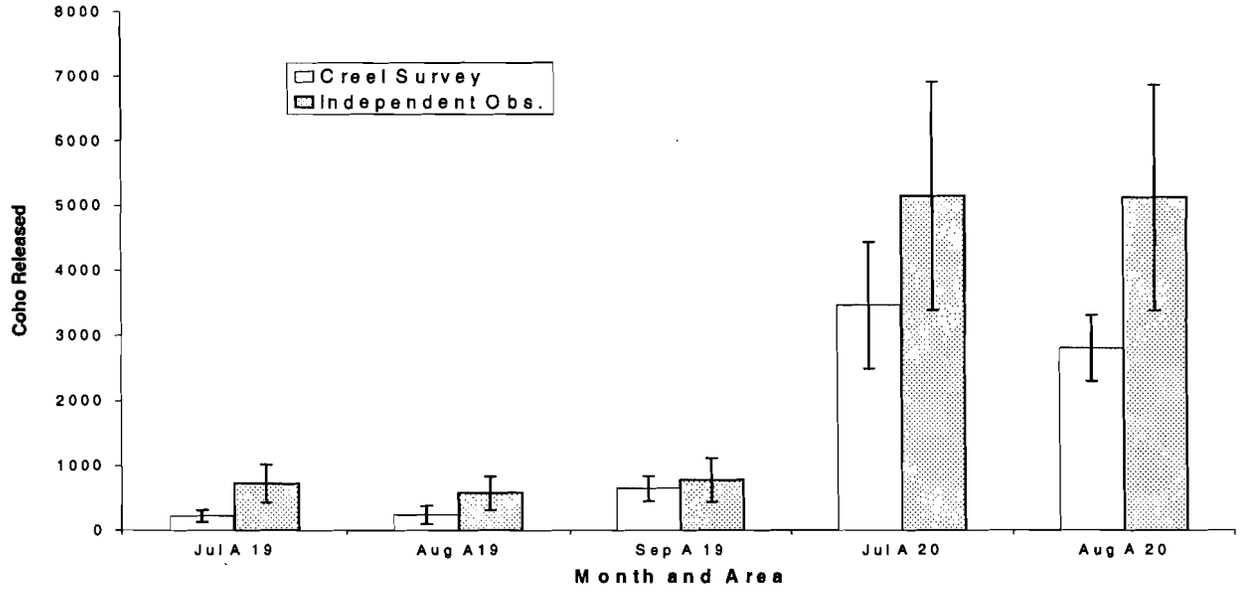

Figure 13. Monthly estimates and associated error values for released coho salmon from DFO Statistical Areas 19 and 20 based on creel survey interviews and on the independent observer data.

DISCUSSION

Recreational angler surveys are important for providing sound information on which to base fisheries management decisions. One assumption of all surveys is that angler interviews provide accurate catch and release data, which relies on angler recall and truthfulness (Pollock 2001). Some surveys have noted discrepancies in angler honesty and have postulated that these occur for a variety of reasons (Palermo 2001). The goal of the current study was to assess potential biases in interview responses. The monitoring of 191 recreational angling trips by on-board observers represented a reasonable sample of the total angling effort for the same areas and months. The observed catch and release information generated by the program provided an independent sample for comparison with creel survey interviews. Since our goal was to assess biases in interview responses, the direct monitoring of 191 angling trips was likely sufficient to detect any consistent directional bias in the interview response data set.

The species composition of the total recreational fishery catch (kept and released fish) differed based on creel survey interview responses and on the independent observer data. When the results were stratified by kept and released fish the difference was not statistically significant for kept fish but was highly significant for released fish. Since creel survey staff inspect all kept fish, it follows that survey results accurately reflect catch rates for kept fish. The consistency in the species composition of kept fish between creel survey interview responses and the independent observer data indicates that the creel survey accurately reflects the number of fish kept by anglers. It also suggests that anglers included in the independent observer group were representative of the general angling population.

The highly significant difference in species composition between the creel survey interview responses and the independent observer data for released fish suggests that creel survey responses may not be reflective of the true released fish population. Since on-board observers recorded each encounter as it occurred, it follows that this record of released fish more accurately represents the true composition of the released fish population. The differences that were observed between the two data sets suggest that angler recall of encounters that resulted in the release of a fish may not have reflected the true number of releases.

Encounter frequency distributions based on creel survey interview responses and the independent observer data were compared using the Mann-Whitney test. This non-parametric test was used due to the highly skewed nature of the data. The Mann-Whitney test is one of the most powerful non-parametric tests available. When either the Mann-Whitney test or the t-test is applicable, the former is about 95% as powerful as the latter and when the assumptions of the t-test are seriously violated the Mann-Whitney test may be much more powerful (Zar 1996). For total encounters of kept fish, there were no statistically significant differences between creel survey interview responses and the independent observer data for any of the species or species groups. For total encounters of released fish, significantly more chinook salmon, coho salmon and rockfish were recorded as encountered and released based on the independent observer data. This result strongly suggests that while the creel survey accurately estimates the number of fish kept by anglers, it likely underestimates the number of chinook salmon, coho salmon and rockfish that are caught and released by anglers fishing in the southern portion of Georgia Strait.

Encounters were further examined by determining the number and percentage of trips that encountered at least one fish in each of the species or species group categories based on creel survey interview responses and on the independent observer data. This assessment simply compared the number of successful versus unsuccessful fishing trips regardless of the number of fish encountered. Since extreme values were removed from this analysis, a more reflective picture of the overall degree of fishing success within each group was revealed. For encounters that resulted in a fish being kept, there were no significant differences between creel survey interview responses and the independent observer data. The lack of difference between samples again suggests that the anglers included in the independent observer group were representative of the overall angling population and that the creel survey accurately estimates the number of fish kept by anglers.

Creel survey and independent observer encounters that resulted in at least one fish being released were compared using the same methodology. Results indicated that significantly more independent observer trips encountered and released at least one chinook salmon, coho salmon or rockfish. Since creel survey interviews depend on angler recall accuracy and truthfulness to determine species specific release values while independent observer data were recorded immediately as each release occurred, it follows that the creel survey likely underestimated the number of fishing trips resulting in the capture and release of these species. While a significantly higher number of creel survey interviews recorded at least one "other salmon" encountered and released, only two independent observer trips were included in the assessment of this group thus limiting the strength of the result.

Estimates of the total recreational catch by area and month were determined based on creel survey interview responses and on the independent observer data. While differences in the estimates of chinook salmon kept based on the two methods showed no clear trend, estimates of the number of chinook released were higher based on the independent observer data in four of the five area and month strata. The same pattern was evident for coho salmon as the estimates of releases based on the independent observer data were higher in all five of the area and month strata. When total estimated releases of coho and chinook salmon were summed across areas and months, release estimates based on the independent observer data were approximately 40% higher than those based on creel survey interview responses. This result suggests that the creel survey may be significantly underestimating the number of chinook and coho salmon that are released by anglers. If the true release values are of the magnitude indicated by the independent observer program, then the overall impact of the recreational fishery on vulnerable chinook and coho stocks may be much greater than current estimates suggest.

The potential for the creel survey to underestimate total chinook and coho releases may have a significant impact on the total mortality estimates generated from these data. Further study is needed to assess the magnitude of the potential underestimates in other areas and times. In addition, drop-off mortality (mortality associated with the catch and release activity caused by predators) is not currently included in post-release mortality values for either chinook or coho salmon (Diewert *et al.* 2002). If creel survey release underestimation is coupled with post-

release drop-off mortality, the overall measure of total mortality and exploitation currently utilized by fishery managers might be substantially less than the true value.

ACKNOWLEDGEMENTS

We thank all the fishers (guides and non-guided anglers) in the Victoria area that participated in the on-water independent observer program for their cooperation and helpful assistance. We also thank the local marinas that were involved in allowing the observers access to the fishing fleet. We thank LGL Ltd. (Victoria) for coordinating the data collection component of this study. Ted Carter, DFO fishery monitoring technician, reviewed the manuscript and provided helpful editorial comments and Rob Houtman, DFO fishery monitoring analyst, provided helpful analytical and statistical suggestions.

REFERENCES

DFO Unpublished Report. 1998. WCVI Creel Survey Verification Program, 1998.

Diewert, R.E., Nagtegaal, D.A., and Patterson, J. 2002. Results of a marine recreational chinook and coho catch and release mortality study conducted in the lower Strait of Georgia during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2625: 32p.

English, K. 2001. Strait of Georgia sport fishery and creel survey program 1980 - 1999. *In:* Proceedings of the 2000 creel workshop. Edited by J. C. Sturhahn and D. A. Nagtegaal. Can. Manuscr. Rep. Fish. Aquat. Sci. 2558: 40p.

Hardie, D.C., Nagtegaal, D.A., and Nagy, L. 2001. Strait of Georgia and Northern Vancouver Island sport fishery creel survey statistics for salmon and groundfish, 1999. Can Manuscr. Rep. Fish. Aquat. Sci. 2553: 111p.

Hardie, D.C., Nagtegaal, D.A, Hein, K., and Nagy, L. 2003. Strait of Georgia and Vancouver Island sport fishery creel survey statistics for salmon and groundfish, 2001. Can Manuscr. Rep. Fish. Aquat. Sci. 2640: 107p.

Palermo, V. 2001. Lower Fraser River and Harrison River survey. *In:* Proceedings of the 2000 creel workshop. Edited by J. C. Sturhahn and D. A. Nagtegaal. Can. Manuscr. Rep. Fish. Aquat. Sci. 2558: 40p.

Pollock, K. 2001. Georgia Strait recreational angler survey review. *In:* Proceedings of the 2000 creel workshop. Edited by J. C. Sturhahn and D. A. Nagtegaal. Can. Manuscr. Rep. Fish. Aquat. Sci. 2558: 40p.

Pollock, K.H., Jones, C.M., and Brown, T.L. 1994. Angler Survey Methods and their Applications in Fisheries Management. Am. Fish. Soc. Spec. Publ. 25.

Zar, J.H. 1996. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

APPENDICES

Appendix 1. Mann-Whitney U test results of the comparison of species specific encounter rates for kept and released fish combined based on creel survey interviews and independent observer data.

Chinook

Observations (x) in Chin CS all = 1076 median = 0 rank sum = 669032
Observations (y) in Chin IO all = 191 median = 0
U = 89606 U' = 115910

Normalised statistic = -3.792585 (adjusted for ties)
Lower side P < 0.0001 (H_1: x tends to be less than y)
Upper side P > 0.9999 (H_1: x tends to be greater than y)
Two sided P = 0.0001 (H_1: x tends to be distributed differently to y)

Coho

Observations (x) in Coho CS all = 1076 median = 0 rank sum = 668396.5
Observations (y) in Coho IO all = 191 median = 0
U = 88970.5 U' = 116545.5

Normalised statistic = -5.089454 (adjusted for ties)
Lower side P < 0.0001 (H_1: x tends to be less than y)
Upper side P > 0.9999 (H_1: x tends to be greater than y)
Two sided P < 0.0001 (H_1: x tends to be distributed differently to y)

Groundfish

Observations (x) in GDF CS all = 1076 median = 0 rank sum = 685566
Observations (y) in GDF IO all = 191 median = 0
U = 106140 U' = 99376

Normalised statistic = 0.834008 (adjusted for ties)
Lower side P = 0.7979 (H_1: x tends to be less than y)
Upper side P = 0.2021 (H_1: x tends to be greater than y)
Two sided P = 0.4043 (H_1: x tends to be distributed differently to y)

Rockfish

Observations (x) in RKF CS all = 1076 median = 0 rank sum = 679846.5
Observations (y) in RKF IO all = 191 median = 0
U = 100420.5 U' = 105095.5

Normalised statistic = -0.652745 (adjusted for ties)
Lower side P = 0.257 (H_1: x tends to be less than y)
Upper side P = 0.743 (H_1: x tends to be greater than y)
Two sided P = 0.5139 (H_1: x tends to be distributed differently to y)

Appendix 2. Frequency distributions for total encounters of all fish combined (kept and released) based creel survey interviews and on the independent observer data.

Frequency analysis for Chinook Creel Survey interview data:
Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	840	78.066914	840	78.066914
1	147	13.66171	987	91.728625
2	43	3.996283	1030	95.724907
3	21	1.951673	1051	97.67658
4	10	0.929368	1061	98.605948
5	7	0.650558	1068	99.256506
6	2	0.185874	1070	99.442379
7	1	0.092937	1071	99.535316
8	3	0.27881	1074	99.814126
10	2	0.185874	1076	100

Frequency analysis for Chinook Independent Observer data:
Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	126	65.968586	126	65.968586
1	34	17.801047	160	83.769634
2	16	8.376963	176	92.146597
3	7	3.664921	183	95.811518
4	3	1.570681	186	97.382199
5	3	1.570681	189	98.95288
9	1	0.52356	190	99.47644
15	1	0.52356	191	100

Appendix 2. (continued)

Frequency analysis for Coho Creel Survey interview data:
Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	959	89.126394	959	89.126394
1	72	6.69145	1031	95.817844
2	27	2.509294	1058	98.327138
3	7	0.650558	1065	98.977695
4	2	0.185874	1067	99.163569
5	3	0.27881	1070	99.442379
6	2	0.185874	1072	99.628253
7	2	0.185874	1074	99.814126
10	2	0.185874	1076	100

Frequency analysis for Coho Independent Observer data:
Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	145	75.91623	145	75.91623
1	26	13.612565	171	89.528796
2	7	3.664921	178	93.193717
3	7	3.664921	185	96.858639
4	3	1.570681	188	98.429319
5	2	1.04712	190	99.47644
6	1	0.52356	191	100

Appendix 2. (continued)

Frequency analysis for Groundfish Creel Survey interview data:
Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	668	62.081784	668	62.081784
1	160	14.869888	828	76.951673
2	87	8.085502	915	85.037175
3	56	5.204461	971	90.241636
4	22	2.04461	993	92.286245
5	20	1.858736	1013	94.144981
6	23	2.137546	1036	96.282528
7	2	0.185874	1038	96.468401
8	8	0.743494	1046	97.211896
9	1	0.092937	1047	97.304833
10	10	0.929368	1057	98.234201
12	3	0.27881	1060	98.513011
14	1	0.092937	1061	98.605948
15	6	0.557621	1067	99.163569
20	2	0.185874	1069	99.349442
21	1	0.092937	1070	99.442379
24	1	0.092937	1071	99.535316
25	3	0.27881	1074	99.814126
30	1	0.092937	1075	99.907063
40	1	0.092937	1076	100

Frequency analysis for Groundfish Independent Observer data:
Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	117	61.256545	117	61.256545
1	46	24.08377	163	85.340314
2	12	6.282723	175	91.623037
3	11	5.759162	186	97.382199
4	1	0.52356	187	97.905759
5	2	1.04712	189	98.95288
6	1	0.52356	190	99.47644
9	1	0.52356	191	100

Appendix 2. (continued)

Frequency analysis for Rockfish Creel Survey interview data:
Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	803	74.628253	803	74.628253
1	93	8.643123	896	83.271375
2	69	6.412639	965	89.684015
3	35	3.252788	1000	92.936803
4	17	1.579926	1017	94.516729
5	15	1.394052	1032	95.910781
6	17	1.579926	1049	97.490706
7	2	0.185874	1051	97.67658
8	9	0.836431	1060	98.513011
9	1	0.092937	1061	98.605948
10	7	0.650558	1068	99.256506
11	1	0.092937	1069	99.349442
12	3	0.27881	1072	99.628253
13	1	0.092937	1073	99.72119
15	1	0.092937	1074	99.814126
18	1	0.092937	1075	99.907063
20	1	0.092937	1076	100

Frequency analysis for Rockfish Independent Observer data:
Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	137	71.727749	137	71.727749
1	27	14.136126	164	85.863874
2	8	4.188482	172	90.052356
3	3	1.570681	175	91.623037
4	2	1.04712	177	92.670157
5	1	0.52356	178	93.193717
6	5	2.617801	183	95.811518
8	4	2.094241	187	97.905759
13	1	0.52356	188	98.429319
15	1	0.52356	189	98.95288
17	1	0.52356	190	99.47644
22	1	0.52356	191	100

Appendix 3. Mann-Whitney U test results of the comparison of species specific encounter rates for kept fish only based on creel survey interviews and independent observer data.

Chinook

Observations (x) in CS Chin Enc Kept = 1076 median = 0 rank sum = 678019.5
Observations (y) in IO Chin Enc Kept = 191 median = 0
U = 98593.5 U' = 106922.5

Normalised statistic = -1.609237 (adjusted for ties)
Lower side P = 0.0538 (H_1: x tends to be less than y)
Upper side P = 0.9462 (H_1: x tends to be greater than y)
Two sided P = 0.1076 (H_1: x tends to be distributed differently to y)

Groundfish

Observations (x) in CS GDF Enc Kept = 1076 median = 0 rank sum = 684739
Observations (y) in IO GDF Enc Kept = 191 median = 0
U = 105313 U' = 100203

Normalised statistic = 1.308509 (adjusted for ties)
Lower side P = 0.9046 (H_1: x tends to be less than y)
Upper side P = 0.0954 (H_1: x tends to be greater than y)
Two sided P = 0.1907 (H_1: x tends to be distributed differently to y)

Rockfish

Observations (x) in CS RKF Enc Kept = 1076 median = 0 rank sum = 682202
Observations (y) in IO RKF Enc Kept = 191 median = 0
U = 102776 U' = 102740

Normalised statistic = 0.006677 (adjusted for ties)
Lower side P = 0.5027 (H_1: x tends to be less than y)
Upper side P = 0.4973 (H_1: x tends to be greater than y)
Two sided P = 0.9947 (H_1: x tends to be distributed differently to y)

Appendix 4. Frequency distributions for total kept fish encounters based on creel survey interviews and on the independent observer data.

Frequency analysis for Chinook Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	958	89.033457	958	89.033457
1	94	8.736059	1052	97.769517
2	18	1.672862	1070	99.442379
3	5	0.464684	1075	99.907063
4	1	0.092937	1076	100

Frequency analysis for Chinook Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	162	84.816754	162	84.816754
1	26	13.612565	188	98.429319
2	2	1.04712	190	99.47644
3	1	0.52356	191	100

Frequency analysis for Groundfish Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	1005	93.401487	1005	93.401487
1	44	4.089219	1049	97.490706
2	15	1.394052	1064	98.884758
3	7	0.650558	1071	99.535316
4	3	0.27881	1074	99.814126
5	1	0.092937	1075	99.907063
6	1	0.092937	1076	100

Appendix 4. (continued).

Frequency analysis for Groundfish Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	183	95.811518	183	95.811518
1	7	3.664921	190	99.47644
2	1	0.52356	191	100

Frequency analysis for Rockfish Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	939	87.267658	939	87.267658
1	56	5.204461	995	92.472119
2	28	2.60223	1023	95.074349
3	15	1.394052	1038	96.468401
4	10	0.929368	1048	97.39777
5	6	0.557621	1054	97.95539
6	8	0.743494	1062	98.698885
7	2	0.185874	1064	98.884758
8	7	0.650558	1071	99.535316
9	1	0.092937	1072	99.628253
10	1	0.092937	1073	99.72119
11	1	0.092937	1074	99.814126
13	1	0.092937	1075	99.907063
18	1	0.092937	1076	100

Frequency analysis for Rockfish Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	167	87.434555	167	87.434555
1	6	3.141361	173	90.575916
2	8	4.188482	181	94.764398
3	5	2.617801	186	97.382199
6	4	2.094241	190	99.47644
16	1	0.52356	191	100

Appendix 5. Mann-Whitney U test results of the comparison of species specific encounter rates for released fish only based on creel survey interviews and independent observer data.

Chinook

Observations (x) in CS Chin Enc Rel = 1076 median = 0 rank sum = 666388.5
Observations (y) in IO Chin Enc Rel = 191 median = 0
U = 86962.5 U' = 118553.5

Normalised statistic = -5.738608 (adjusted for ties)
Lower side P < 0.0001 (H_1: x tends to be less than y)
Upper side P > 0.9999 (H_1: x tends to be greater than y)
Two sided P < 0.0001 (H_1: x tends to be distributed differently to y)

Coho

Observations (x) in CS Coho Enc Rel = 1076 median = 0 rank sum = 668311
Observations (y) in IO Coho Enc Rel = 191 median = 0
U = 88885 U' = 116631

Normalised statistic = -5.134596 (adjusted for ties)
Lower side P < 0.0001 (H_1: x tends to be less than y)
Upper side P > 0.9999 (H_1: x tends to be greater than y)
Two sided P < 0.0001 (H_1: x tends to be distributed differently to y)

Groundfish

Observations (x) in CS GDF Enc Rel = 1076 median = 0 rank sum = 681155.5
Observations (y) in IO GDF Enc Rel = 191 median = 0
U = 101729.5 U' = 103786.5

Normalised statistic = -0.266893 (adjusted for ties)
Lower side P = 0.3948 (H_1: x tends to be less than y)
Upper side P = 0.6052 (H_1: x tends to be greater than y)
Two sided P = 0.7896 (H_1: x tends to be distributed differently to y)

Rockfish

Observations (x) in CS RKF Enc Rel = 1076 median = 0 rank sum = 673264
Observations (y) in IO RKF Enc Rel = 191 median = 0
U = 93838 U' = 111678

Normalised statistic = -3.168903 (adjusted for ties)
Lower side P = 0.0008 (H_1: x tends to be less than y)
Upper side P = 0.9992 (H_1: x tends to be greater than y)
Two sided P = 0.0015 (H_1: x tends to be distributed differently to y)

Appendix 6 Frequency distributions for total released fish encounters based on creel survey interviews and on the independent observer data.

Frequency analysis for Chinook Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	958	89.033457	958	89.033457
1	53	4.925651	1011	93.959108
2	25	2.32342	1036	96.282528
3	16	1.486989	1052	97.769517
4	9	0.836431	1061	98.605948
5	7	0.650558	1068	99.256506
6	2	0.185874	1070	99.442379
7	1	0.092937	1071	99.535316
8	3	0.27881	1074	99.814126
10	2	0.185874	1076	100

Frequency analysis for Chinook Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	140	73.298429	140	73.298429
1	26	13.612565	166	86.910995
2	16	8.376963	182	95.287958
3	2	1.04712	184	96.335079
4	5	2.617801	189	98.95288
9	1	0.52356	190	99.47644
12	1	0.52356	191	100

Appendix 6. (continued).

Frequency analysis for Coho Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	960	89.219331	960	89.219331
1	71	6.598513	1031	95.817844
2	27	2.509294	1058	98.327138
3	7	0.650558	1065	98.977695
4	2	0.185874	1067	99.163569
5	3	0.27881	1070	99.442379
6	2	0.185874	1072	99.628253
7	2	0.185874	1074	99.814126
10	2	0.185874	1076	100

Frequency analysis for Coho Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	145	75.91623	145	75.91623
1	26	13.612565	171	89.528796
2	7	3.664921	178	93.193717
3	7	3.664921	185	96.858639
4	3	1.570681	188	98.429319
5	2	1.04712	190	99.47644
6	1	0.52356	191	100

Appendix 6. (continued).

Frequency analysis for Groundfish Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	739	68.680297	739	68.680297
1	116	10.780669	855	79.460967
2	72	6.69145	927	86.152416
3	49	4.553903	976	90.70632
4	19	1.765799	995	92.472119
5	19	1.765799	1014	94.237918
6	22	2.04461	1036	96.282528
7	2	0.185874	1038	96.468401
8	8	0.743494	1046	97.211896
9	1	0.092937	1047	97.304833
10	10	0.929368	1057	98.234201
12	3	0.27881	1060	98.513011
14	1	0.092937	1061	98.605948
15	6	0.557621	1067	99.163569
20	2	0.185874	1069	99.349442
21	1	0.092937	1070	99.442379
24	1	0.092937	1071	99.535316
25	3	0.27881	1074	99.814126
30	1	0.092937	1075	99.907063
40	1	0.092937	1076	100

Frequency analysis for Groundfish Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	122	63.874346	122	63.874346
1	42	21.989529	164	85.863874
2	12	6.282723	176	92.146597
3	10	5.235602	186	97.382199
4	2	1.04712	188	98.429319
5	2	1.04712	190	99.47644
9	1	0.52356	191	100

Appendix 6. (continued).

Frequency analysis for Rockfish Creel Survey data:

Total = 1076

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	940	87.360595	940	87.360595
1	37	3.438662	977	90.799257
2	41	3.810409	1018	94.609665
3	20	1.858736	1038	96.468401
4	7	0.650558	1045	97.118959
5	9	0.836431	1054	97.95539
6	9	0.836431	1063	98.791822
8	2	0.185874	1065	98.977695
10	6	0.557621	1071	99.535316
12	3	0.27881	1074	99.814126
15	1	0.092937	1075	99.907063
20	1	0.092937	1076	100

Frequency analysis for Rockfish Independent Observer data:

Total = 191

Value	Frequency	Relative %	Cumulative	Cumulative Relative %
0	149	78.010471	149	78.010471
1	25	13.089005	174	91.099476
2	3	1.570681	177	92.670157
3	4	2.094241	181	94.764398
4	1	0.52356	182	95.287958
5	3	1.570681	185	96.858639
6	2	1.04712	187	97.905759
7	1	0.52356	188	98.429319
9	1	0.52356	189	98.95288
11	1	0.52356	190	99.47644
16	1	0.52356	191	100