Sportfishery Information for Managing Glacier Bay National Park and Preserve

Volume 1

Catch, Harvest, and Effort for the Gustavus and Elfin Cove Sportfishery in the Cross Sound and Icy Strait Region of Northern Southeast Alaska during 2003

Final Report to the National Park Service
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Purpose of Study

Glacier Bay National Park and Preserve (GBNPP) ("Park") is located in northern Southeast Alaska. The Park includes Glacier Bay proper (north of Point Carolus and Point Gustavus), the marine waters of Icy Strait and Cross Sound (including Dundas Bay and Excursion Inlet), and marine waters three miles offshore along the outer coast from Cape Spencer north to Cape Fairweather. Charter sportfishing operations and a small number of private recreational anglers based in the communities of Gustavus and Elfin Cove operate primarily throughout the Cross Sound/Icy Strait region. These anglers generally fish during the summer months (June through mid-September) for halibut (*Hippoglossus stenolepis*), salmon (*Oncorhynchus* spp.*),* rockfish (*Sebastes* spp.), and lingcod (*Ophiodon elongates*).

The Alaska Department of Fish and Game (ADF&G) and the National Park Service (NPS) are responsible for managing sportfishing in the Cross Sound/Icy Strait and GBNPP regions. The NPS claims proprietary jurisdiction for marine waters within GBNPP and is institutionally mandated to insure that sportfishing activities do not damage Park resources. However, ADF&G is the principal agency responsible for management of the region's sportfish resources.

Sportfishing activity in this area is currently assessed using two methods: (1) An annual ADF&G mail survey of randomly selected holders of Alaska fishing licenses, and (2) separate logbook programs instituted by ADF&G and NPS for charterfishing guides operating throughout Southeast Alaska and within the Park, respectively. Although an NPS permit is required when operating commercially in the Park, there is anecdotal evidence of unpermitted recreational charterfishing activity in Park waters.

The annual mail surveys and logbook programs instituted by the ADF&G and NPS are inadequate for monitoring and assessing sportfishing effort and harvest within GBNPP. For instance, the statistical areas used in the ADF&G's mail survey and logbook program, for which effort and harvest data are reported, align poorly with Park boundaries. Moreover, the validity of these self-reported data remains unverified and the volume of unpermitted charterfishing activity within Park waters remains unknown. Thus, patterns of sportfishing use and harvest in GBNPP and the Cross Sound/Icy Strait region of northern Southeast Alaska are poorly understood.

The NPS initiated a task agreement in 2002 with the University of Washington School of Marine Affairs (UW-SMA) against the Pacific Northwest Cooperative Ecosystem Studies Unit (PNW CESU) cooperative agreement. The task agreement outlined two distinct projects:

(1) Develop and conduct a creel survey of charter sportfishing use in the Park, and

(2) Develop and test a mail and phone survey to collect recreational angler catch information for Glacier Bay proper.

Both projects were conducted cooperatively by the UW-SMA, PNW CESU, and GBNPP. This report focuses on the creel survey (Project 1), for which the UW-SMA was primarily responsible. The mail and phone surveys, for which the PNW CESU was primarily responsible, are not discussed in this report but can be found in Osterhoudt et al. (2004).

The geographic range of the creel survey did not include the Preserve and included only a small portion of the Park (i.e., excluding Glacier Bay proper and the outer coast portion from Icy Point to Cape Fairweather). The survey was organized around the following objectives:

(1) Estimate halibut, salmon, and rockfish catch for waters within and adjacent to the Park in Cross Sound and Ict Strait,

(2) Estimate bottom- and salmon-fishing effort within and adjacent to the Park, and

(3) Describe catch and effort by locality, port (Gustavus and Elfin Cove), fishing type (bottom or salmon fishing), and trip type (charter or private).

Methods

Creel censuses were conducted at the Gustavus dock and in the community of Elfin Cove during the summers of 2002 and 2003. The geographic bounds of the study area included all marine waters in Excursion Inlet, Icy Passage, North Passage, Dundas Bay, North Inian Pass, Cross Sound, the western half of Icy Strait, and the outer coast to Icy Point. Creel technicians collected catch, harvest, and effort data from charter and private marine anglers as boats returned to homeports at the end of their fishing trips. For each interviewed boating party, creel technicians recorded the total number of rods, hours fished, fishing locations, trip type (charter or private), and fishing type (bottom or salmon fishing) on water-resistant optical scan forms designed by the ADF&G. The creel census at the Gustavus dock was accomplished cooperatively by UW-SMA and ADF&G, using ADF&G's survey methodology and assisted by an ADF&G creel technician at the Gustavus dock location. The Gustavus creel census also utilized aerial data from the Outer Waters Vessel Activity Survey (OWVAS) on the distribution, identity, and activity of charter vessels in Park waters to quantify reporting errors by charter anglers.

Results

- **Overall sportfishing effort:** Gustavus charter anglers accounted for most (76%) sportfishing effort. Gustavus and Elfin Cove anglers spent 60–75% of their total fishing effort pursuing groundfish (halibut, lingcod, rockfish).

- **Within-Park fishing effort:** Charter fishing effort in Park waters accounted for 2% of the total estimated fishing effort for Gustavus and Elfin Cove combined. Gustavus charter anglers accounted for 76% of the total reported effort in Park waters. Anglers fishing in Park waters generally pursued groundfish.

- **Halibut and salmon catch by homeport:** Gustavus charter anglers harvested 2.6 times more halibut than Elfin Cove *charter* anglers and Gustavus private anglers combined. Similarly, Gustavus charter anglers caught 1.4 times more salmon than Elfin Cove charter anglers and Gustavus private anglers combined.

- **Groundfish catch by homeport:** Elfin Cove charter anglers accounted for the vast majority of groundfish harvests (i.e., 86% of lingcod, 79% of yelloweye rockfish, and 69% of all other rockfish).

- **Within-Park fishing location by homeport:** When fishing in Park waters, Gustavus anglers generally occupied areas directly adjacent to Glacier Bay proper (near Point Gustavus and Point Carolus, and north of Lemesurier Island), whereas Elfin Cove anglers focused their within-Park fishing effort in Dundas Bay and around the Inian Islands and Yakobi Island.

- **Within-Park salmon and groundfish catch:** Almost no salmon or rockfish were caught in Park waters. Of the total dogfish catch, 10% (53 sharks) was reported released in Dundas Bay.

- **Within-Park halibut catch:** Gustavus charter operators underreported halibut catch in Park waters by approximately 19%. However, halibut catch and harvest in Park waters were lower than in surrounding state waters of Cross Sound and Icy Strait.

- **Halibut size at harvest**: Halibut landed in Gustavus were, on average, larger than those landed in Elfin Cove. The largest halibut were caught directly adjacent to Glacier Bay proper.

- **Rockfish age at harvest:** Estimated median age for harvested yelloweye rockfish was 48 years. Rockfish between 20 and 24 years and 100+ years (estimated) comprised most of the rockfish harvest. However, because these estimates are based on various assumptions outlined in this paper, they should be interpreted *only* as a general representation of rockfish age at harvest.

Recommendations

• **Continue creel sampling program at the Gustavus Pier in cooperation with the ADF&G.** Cooperation between the two agencies resulted in a sharing of data and costs and provided sportfishery information for both Park and state waters. Many rockfish, halibut, and salmon stocks impacted by sportfishing pressure likely use both state and Park waters.

• **Mesh future creel-survey programs with fishery-independent methods.** Fishery-independent methods (such as boat-based methods or aerial surveys) in conjunction with dockside creel surveys may quantify misreporting. Sportfishing and OWVAS data indicated that a large portion of charter sportfishing activity in Park waters was not reported. Cooperation between the ADF&G and the Park could provide independent validation at a reduced cost for each agency.

• **Determine species composition and mortality of released rockfish.** Rockfish caught below 10 fathoms have very high mortality rates. Because a large number of rockfish were released within and adjacent to Park waters, mortality is probably much higher than indicated by harvest statistics due to release mortality. Placing observers aboard charter vessels would fill this data need. The National Marine Fisheries Service is currently considering observer programs for Gulf of Mexico charter fisheries that may provide a model for an observer program that could be initiated by the Park. An observer program would undoubtedly enhance compliance with fishery regulations and NPS commercial permitting requirements.

• **Conduct fishery-independent assessments of halibut size, movement, and local abundance within Glacier Bay proper and adjacent state waters.** A standardized assessment (e.g., longline surveys) of halibut abundance, distribution, and size may be a quantitatively sound method for determining the effect of Glacier Bay proper as a halibut refuge. The mouth of Glacier Bay proper is a transition zone between an area of relatively low fishing pressure (Glacier Bay proper) and high fishing pressure (Cross Sound/Icy Strait). The transition zone facilitates hypothesis testing for differences in fishing pressure and spillover effects of halibut from Glacier Bay proper.

• **Incorporate age-length information for rockfish into future creel surveys.** Age estimates provided in this report for yelloweye rockfish should be cautiously interpreted because they encompass considerable error due to variation in fish length at age. A directed age-and-growth study as a component of future creel surveys would provide an accurate assessment of sportfishery effects on rockfish age structure.

• **Resolve the unpermitted charter issue within Park waters.** This is not only a legal issue in terms of NPS permitting requirements for commercial operations, but also a fairness issue for permitted charter operators who pay for the privilege of operating within Park waters. A two-pronged approach of education and enforcement is recommended. The NPS should alert all area charter businesses to the permitting requirement for Park waters. A more visible presence of NPS rangers and vessels in waters outside Glacier Bay proper would further reduce unpermitted charter activity.

INTRODUCTION

Study Area

Sport anglers are attracted to the Glacier Bay region's large mountains, deep fjords, and abundant fishery and wildlife resources. Lodge and charter businesses are based within the communities of Gustavus, Elfin Cove, and Hoonah; a small local and primarily seasonal population of anglers is active throughout the region.

Glacier Bay National Park and Preserve (GBNPP) ("Park") is located about 90 miles west of Juneau, Alaska. The Park's marine waters encompass 243,393 km^2 and include Glacier Bay proper, waters within the Cross Sound/Icy Strait region, and the outer coast of Alaska from Cape Spencer to Sea Otter Creek west of Cape Fairweather (Fig. 1). About 45% of the Park's marine waters (110,000 km^2) lie outside Glacier Bay proper.

The geographic range of this sportfishery study excluded the Preserve and included only a small portion of the Park (i.e., excluding Glacier Bay proper and the outer-coast portion from Icy Point to Cape Fairweather).

Background

Charter sportfishing has gained prominence in the Glacier Bay region over the last 15 years. Charter numbers have increased by 136% in Southeast Alaska over the last decade from 903 to 1,233 registered vessels (White & Jaenicke 2003).

Charter and private sportfishing in the area is focused on the arrival of anadromous salmonids and the movement of halibut into the area during the summer months (May 15–September 15). The primary species targeted by sport anglers in the Glacier Bay Region are halibut (*Hippoglossus stenolepis*), salmon (*Oncorhynchus* spp.), and rockfish (*Sebastes* spp.).

Fishing effort is largely distributed among three communities: Gustavus, Elfin Cove, and Bartlett Cove. There are four primary user groups in the sportfishery: marine anglers based out of (1) Gustavus, (2) Elfin Cove, and (3) Bartlett Cove, and (4) those entering Glacier Bay proper during the Park's visitor-use season (June 1–August 31). Up to 25 private vessels are allowed within Glacier Bay proper during the visitor use period, and daily entries may not exceed six vessels.

All charter operators fishing within Park waters are required to have at least one of two types of permits.

(1) *Incidental Business Permits* (IBP) authorize "...charter vessel services in Glacier Bay National Park marine waters except as follows: use of Glacier Bay proper (north of a line from Point Gustavus to Point Carolus) and Dundas Bay (north of a line from Point Dundas to Point Wimbledon) are not authorized from May 16 to September 30" (GBNPP website).

(2) *Concessions Permits* authorize operation of charter vessels in Glacier Bay proper or Dundas Bay from May 16 to September 30 and year-round in all other Park waters.

Charterfishing accounts for most of the catch, harvest, and effort outside Glacier Bay proper, as discussed in this report. The Alaska Commercial Fisheries Entry Commission (CFEC) reported in 2003 that 29 charterboats were registered for Gustavus and 38 for Elfin Cove. Charterboats registered in neighboring communities (i.e., Pelican, Hoonah, Juneau, Excursion Inlet) operate irregularly in the waters within and adjacent to the Park.

Private and charter recreational fishing activity (catch, harvest, effort) for anglers in the greater Glacier Bay region has been documented by existing state and Park programs. These programs comprise a charter logbook program implemented by the Park since 1995 and a mail-out survey (statewide harvest survey; SWHS) administered by the Alaska Department of Fish and Game (ADF&G). However, the SWHS is not ideal for understanding Park sportfish activity because it fails to delineate catch, harvest, and effort *within* Park boundaries (C. Soiseth, pers. comm. 2004). Boundaries for the state's SWHS Glacier Bay Area (Area G) include Glacier Bay National Park waters plus outside waters along northern Chichagof Island and all of Cross Sound and Icy Strait bays and inlets (i.e., Lisianski Strait and Inlet, Port Althorp, Idaho Inlet, Mud Bay, Excursion Inlet, and Port Frederick). Moreover, in areas such as the Glacier Bay region where respondent numbers are generally low, the SWHS is generally used *only* as an index to determine relative sportfishing activity between marine areas and stream systems (B. Glynn, ADF&G, Douglas, AK, pers. commun. 2004).

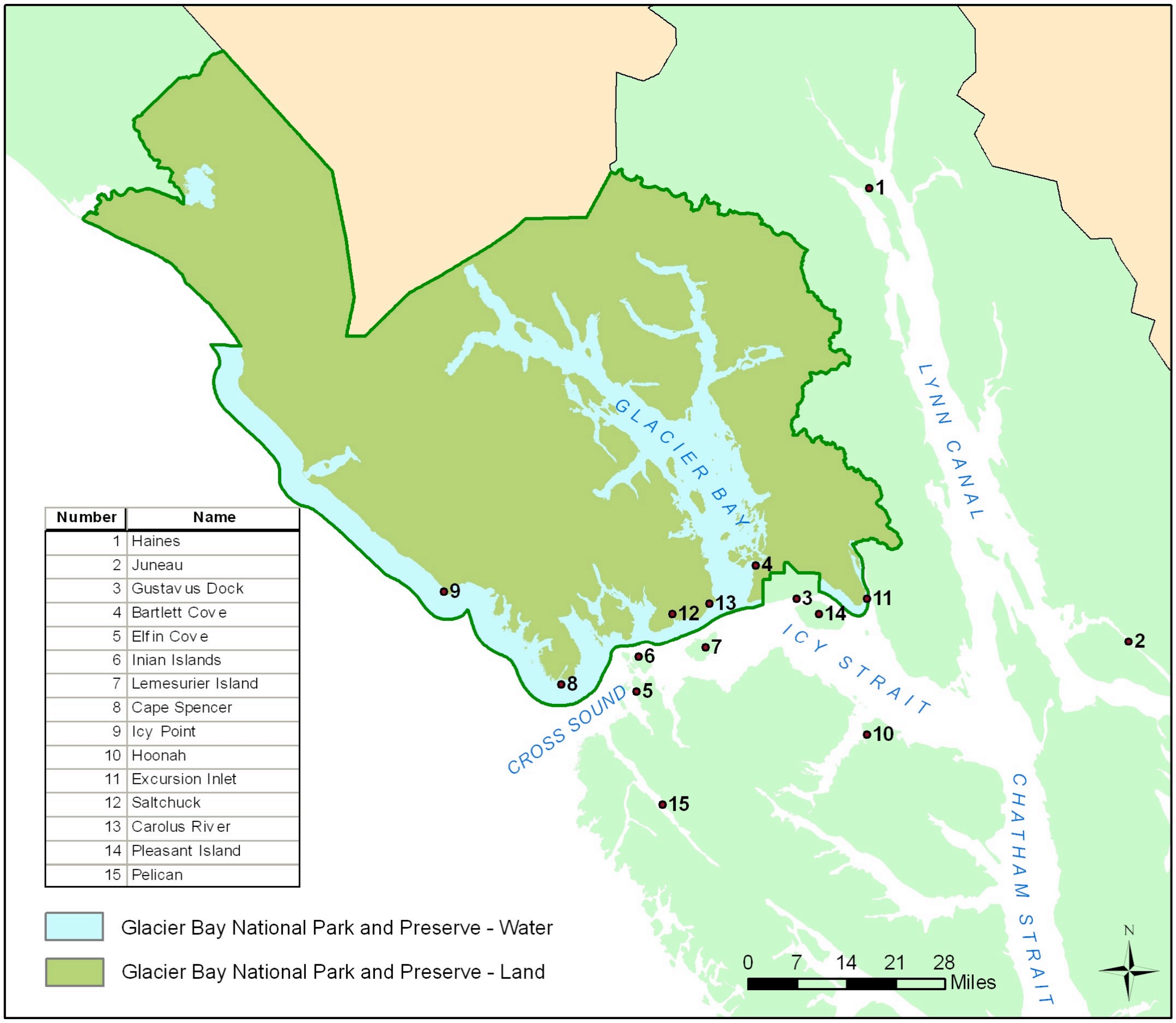

Figure 1. Glacier Bay/Cross Sound/Icy Strait region of Southeast Alaska.

Like the SWHS, the Park logbook program has a limited ability to assess fishing activity relative to Park boundaries. Preliminary analyses suggest that the logbook program may not accurately reflect charterfishing activity in the Park (C. Soiseth, pers. comm. 2004) for two primary reasons: (1) It incorporates only National Park Service (NPS)-permitted charterboats, to the exclusion of private anglers and unpermitted (illegally fishing) charterboats, and (2) it is self-reported and not independently validated. Although a mandatory state charter logbook program also exists, it fails to report harvest within Park boundaries and is also self-reported.

The lack of accurate sportfishery data specific to the Park and surrounding waters makes it difficult for managers to ascertain the level of resource "impairment"[1] and types of management actions needed to achieve

[1] Impairment is defined by NPS Director's Order #55, November 17, 2000, as "...an impact that, in professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or value."

conservation mandates outlined in the Organic Act (16 USC 1), General Authorities Act (1970), Redwood Amendment (1978) to the General Authorities Act, and the GBNPP General Management Plan (NPS 1984). This project report provides an initial, statistically robust analysis of resource use by sport anglers in the region.

Study Objectives

The National Park Service initiated a task agreement in 2002 and 2003 with the University of Washington School of Marine Affairs (UW-SMA) against their cooperative agreement with the Pacific Northwest Cooperative Ecosystem Studies Unit (PNW CESU). The task agreement outlined two distinct projects carried out cooperatively by the UW-SMA, PNW CESU, and GBNPP:

(1) Develop and conduct a creel survey of the Glacier Bay region's charter and private sportfishery;

(2) Develop and test a mail and phone survey to collect recreational angler catch information for Glacier Bay proper.

This report focuses on the creel survey (Project 1) for which the UW was primarily responsible. The PNW CESU was primarily responsible for the mail/telephone surveys (Project 2) not discussed in this report but that are found in Osterhoudt et al. (2004).

Sampling cooperation between the UW-SMA, ADF&G, and NPS occurred in both Elfin Cove and Gustavus. It should be noted that the ADF&G Sportfish Division played a considerable role in making this project successful by providing one creel technician in Gustavus and computer-scannable data forms for all ports, and by attending public meetings on the sampling program. ADF&G also digitized computer-scannable sampling forms and performed quality control on the electronic data set, which was subsequently compared with hard copies by UW-SMA and ADF&G. To accommodate ADF&G's needs, UW-SMA agreed to collect coded-wire-tag and length information for salmon.

Two tasks were associated with the creel census (Project 1). Task 1 was to develop a creel survey program for Elfin Cove and Gustavus to be conducted, where possible, by local-hire creel technicians. Task 2 was to collect creel-survey data (effort, catch, and harvest) from charterboats fishing within Park waters and operating from Elfin Cove and Gustavus, June–September, for two seasons.

A key component of this work was to inform charter operators and clients of the critical management need for this information. The cooperators' goal was to promote program support and achieve "buy in" by charter operators and clients through community meetings, solicitation of management information, periodic project feedbacks, and frequent updates of study results (such as this report).

This report focuses on effort, catch, and harvest results (from Tasks 1 and 2) for the Elfin Cove and Gustavus creel survey programs. Results are presented in a format that describes catch, effort, and harvest both regionally and as angling use relative to Park boundaries, sampling site, and user group (private or charter). A discussion of these results, and a summary of recommendations derived from the results and discussion, can be found at the end of this report.

Survey data for 2002 are not presented in a statistically expanded form due to statistical concerns stemming from our lack of previous sampling experience in the area. This data-limited situation made it difficult to design a representative survey that would provide unbiased data. For example, it was often necessary to sample low-use and highly variable time strata to determine angler arrival patterns or identify the types of anglers using a sampling site (charter or private), particularly in Elfin Cove where multiple docks were sampled. The lack of fishery information and use of artificial weighting in terms of sampling effort may have resulted in biased estimates.

There were also many other statistical concerns with the 2002 data set. These include new, untrained survey technicians and their ability to consistently record accurate data; changes to statistical area size and boundaries potentially affecting interannual comparisons; the "newness" of the creel survey to anglers and their inherent lack of trust that may have affected data accuracy; and variation among creel technicians in terms of standardized, accurate, and consistent recording and reporting procedures.

Many anglers were initially suspicious of the project. This was drastically reduced by the end of the 2002 sampling season, as the newness of the survey diminished and anglers understood the types of information being collected and the reasoning behind the study.

Because of the previously described statistical concerns, 2002 survey data are presented in Appendix Tables A–G as *observations onl*y. No attempt is made to provide estimates or adjust for sampling effort. The authors do not recommend using these data for comparisons between 2002 and 2003, due to the lack of a consistent sampling protocol. Elfin Cove observations are especially likely to be vastly different due to changes made in sampling fishing effort during the 2003 season.

METHODS

Creel surveys were conducted at the Gustavus dock and sites within the community of Elfin Cove during the June 1–September 7, 2003 sampling period. The Elfin Cove sampling site contained seven spatially distributed access sites (Fig. 2) whereas the Gustavus dock consisted of a single access point.

Creel technicians collected catch, harvest, and effort data from marine anglers fishing on boats originating from Gustavus and Elfin Cove. Data were collected for an entire boating party upon completion of the day's fishing trip. For each boating party, the total number of rods, hours fished, fishing locations, trip type (charter or private), and fishing type (bottom or salmon fishing) were recorded by a creel technician on water-resistant machine-readable forms designed by ADF&G (Heinemen 1991).

The GBNPP fisheries biologist, PNW-CESU cooperators, the UW-SMA, and the ADF&G reviewed creel-survey interview questions and methods before mandatory Federal approval through the Office of Management and Budget (OMB). Interview methods used in the creel survey were adapted from those used by ADF&G for sportfish surveys, with interviews focused on gathering catch, effort, harvest, location, and trip-type information.

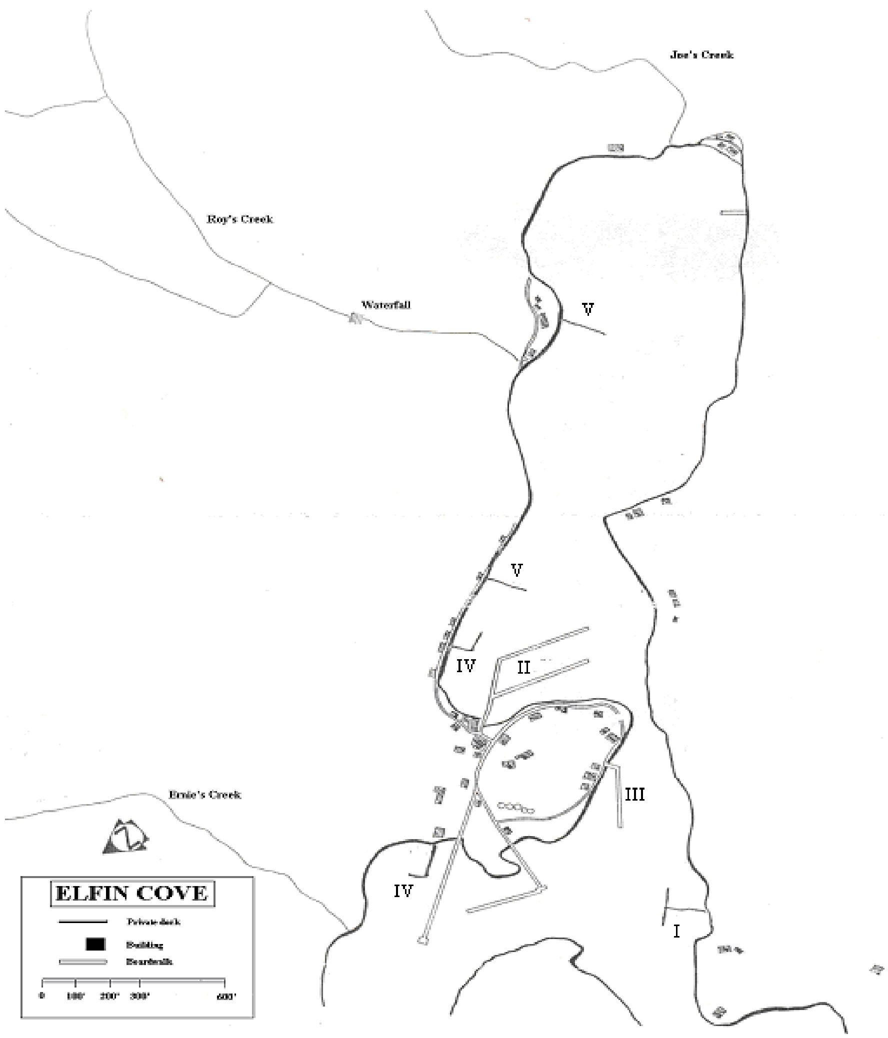

Figure 2. Elfin Cove, Alaska sportfishery sampling site.
Roman numerals designate sampling strata.

Harvest, effort, and catch were delineated by location using statistical areas that followed conventions used by the ADF&G (Fig. 3). The use of ADF&G's statistical areas facilitated data-sharing between NPS and ADF&G and insured that future spatial/temporal comparisons could be made. However, Statistical Sub-Areas 26-1, 29-1, 29-2, 37-1, 46-1, and 47-1 were created for this project because traditional ADF&G convention does not differentiate fishing activities occurring *within* Park waters from those occurring *outside*.

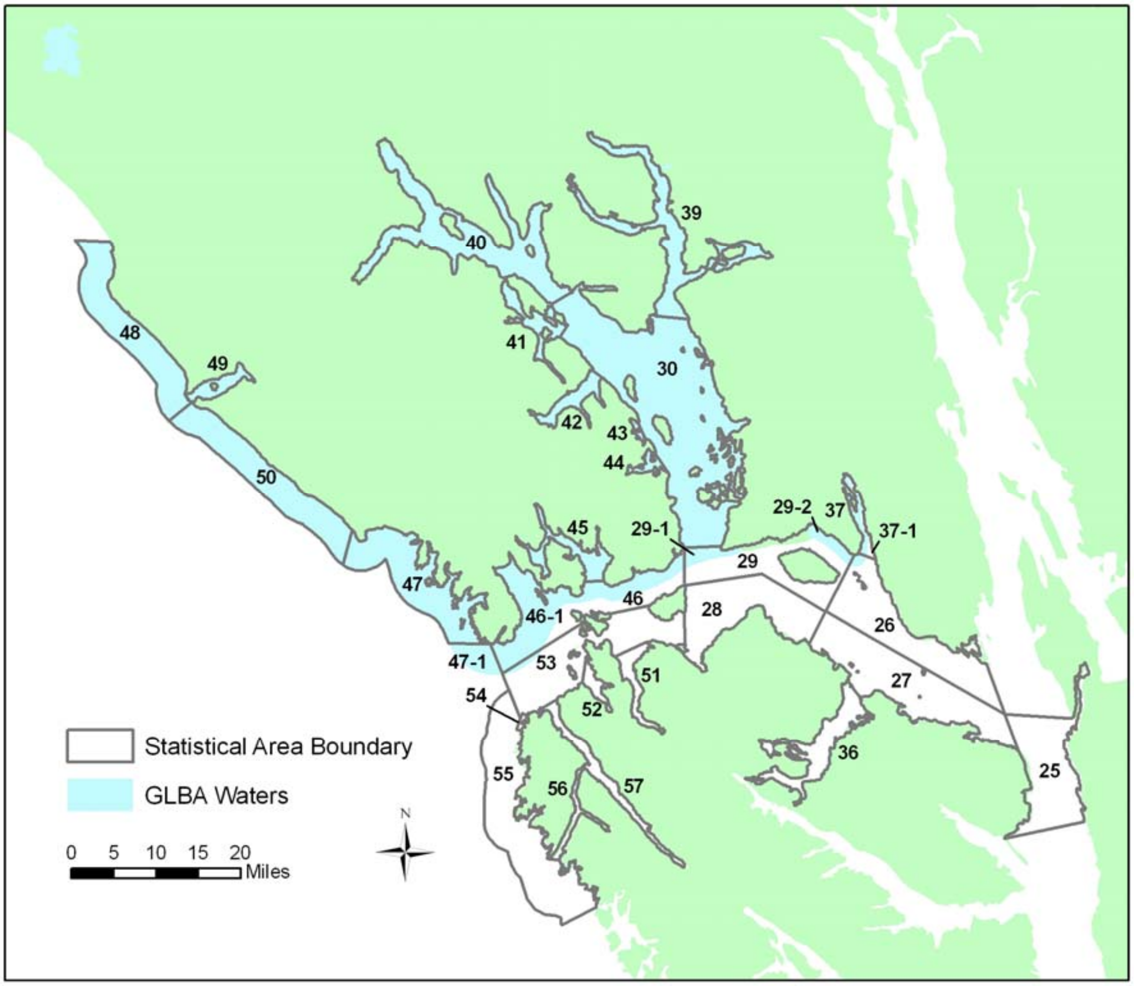

Figure 3. Glacier Bay National Park and Preserve, surrounding areas, and Statistical Areas used for this study. Note that Areas 26-1, 29-1, 29-2, 46-1, and 47-1 are all Sub-Areas located within Park waters.

Quality control for fish length and dockside interview data was conducted during several phases of the project: (1) By creel technicians onsite (after interviews) who insured that forms were filled out correctly, length measurements were accurate, and that most of the harvested fish on the dock were counted; (2) by ADF&G officials who re-verified fish length and harvest before and after scanning the machine-readable forms; and (3) by the UW-SMA graduate student who compared the hardcopy sampling forms after scanning with data sets obtained from ADF&G. All data analyses were conducted using SPSS version 10.1, Microsoft Excel 2000, and Microsoft Access 2000. The ADF&G official used the SAS statistical program (SAS Inst., Inc., Cary NC, 1999 version).

The following assumptions are valid for both the Gustavus and Elfin Cove creel surveys:

1. Catch, harvest, number of rods used during a fishing trip, location of fishing activity, and number of hours spent fishing are accurately and honestly reported by anglers. Although creel technicians could verify harvested fish, they could not verify released fish or observe effort and location. Thus, although numbers of harvested fish are likely accurate due to onsite verification by creel technicians, the reported releases, effort, and fishing locations are not verified.
2. Catch, harvest, effort, and length information is accurately recorded by creel technicians.
3. Distribution of length samples for halibut and rockfish accurately represents the length distribution of harvested fish.
4. Sampling effort adequately represents fishery activity. It is assumed that fishing does not occur at night, that >90% of the fishing activity at Gustavus occurs during the sampling period, and that selected sampling sites (docks) in Elfin Cove adequately represent charterfishing effort in Elfin Cove.
5. Randomly sampled days are representative for all days within the sampling period

Elfin Cove Charterboat Creel Survey

Catch and effort were estimated for *charter* sportfishing boats operating from Elfin Cove using a stratified proportional allocation method (Cochran 1977, Pollock et al. 1994). Strata consisted of access points (docks) that exhibited similar angling effort levels (as determined from the 2002 pilot study), and the number of days a stratum was sampled reflected its size and variability. Strata that were large (measured in terms of fishing effort) and variable received the greatest sampling effort (Table 1). Sampling was conducted from June 1 to September 7, 2003.

Table 1. Parameters used to estimate fishing effort, harvest, and catch within five strata for the Elfin Cove, Alaska creel survey during the 2003 sampling period. Strata weight (W_h) calculated using equation 1.3.

Strata	No. sport boats (b_h)	No. docks	No. days sampled (d_h)	Strata weight (w_h)
I	7	1	26	0.26
II	4	1	9	0.15
III	2	1	12	0.07
IV	10	2	22	0.37
V	4	2	10	0.15
Total	27	7	79	1

Equations 1.1–1.5 were adapted from Pollock et al. (1994) and Cochran (1977) to estimate catch and effort by substituting the appropriate statistic. The term “sampling period” refers to the population of charter anglers operating from sampled sites in Elfin Cove for 98 days (June 1–September 7, 2003).

Total harvest and catch (Y_h) for all boating parties interviewed within a stratum (h) was calculated using equation 1.1,

$$Y_h = \sum_i \sum_j Y_{hij} \tag{1.1}$$

where:
y_{hij} = number of fish harvested in stratum h, day i, and boating party j.

The final harvest and effort estimates ($\hat{E}$) were obtained using equation 1.2,

$$\hat{E} = D \sum_{h=1}^{5} W_h \frac{Y_h}{d_h} \tag{1.2}$$

where:
d_h = total number of days sampled within stratum h,
D = number of days in the sampling period, and
W_h = proportional contribution of stratum h's component to the total capacity for all dock sites sampled at Elfin Cove.

Dock capacity is a measure of the maximum number of Coast Guard-licensed charterboats operating within a stratum. All licensed charterboats were allowed to carry a maximum of six passengers.

Estimated dock capacities were used to calculate strata weights (W_h) using equation 1.3. Individual dock capacities were based on estimates provided by dock owners.

$$W_h = \frac{b_h}{B} \tag{1.3}$$

where:
b_h = maximum number of boats operating in a specific stratum, and
B = maximum possible number of charterboats operating from Elfin Cove.

An unbiased variance estimate of the total harvest (*Var(N)*) will be obtained using equation 1.4,

$$Var(\hat{N}) = D^2 \sum_{h=1}^{L} W_h^2 \frac{S_h^2}{d_h} \left(\frac{D_h - d_h}{D_h} \right) \tag{1.4}$$

where:
S_h^2 = variance between sampling days within each stratum h. S_h^2 was calculated using equation 1.5,

$$S_h^2 = \frac{\sum_{i=1}^{L} \left(y_{hi} - \bar{Y}_h \right)^2}{d_h - 1} \ . \tag{1.5}$$

Dock-specific catch and effort results from a pilot study conducted in 2002 were used to delineate strata based on statistical differences in effort levels. Statistical expansions using equation 1.2 assume that the average statistic observed for days and sites was representative for all days within the sampling period.

Gustavus Private & Charterboat Creel Survey

A single access point was used on a daily basis by both private and charter vessels in Gustavus. Most Gustavus private and charter vessels departed from and returned to the Gustavus dock (about 1 mile southeast of the mouth of the Salmon River). Our 2002 pilot study showed that about 90% of the daily activity occurred between 1200 and 1900 hours and that sportfishing effort occurred primarily between May 15 and September 15. Thus, the sampling frame consisted of private and charter anglers aboard boats landing at the Gustavus dock from May 15 to September 15, 2003 between 1200 and 1900 hours.

Estimates of catch, harvest, and effort for various species in the Gustavus fishery were made using a two-stage stratified random sample as described by Cochran (1977). The first stage consisted of the days sampled and the second stage was composed of boating parties. Sampling days were divided into weekend and weekday strata. All days within the weekend stratum were sampled, and 3–5 days were randomly sampled during the weekday stratum.

The following equations were used to estimate catch and effort by substituting the appropriate statistic. Equations 2.1–2.7 were obtained from Bernard et al. (1998) and Cochran (1977). An estimate of the fishery statistic (Y_{hi}) on day i within stratum h was estimated using equation 2.1.

$$\hat{Y}_{hi} = M_{hi}\bar{y}_{hi} \qquad (2.1)$$

where:
M_{hi} = count of boating parties in stratum h (weekend or weekday) during day i, and
$\bar{y}_{hi}$ = mean statistic of interviewed anglers in the h^{th} stratum on the i^{th} day.

The estimate of the fishery statistic (Y_h) for stratum h is described in equation 2.2.

$$\hat{Y}_h = D_h \frac{\sum_{i=1}^{d_h} \hat{Y}_{hi}}{d_h} \qquad (2.2)$$

where:
D_h = number of days in the sampling frame,
d_h = number of days sampled, and
$\hat{Y}_h$ = parametric fishery-statistic estimate for stratum h.

An estimate of the variance ($Var(Y_h)$) is:

$$Var(\hat{Y}_h) = (1 - f_{1h})D_h^2 \frac{S_{h1}^2}{d_h} + f_{1h}^{-1} \sum_{i=1}^{d_h} M_{hi}^2 (1 - f_{2hi}) \frac{s_{2hi}^2}{m_{hi}} \qquad (2.3)$$

where:

$$f_{1h} = \frac{d_h}{D_h}, \qquad (2.4)$$

$$f_{2hi} = \frac{m_{hi}}{M_{hi}}, \qquad (2.5)$$

m_{hi} = total number of boating parties interviewed in stratum h on day i, and
M_{hi} = total number of boating parties counted in stratum h on day i.

The sample variance (s^2_{2hi}) was estimated using equation 2.6.

$$s_{2hi}^2 = \frac{\sum_{j=1}^{m_{hij}} (y_{hij} - \bar{y}_{hi})^2}{m_{hi} - 1}, \qquad (2.6)$$

y_{hij} = fishery statistic for boating party j on day i in stratum h.

The sample variance as calculated in equation 2.6 is an unbiased estimate of the population variance (S^2_{1h}) as shown in equation 2.7.

$$S_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\hat{Y}_{hi} - \hat{\bar{Y}}_h)^2}{d_h - 1}, \text{ and} \qquad (2.7)$$

$\hat{Y}_{hi}$ = statistic for day i in stratum h. Note: $Y_{hi} = \sum y_{hij}$ when $M_{hi} = m_{hi}$.

Analysis of Fish Length, Weight & Age

Length information is used by management agencies to calculate total biomass removals (harvested fish). Total biomass estimate is a standardized index used to model future and historical fishing mortality rates, recruitment, and abundance. This report provides the necessary length information to insure that biomass estimates can be extracted from the creel survey data.

Halibut

A total of 1,990 halibut were measured in Gustavus and 382 in Elfin Cove. Halibut measurements were taken on randomly selected days for Elfin Cove and Gustavus. Halibut total lengths were measured to the nearest 5 mm from randomly selected boats. All halibut within a bag (i.e., total boat harvest for a completed fishing trip, unique to each species harvested) were measured to insure that the sampler did not introduce a size-selection bias. Fish were measured from the tip of the snout to the tip of the center lobe of the tail. Length-weight relationships were determined using an exponential growth function as described in equation 3.1. Predicted weights (W) were estimated for each fish from total length measurements. Predicted weight (W) is reported in pounds because this is the normal notation used by the primary halibut management body (International Pacific Halibut Commission).

$$W = aL^b \qquad (3.1)$$

where:
a = 6.921×10^{-6} for the eviscerated head-off weight and 9.0205×10^{-6} for round weight (Clark 1992),
L = observed length in centimeters, and
b = 3.92 (Clark 1992).

The variances of weights were estimated using standard normal procedures (Zar 1999).

The Kolmogorov-Smirnov Goodness of Fit (K-S test) was used to determine if lengths differed significantly from a normal distribution. Comparisons between normally distributed data were made using a t-test, and Mann Whitney U-tests were used to make comparisons between non-parametric data (data not normally distributed). Since sample sizes were often large, both tests are often reported to demonstrate significant results regardless of the sample distribution.[1]

Rockfish

As with halibut, rockfish length measurements are important for estimating total biomass removals and the age distribution of harvested fish. This paper uses the length distribution from harvested rockfish to provide a rough estimate of age (yelloweye *only*) and to facilitate future biomass calculations.

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[1] Non-parametric tests have lower power (and/or efficiency) than parametric tests. Statistical tests with low power make hypothesis testing difficult and also increase the probability for Type I Error. Since most sample sizes in this study were large (>100 samples), parametric tests are appropriate. In situations with small sample sizes that are not normally distributed, non-parametric tests are appropriate.

Rockfish measurements were taken on randomly selected days for Elfin Cove. Total lengths were obtained from a sample of 132 yelloweye and 72 black rockfish caught by charter anglers in Elfin Cove. Total length was measured from the tip of the snout to a line between caudal fin tips (nearest 5 mm). All rockfish within a bag were measured to insure that the sampler did not introduce a size-selection bias. Rockfish length information was not collected at Gustavus Pier due to inadequate sample size.

Total lengths were converted to fork-length measurements using equation (3.3), and weight was estimated for measured fish using the exponential growth function in equation (3.1).

Yelloweye rockfish parameter estimates:

a = 0.0074 (Rosenthal et al. 1982),
b = 3.222 (Rosenthal et al. 1982), and
L = fork length in centimeters.

Black rockfish parameter estimates:

a = 0.0043 (Rosenthal et al. 1982),
b = 3.362 (Rosenthal et al. 1982), and
L = fork length in centimeters.

Combined male and female yelloweye rockfish length measurements were fit to a von Bertalanffy model and used to estimate the mean age for harvested rockfish from Elfin Cove. The modeled parameters were based on published yelloweye growth parameters from Southeast Alaska (O'Connell et al. 2003).

The von Bertalanffy equation was algebraically rearranged from the standard form (equation 3.2) so that ages (t) could be estimated from length data. Life-history parameters for male and female rockfish (combined) from O'Connell et al. (2003) were used to estimate yelloweye rockfish ages:

$$t = -\frac{1}{k}\ln(1 - L / L_{\text{inf}}) + t_0 \qquad (3.2)$$

where:
t = age of fish at length L (fork),
t_0 = time when length is theoretically zero (–13.0505),
L_{inf} = mean maximum length of 65.6916 cm, and
k = growth constant of 0.0369.

Because of biases associated with using length data to estimate age, the age estimates in this report should be used *only* as a general reference to approximate age at capture. Length measurements are subject to sampling error when used as model inputs; when lengths approach L_{inf}, rounding bias and sampling precision have profound effects on age estimates. Furthermore, age estimates made in this study are subject to error associated with (1) the published von Bertalanffy model, (2) the total-length to fork-length conversion used, and (3) the overlap of lengths for a given age cohort. Considerable length-at-age variability also exists between geographic locations (i.e., northern vs. southern Southeast Alaska) (O'Connell et al. 2003).

Rockfish total lengths were converted to fork lengths using equation 3.3 (Love et al. 2002) and parameters from Echeverria & Lenarz (1984):

$$FL = \alpha + \beta(TL) \qquad (3.3)$$

where:
TL = total length,
α = 1.296, and
β = 0.981.

Catch & Harvest Rates

Mean catch per unit of effort (CPUE) and harvest per unit of effort (HPUE) are used as indices of abundance under the traditional linear model:

$$\left[c/e_i\right] = qA + \varepsilon_i \tag{4.1}$$

where:
c/e_i or h/e_i is the CPUE or HPUE for a boating party on day i,
A = fish abundance,
q = the catchability coefficient, and
ε = the random error with a mean of 0 and variance σ^2.

Under the assumption of a general linear model (4.1), each boating party is considered a separate, replicated sample of the fishery (Bernard et al. 1998).

Stratification of boating parties by fishing ability (i.e., *charter* vs. *private* anglers) and using in-season catch-rate estimates for comparisons can decrease the risk of management errors by improving the accuracy of the catchability coefficient. To reduce variability, this study stratified respondents into private and charter anglers. These groups reflected differing levels of resource use, angling behavior, and angling proficiency.

Charter anglers typically have high resource-use levels, use advanced technology (e.g., GPS, downriggers), communicate as a group to determine the best fishing locations, use larger boats that can travel long distances, typically fish in large numbers (3–6 people/vessel), and are often more proficient at catching fish than private anglers. *Private anglers* typically exhibit less average proficiency and greater variability in terms of fishing techniques used, use of technology, level of communication among anglers, distance traveled from a homeport, and angling group size. Charter angling data better represent fish abundance than private angling data, but should be used with caution and *only* as a relative index.

Catch and harvest rates (r_{hi}) were estimated from Bernard et al. (1998) as described in equation 4.2:

$$r_{hi} = \frac{c_{hi}}{e_{hi}} \tag{4.2}$$

where:
r_{hi}= CPUE or HPUE statistic for boating party i in stratum h (private or charter),
c_{hi}= catch or harvest for boating party i in stratum h, and
e_{hi}= effort (in rod hours by fishing type) for boating party i in stratum h.

The mean CPUE and HPUE statistics ($\overline{r}_h$) were estimated using equation 4.3 (Bernard et al. 1998).

$$\overline{r}_h = \frac{\sum_{i=1}^{m_h} r_{hi}}{m_h} \tag{4.3}$$

The variance estimate ($Var(r_h)$) is described in equation 4.4.

$$Var\left(\overline{r}_h\right) = \frac{\sum_{i=1}^{m_h} (r_{hi} - \overline{r}_h)^2}{m_h(m_h - 1)} \tag{4.4}$$

Species-specific catch and harvest rates were calculated using the following types of fishing effort (in rod hours): Halibut HPUE and CPUE utilized bottomfishing effort; salmon CPUE and HPUE utilized salmon-fishing effort (very few salmon were caught while bottomfishing); and rockfish, lingcod, and dogfish HPUE and CPUE utilized both bottom- and salmon-fishing effort. The type(s) of fishing effort selected to calculate catch and harvest rates for a particular species reflected the use of fishing technique(s) that yielded the most consistent catch of that species.

Fishery-Independent Methods for Estimating Halibut Catch & Harvest

Outer Waters Vessel Activity Surveys (OWVAS) were conducted by the National Park Service (NPS) using fixed-wing aircraft to document the type and amount of charterboat use in Park waters *outside* Glacier Bay proper in the Cross Sound and Icy Strait area (Soiseth et al., in review). Methods used to estimate the numbers of boats for NPS purposes were adapted to fit the needs of this study and will not be discussed in detail. Instead, this paper focuses on the methodologies used to estimate halibut catch and harvest from OWVAS data.

Aerial survey data were used in this study to quantify reporting error (*within* Park waters) by charter anglers in the creel survey. The geographic bounds of the study area included all Park waters in Excursion Inlet, Icy Passage, North Passage, North Inian Pass, Cross Sound, and the outer coast to Icy Point. The type of boating trip (charter or private) and activity (fishing, anchored, or transit) and location of fishing were recorded for observed vessels during each aerial survey. Charterboats were photographed from the air using a digital camera equipped with a 300-mm lens, and the boats' locations were marked as waypoints using GPS.

Catch and effort information was categorized according to fishing type, location(s) fished, trip type (charter or private), and origin (Gustavus, Elfin Cove, or unknown) for each boat observed in the aerial survey. Boat origin was determined by matching photographed charterboat names or vessel license numbers to boats in Gustavus and Elfin Cove using the Alaska Commercial Fisheries Entry Commission (CFEC) online database (http://www.cfec.state.ak.us). Fishery data were collected at the Gustavus and Elfin Cove sampling sites the same day an aerial survey was conducted. Anglers were not notified that an aerial survey was being conducted.

Catch was estimated using the number of charterboats observed operating *within* Park waters (during 1.5-hour aerial surveys) using equations 5.1 and 5.2 (Cochran 1977). Catch and effort information was obtained at the Gustavus Pier for charterboats observed during the aerial survey. It was assumed that charterboat captains would correctly report fishing within a large statistical area (Area 29, for instance). Thus, estimated fishing catch and effort for charterboats observed during the aerial survey were derived from catch reported during the creel survey. The time and dates for aerial survey flights were randomly chosen, resulting in a simple random sample of vessels fishing within Park waters. Equations 5.1 and 5.2 describe the estimated expansion for a simple random sample of catch and effort during the June 15–September 15, 2004 sampling period for charterboats observed during both aerial and creel surveys.

An expanded estimate of the total number of charterboats operating within Park waters during the sampling period was not available through the OWVAS project at the time of this report. Therefore, effort, catch, and harvest estimates were based on a limited number of OWVAS aerial surveys of charterboats *without* proportional expansion over the period of interest. These estimates also assume that charter anglers observed during the OWVAS survey spent 100% of their time within Park waters. Although this assumption is likely violated in some instances, the estimates provided in equations 5.1–5.2 are likely indications of minimum harvest, catch, and effort given the limited number of OWVAS observations and lack of proportional expansion over the fishing season.

Catch ($\hat{C}_{ij}^{p}$) was estimated for charterboats operating from port i in statistical area j during the OWVAS aerial surveys.

$$\hat{C}_{ij}^{p} = \overline{c}_{ij}^{p} N_{ij}^{p} \tag{5.1}$$

where:

$\overline{c}_{ij}^{p}$ = estimated mean catch in Park waters (^{p}) from charterboats observed during both the creel and aerial surveys for port i in statistical area j, and

N_{ij}^{p} = total number of charterboats observed fishing in Park waters (^{p}) during OWVAS aerial surveys from port i in statistical area j.

The variance estimate (Vâr($\hat{C}_{ij}^{p}$) is described in equation 5.2,

$$V\hat{a}r(\hat{C}_{ij}^{p}) = N_{ij}^{p2}\left(1 - \frac{n_{ij}^{p}}{N_{ij}^{p}}\right)\frac{S^2}{n_{ij}^{p}} \tag{5.2}$$

where:
n_{ij} = number of charterboats from port i in statistical area j observed during OWVAS aerial surveys and identified during the creel census for the sampling frame.

The sample variance (s^2) is a non-biased estimate of the population variance (S^2),
where:

$$S^2 = s^2 = \frac{\sum (c_{zij}^{p} - \overline{c}_{ij}^{p})^2}{n_{ij}^{p} - 1}\ .$$

Z denotes individual charterboats sampled in both the creel and OWVAS surveys.

Creel census data from Elfin Cove and Gustavus were used to model regression relationships between catch and harvest within a given statistical area and port of origin for charterboats. The response variable was catch (number of fish), with effort reported in rod hours as the independent variable. These regressions were used to estimate catch observed during the creel census from effort observed in Park waters during the aerial and creel surveys.

Effort in aerial survey units (number of boats) was converted to creel survey units (rod hours) by using the observed mean effort from the creel surveys for a charterboat originating from port i and fishing in statistical area j using equation 6.1. We estimated total fishing effort ($\hat{F}_{ij}$) for all charterboats observed during OWVAS aerial surveys (N_{ij}).

$$\hat{F}_{ij} = \overline{e}_{ij} N_{ij}^{p} \tag{6.1}$$

where:

$\overline{e}_{ij}$ = mean effort (rod hours) for bottomfishing charterboats observed in the creel census from port i in statistical area j.

The proportion of time that charter anglers spent fishing for a particular species of fish *inside* vs. *outside* the Park boundaries was recorded using boat-based visual observations for two specific fishery grounds: Point Gustavus and North Lemesurier Island.

Boat-based observations were used to weight total fishing effort ($\hat{F}_{ij}$) as described in equation 6.2. Three 8-hour observations were made from near Point Gustavus, and two 8-hour observations were made from near North Lemesurier Island (Salt Chuck). Five out of six charterboats were identified within a 1-mile radius of Point Gustavus using Zeiss 20x60 image-stabilized binoculars. Observations corresponded with peak charterfishing periods determined from the creel census (8 am–5 pm). Park boundaries and distances between the observation boat and observed charterboats were noted using marine GPS and radar.

We estimated within-Park bottomfishing effort ($\hat{E}_{ij}^{p}$) for charter anglers from port i in statistical area j using equation 6.2.

$$\hat{E}_{ij}^{p} = p_{ij}\hat{F}_{ij} \quad (6.2)$$

where:
p_{ij} = proportion of time that charterboats from port i were engaged in bottomfishing *inside* vs. *outside* the Park in statistical area j.

Regression models were used to obtain equations 6.3 and 6.4 as described in the Results and Discussion sections. Equation 6.3 represents a least-squares linear regression describing the relationship between halibut catch and bottomfishing effort in Statistical Areas 29 and 46 combined for charter anglers operating from Gustavus (Fig. 4).

$$\hat{C}_{Gustavus} = 0.8407\hat{E}_{ij}^{p} + 0.6555 \quad (6.3)$$

Equation 6.4 represents a linear least-squares regression describing the relationship between charter halibut catch and bottomfishing effort in Statistical Areas 46 and 53 combined for charter anglers operating from Elfin Cove (Fig. 5).

$$\hat{C}_{ElfinCove} = 0.2506E_{ij}^{p} + 2.0549 \quad (6.4)$$

To obtain harvest estimates, the number of fish harvested within Park boundaries was estimated by determining the proportion of total halibut catch harvested by charterboats observed simultaneously in the aerial and creel surveys. Harvest occurring within Park waters (^{p})($\hat{H}_{i}^{p}$) by charterboats observed from port (i) during the aerial survey was estimated as follows:

$$\hat{H}_{i}^{p} = \hat{C}_{i}^{p}\frac{a_{ij}}{c_{ij}} \quad (6.5)$$

where:
a_{ij} = number of halibut harvested from port i in statistical area j,
c_{ij} = number of halibut caught by charterboats from port i in statistical area j, and
$\hat{C}_{i}^{p}$ = within-Park (^{p}) catch estimate from port i (Gustavus or Elfin Cove) as described in equations 6.3 and 6.4.

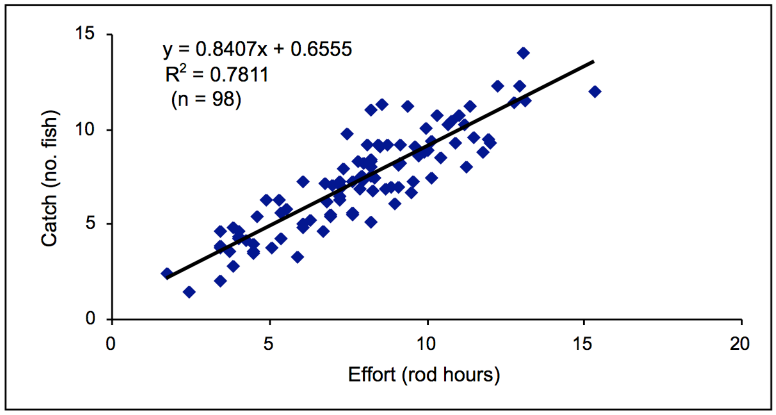

Figure 4. Linear relationship between halibut catch and bottomfishing effort in Statistical Areas 29 and 46 combined for charter sportfishing boats from the Gustavus, Alaska sampling site during the 2003 sampling period. Dependent and independent variables are square-root transformed to meet statistical assumptions of normality.

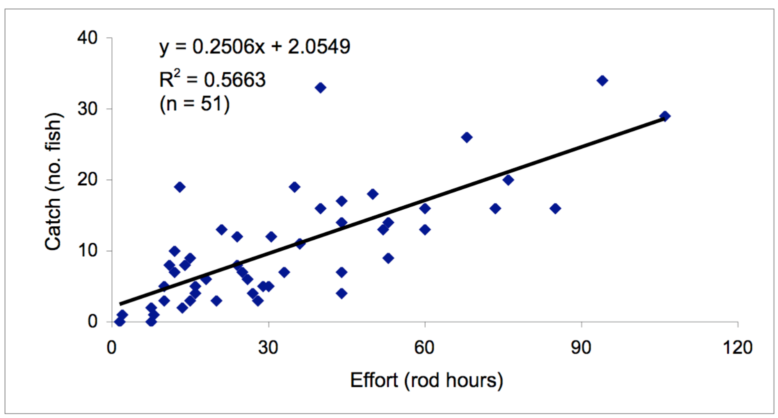

Figure 5. Linear relationship between halibut catch and bottomfishing effort in Statistical Areas 46 and 53 combined for charter sportfishing boats from Elfin Cove, Alaska during the 2003 sampling period.

RESULTS 1

Elfin Cove Charterboat Creel Survey

Stratification & Sampling

A total of 24 charterboats were surveyed during the 79 days that were randomly sampled within the 98-day sampling period. One charterboat and its corresponding dock were not included in the study due to infrequent operation. The total number of 2003 CFEC-registered charterboats operating from Elfin Cove was 38. Thus, 71% of all Elfin Cove charterboats were included in the survey. It is likely that some CFEC-registered charterboats were not active during the sampling period.

Total Fishing Effort

An estimated 5,950 rod hours were reported during the sampling frame for charter anglers operating from Elfin Cove (Table 2). Bottomfishing accounted for 54% of the observed effort and salmon fishing accounted for the remaining 46%. Reported bottomfishing effort peaked in July, and salmon-fishing effort peaked in May.

Bottomfishing

Total estimated bottomfishing effort for Elfin Cove was 3,219 rod hours distributed over ten statistical areas (Table 2). Statistical Area 53 exhibited the highest effort level, 44% (1,422 rod hours); Area 55 comprised 23% (738 rod hours); and Area 46 comprised 15% (488 rod hours). The remaining estimates of bottomfishing effort were distributed across statistical areas as shown in Table 2.

Salmon Fishing

Total estimated salmon-fishing effort for Elfin Cove was 2,731 rod hours distributed over eight statistical areas (Table 2). Area 55 exhibited the highest effort level, 60% (1,624 rod hours); Area 53 comprised 24% (658 rod hours); and Area 57 comprised 5% (142 rod hours). The remaining estimates of salmon-fishing effort are distributed across statistical areas as shown in Table 2.

Within-Park Fishing Effort

A small amount of bottomfishing effort was reported in two statistical areas within Park boundaries: Areas 47 (20 rod hours) and 45 (64 rod hours) (Table 2). Salmon-fishing effort within Park waters was 20 rod hours in Area 47.

Table 2. Distribution of estimated fishing effort (*N*=rod hours) for bottomfish and salmon by statistical area for charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within-Park effort (Sub-Areas 29-1 and 46-1; Fig. 3).

Charter Effort		Statistical Area										
		28	29	45	46	47	51	52	53	54	55	57	Total
Bottom-fish	*N*	266	13	64	488	20	4	*	1422	166	738	38	3219
	SE	86.2	11.6	39.8	95.8	17.4	3.4	*	170.0	45.4	137.0	21.8	280.9
	RP	64.1	174.4	122.4	38.9	174.4	171.9	*	23.7	54.3	36.7	113.0	17.3
Salmon	*N*	*	*	*	37	20	20	91	658	139	1624	142	2731
	SE	*	*	*	26.0	17.0	18.3	44.9	134.0	42.8	187.4	56.0	223.6
	RP	*	*	*	138.2	170.4	178.0	98.0	40.4	61.0	22.9	77.9	16.2

Totals may be inexact due to rounding error; asterisks denote unreported catch; SE = standard error (Cochran 1977); RP is relative precision (= 1.98*SE/estimate x 100).

Halibut Catch

An estimated 786 halibut were harvested and 717 released by charter anglers during the sampling period (Table 3). Statistical Area 53 comprised the largest portion, 33% (262 fish), of total halibut harvest, with 145 halibut released there; Areas 46 and 55 accounted for 16% (126 fish) and 33% (259 fish), respectively.

Catch rates (CPUE) and harvest rates (HPUE) for all statistical areas combined were 0.54 and 0.29 fish/rod hour, respectively (Table 3). Catch rates were highest in Areas 54 and 55, with 0.67 and 1.11 fish/rod hour, respectively. Harvest rates were greatest in Areas 29 and 55, with 0.38 and 0.46 fish/rod hour, respectively. The remaining estimates of HPUE and CPUE were distributed across statistical areas as shown in Table 3.

Reported halibut catch peaked in July at 450 fish (Fig. 6), with CPUE peaking in June at 0.58 fish/rod hour and declining to a low of 0.48 fish/rod hour in August. Harvest rates remained steady during July and August at 0.31 after a June low of 0.25 fish/rod hour.

Within Park Boundaries

Few halibut were reportedly caught within Park waters. Estimated halibut harvest within Park waters was 15 halibut in Area 45 (with 3 fish released) and 3 halibut in Area 47 (Table 3). Catch and harvest in Area 45 peaked in June, with CPUE at 0.63 and HPUE at 0.50 fish/rod hours.

Adjacent to Park Boundaries

Statistical areas adjacent to Park waters (i.e., Area 46) are relevant to Park catch because a portion of the catch from these statistical areas may have originated within Park waters but was likely misreported. However, quantifying within-Park components of halibut—or any catch for that matter—is difficult. Because creel samplers intercepted charter captains and anglers *after* trips were completed, samplers were unable to verify reported fishing locations. Moreover, the small number of charterboats encountered during Outer Waters Vessel Activity Surveys (OWVAS or aerial surveys), designed to assess vessel traffic and activity for a wide variety of vessels, made fishery-independent verification of reported fishing location difficult.

Lingcod Catch

An estimated 146 lingcod were harvested and 1,336 fish released by charter anglers (Table 3). Statistical Area 55 had the highest number of lingcod caught, with 87 fish harvested and 579 fish released. Areas 53 and 54 comprised 32% (439 fish) and 13% (177), respectively, of the total lingcod released. Lingcod releases peaked during July at 128 fish, and reported lingcod harvest peaked in June and August at 18 and 10 fish, respectively (Fig. 7). Reported catch and harvest rates for lingcod were widely disparate, with a peak catch rate of 0.09 fish/rod hour in July and a peak harvest rate of 0.01 fish/rod hour reported in June and August (Fig. 7).

Within Park Boundaries

Lingcod catch in Park waters reportedly occurred only in Area 47. Although 53 fish were caught, the vast majority of these (40 fish) were released (Table 3), and thus only 13 fish were harvested.

Dogfish Catch

Outside Park Boundaries

A total of 503 dogfish were caught and released during the sampling period (Table 3). Statistical Areas 54 and 55 comprised the highest portion, with 66 fish caught and 356 fish released, respectively. Dogfish harvests were not reported during the sampling period.

Within Park Boundaries

An estimated 10% of dogfish catch (53 fish) originated from Dundas Bay (Area 45), which also exhibited the highest catch rates of 0.27 dogfish/rod hour.

Table 3. Distribution by statistical area of estimated numbers (*N*) of *halibut, lingcod, and dogfish* harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) for *charter* anglers from *Elfin Cove*, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within-Park harvest (Sub-Areas 29-1 and 46-1; Fig. 3).

Statistical Area		Halibut				Lingcod				Dogfish	
		Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE	Rel	HPUE
28	*N*	65	59	0.48	0.23	*	*	*	*	*	*
	SE	24.5	25.9	0.05	0.02	*	*	*	*	*	*
	RP	74.6	86.9	*	*	*	*	*	*	*	*
29	*N*	5	3	0.63	0.38	*	*	*	*	*	*
	SE	4.4	2.9	NA	NA	*	*	*	*	*	*
	RP	174.4	174.4	*	*	*	*	*	*	*	*
45	*N*	15	3	0.23	0.19	*	*	*	*	53	0.27
	SE	11.6	2.9	0.15	0.12	*	*	*	*	17.4	0.19
	RP	155.3	174.4	*	*	*	*	*	*	64.4	*
46	*N*	126	55	0.39	0.29	*	71	0.03	*	*	*
	SE	28.0	17.0	0.02	0.01	*	8.7	<0.01	*	*	*
	RP	43.9	61.6	*	*	*	24.2	*	*	*	*
47	*N*	3	*	0.17	0.17	13	40	0.50	0.13	*	*
	SE	2.9	*	NA	NA	4.3	25.9	NA	NA	*	*
	RP	174.4	*	*	*	63.7	127.9	*	*	*	*
51	*N*	1	1	0.50	0.17	*	*	*	*	*	*
	SE	0.6	1.1	NA	NA	*	*	*	*	*	*
	RP	172.1	172.1	*	*	*	*	*	*	*	*
52	*N*	*	*	*	*	*	19	0.04	<0.01	*	*
	SE	*	*	*	*	*	8.3	0.01	<0.01	*	*
	RP	*	*	*	*	*	87.1	*	*	*	*
53	*N*	262	145	0.28	0.18	26	439	0.05	<0.01	28	<0.01
	SE	36.8	47.1	<0.01	<0.01	5.9	70.5	<0.01	<0.01	5.1	<0.01
	RP	27.8	64.4	*	*	45.5	31.8	*	*	36.3	*
54	*N*	48	100	0.67	0.24	12	177	0.18	0.01	66	0.09
	SE	16.8	58.6	0.07	0.02	2.7	56.1	0.02	<0.01	6.9	0.02
	RP	69.7	116.2	*	*	44.5	62.7	*	*	20.5	*
55	*N*	259	351	1.11	0.46	87	579	0.06	0.01	356	0.04
	SE	49.3	145.3	0.04	0.02	5.2	57.9	<0.01	<0.01	32.6	<0.01
	RP	37.7	82.1	*	*	12.0	19.8	*	*	18.1	*
57	*N*	2	*	0.05	0.05	8	11	0.08	0.04	*	*
	SE	1.7	*	0.03	0.03	1.8	2.8	0.02	0.01	*	*
	RP	169.7	*	*	*	44.5	48.2	*	*	*	*
All	*N*	786	717	0.54	0.29	146	1336	0.06	0.01	503	0.01
Areas	SE	73	166.3	0.01	<0.01	11.1	131.2	<0.01	<0.01	38.7	<0.01
	RP	18	46	*	*	15	19	*	*	15.2	*

Totals may be inexact due to rounding error; asterisks denote unreported catch; SE = standard error (Cochran 1977); RP is relative precision (=1.98*SE/estimate x 100); NA = standard error not calculated due to single sample (boating party).

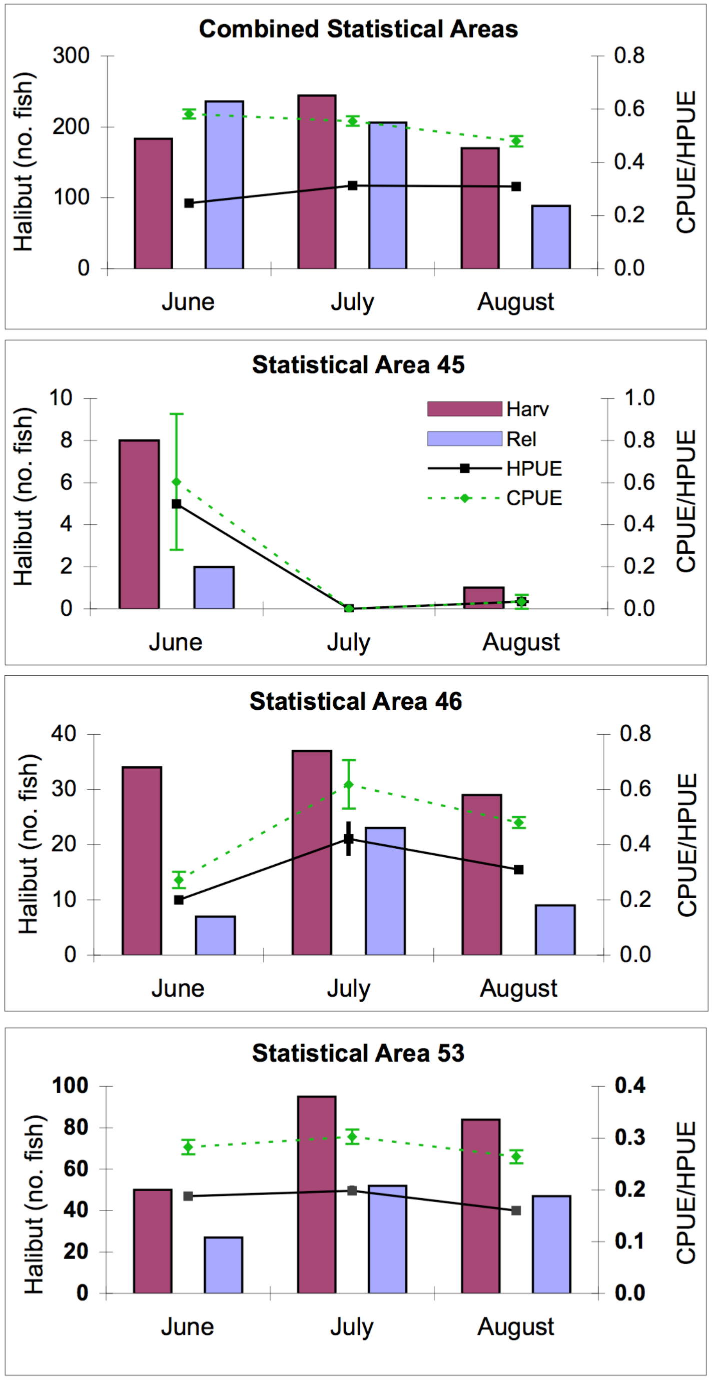

Figure 6. Reported numbers of halibut harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) in Statistical Areas 45, 46, 53 and combined for charter anglers from Elfin Cove, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

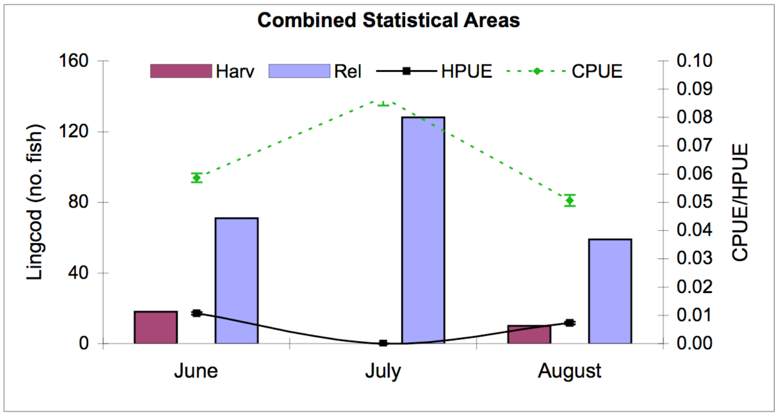

Figure 7. Reported numbers of lingcod harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) across statistical areas for charter anglers from Elfin Cove, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Rockfish Catch

Although charter anglers caught nearly 1,300 rockfish, over half (55%) were released (Table 4). Yelloweye rockfish accounted for most (71%) rockfish harvested by charter anglers, with black (18%), other non-pelagics (7%), and quillback (4%) also harvested. Moreover, harvest rates for yelloweye were three times higher than for other rockfish species.

Yelloweye Rockfish

Charter anglers harvested an estimated 417 yelloweye rockfish during the sampling period (Table 4), with Statistical Area 55 comprising the highest harvest level, 66% (277 fish), and Areas 53 and 54 accounting for 18% (75 fish) and 11% (45 fish), respectively.

Reported yelloweye rockfish harvest peaked in July (86 fish) and was lowest in August (38 fish) (Fig. 9). Harvest rates peaked slightly in July at 0.06 (SE<0.01) fish/rod hour, and similar harvest rates were observed in June and August with 0.05 (SE<0.01) and 0.03 (SE<0.01) fish/rod hour, respectively.

Black Rockfish

An estimated 106 black rockfish were harvested during the sampling period (Table 4), the greatest proportion (41%) of which occurred in Area 55 (43 fish). Areas 53 and 54 comprised 37% (39 fish) and 15% (16 fish), respectively. Harvest rates were generally highest during mid- to late summer, with reported black rockfish harvest peaking in July (51 fish) and lowest in June (3 fish) (Fig. 8). Harvest rates peaked slightly in July at 0.04 (SE<0.01) fish/rod hour, and similar harvest rates were observed in June and August with 0.01 (SE<0.01) fish/rod hour.

Non-Pelagic & Other Rockfish

An estimated 42 unidentified non-pelagic rockfish were harvested in Areas 53 and 55 during the sampling period (Table 4). Harvest was split evenly between Areas 53 (22 fish) and 55 (20 fish). Small numbers (<10) of yellowtail and dusky rockfish were also caught in these areas. An estimated 19 quillback rockfish were harvested during the sampling period, with the highest number (15 fish) harvested in Area 55 (Table 4). Harvest was minimal in other areas as indicated in Table 4.

Released Rockfish

Elfin Cove anglers released an estimated 708 rockfish, with Areas 53 and 55 accounting for the greatest number of rockfish released (319 and 301 fish, respectively) (Table 4). Reported rockfish releases for all statistical areas peaked in July (165 fish) and were similar in magnitude during June and August (73 and 68 fish, respectively) (Fig. 8). Catch rates were highest in Areas 53 and 54 with 0.50 and 0.61 fish/rod hour, respectively (Table 4). Catch rates in Area 53 were highest in June and July with 0.70 (SE=0.10) and 0.82 (SE=0.08) fish/rod hour, respectively (Fig. 8).

Within-Park Rockfish Catch

Black and yelloweye harvests originating from Area 47 were the only species reported caught in Park waters, with estimated harvests of 2 black and 18 yelloweye rockfish (Fig. 9). Rockfish were not reported released in Park waters.

Table 4. Distribution by statistical area of estimated numbers (*N*) of rockfish harvested and released, harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Estimates for Area 46 include within-Park harvest (Sub-Area 46-1; Fig. 3).

Statistical		Rockfish									
		Quillback		Black		Yelloweye		Other non-pelagic		All	
Area		Harv	HPUE	Harv	HPUE	Harv	HPUE	Harv	HPUE	Rel	CPUE
46	*N*	*	*	6	<0.01	1	<0.01	*	*	8	0.02
	SE	*	*	4.3	<0.01	1.0	<0.01	*	*	5.5	<0.01
	RP	*	*	132.5	*	169.7	*	*	*	132.6	*
47	*N*	*	*	2	0.04	18	0.25	*	*	*	*
	SE	*	*	1.5	NA	7.8	NA	*	*	*	*
	RP	*	*	174.4	*	87.2	*	*	*	*	*
52	*N*	*	*	*	*	*	*	*	*	5	<0.01
	SE	*	*	*	*	*	*	*	*	46.7	<0.01
	RP	*	*	*	*	*	*	*	*	1849.3	*
53	*N*	3	<0.01	39	0.05	75	0.03	22	0.14	319	0.50
	SE	3.7	<0.01	19.1	<0.01	16.5	<0.01	37.6	0.03	68.4	0.02
	RP	276.7	*	97.5	*	43.5	*	339.5	*	42.5	*
54	*N*	1	<0.01	16	0.05	45	0.23	*	*	61	0.61
	SE	1.9	<0.01	9.8	0.01	13.4	0.02	*	*	27.2	0.05
	RP	383.2	*	122.1	*	59.1	*	*	*	88.9	*
55	*N*	15	<0.01	43	0.02	277	0.06	20	0.01	301	0.19
	SE	6.9	<0.01	14.9	<0.01	35.6	<0.01	25.7	<0.01	77.8	<0.01
	RP	91.0	*	69.0	*	25.5	*	254.1	*	51.2	*
57	*N*	*	*	1	<0.01	1	<0.01	*	*	3	0.02
	SE	*	*	0.8	<0.01	1.0	NA	*	*	7.3	<0.01
	RP	*	*	169.7	*	169.7	*	*	*	494.8	*
All	*N*	19	<0.01	106	0.02	417	0.04	42	<0.01	708	0.18
Areas	SE	7.3	<0.01	27.3	<0.01	43.6	<0.01	47.1	<0.01	104.4	<0.01
	RP	77.3	*	50.8	*	20.7	*	222.1	*	29.2	*

Totals may be inexact due to rounding error; asterisks denote unreported catch; SE = standard error (Cochran 1977); RP is relative precision (= 1.98*SE/estimate x 100); NA = standard error not calculated due to single sample (boating party).

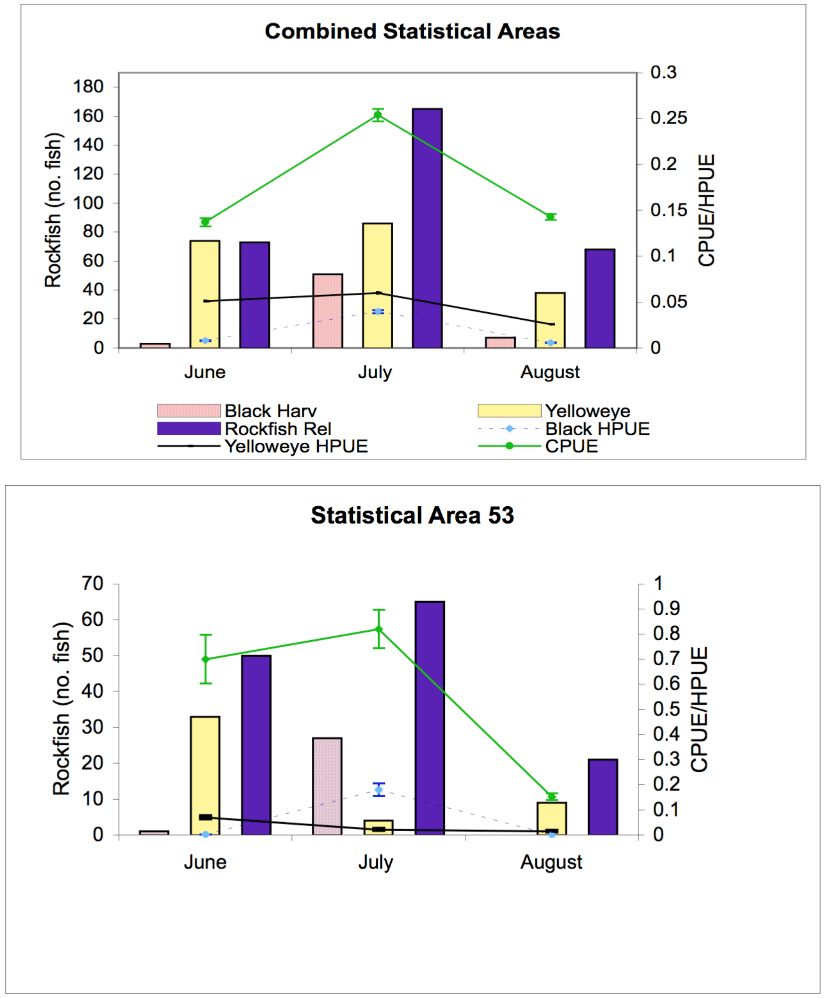

Figure 8. Reported numbers of yelloweye and black rockfish harvested, released, (Rockfish Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours; all species) in Statistical Area 53 and combined areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Salmon Catch

Elfin Cove charter anglers harvested an estimated 2,143 salmon (Table 5). Coho salmon accounted for most (71%) salmon harvested by charter anglers, followed by pink (16%), king (10%), and chum (3%) salmon. Charter anglers retained 97% of coho, 39% of pink, 83% of king, and 96% of chum salmon and released an estimated 45 coho, 534 pink, 43 king, and 3 chum salmon.

Table 5. Distribution by statistical area of estimated numbers (*N*) of salmon harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Area 46 includes within-Park Sub-Area 46-1 (Fig. 3).

Statistical Area		Salmon															
		Coho				King				Pink				Chum			
		Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE
28	*N*	*	*	*	*	*	*	*	*	2	5	B	B	2	*	*	*
	SE	*	*	*	*	*	*	*	*	1.5	4.6	*	*	1.5	*	*	*
	RP	*	*	*	*	*	*	*	*	188.7	188.7	*	*	188.7	*	*	*
46	*N*	58	6	1.04	0.92	*	*	*	*	25	8	1.46	1.25	2	*	0.08	0.08
	SE	32.6	6.1	0.49	0.44	*	*	*	*	21.8	7.7	0.73	0.72	0.2	*	0.05	0.05
	RP	111.1	188.7	*	*	*	*	*	*	174.4	188.7	*	*	24.3	*	*	*
47	*N*	8	2	0.67	0.42	*	*	*	*	*	*	*	*	*	*	*	*
	SE	7.2	1.8	NA	NA	*	*	*	*	*	*	*	*	*	*	*	*
	RP	171.9	192.4	*	*	*	*	*	*	*	*	*	*	*	*	*	*
51	*N*	*	*	*	*	*	*	*	*	1	13	0.73	0.06	*	*	*	*
	SE	*	*	*	*	*	*	*	*	1.4	12.4	0.52	0.06	*	*	*	*
	RP	*	*	*	*	*	*	*	*	187.6	187.6	*	*	*	*	*	*
52	*N*	*	*	*	*	7	*	0.07	0.07	2	*	0.02	0.02	*	*	*	*
	SE	*	*	*	*	4.1	*	0.01	0.01	1.2	*	0.01	0.01	*	*	*	*
	RP	*	*	*	*	118.9	*	*	*	117.6	*	*	*	*	*	*	*
53	*N*	495	12	0.78	0.76	7	3	0.02	0.01	133	170	0.56	0.21	1	*	0.01	0.01
	SE	122.4	8.5	0.03	0.02	3.6	1.8	<0.01	<0.01	49.8	44.6	0.02	0.01	0.1	*	<0.01	<0.01
	RP	49.0	143.1	*	*	106.4	133.8	*	*	74.1	52.0	*	*	21.1	*	*	*
54	*N*	118	*	0.66	0.66	13	2	0.10	0.09	9	30	0.37	0.18	2	*	<0.01	<0.01
	SE	40.7	*	0.07	0.07	5.5	1.5	0.01	0.01	4.9	14.5	0.05	0.04	1.5	*	<0.01	<0.01
	RP	68.1	*	*	*	85.7	188.7	*	*	107.30	96.3	*	*	188.7	*	*	*
55	*N*	801	25	0.46	0.44	183	39	0.18	0.14	150	286	0.29	0.09	50	2	0.03	0.03
	SE	138.8	20.9	0.01	0.01	30.8	9.1	<0.01	<0.01	39.0	87.6	0.01	<0.01	5.8	1.7	<0.01	<0.01
	RP	34.3	165.7	*	*	33.4	46.2	*	*	51.4	60.7	*	*	22.6	169.7	*	*
57	*N*	51	*	0.17	0.17	1	*	0.01	0.01	13	23	0.27	0.09	10	1	0.05	0.04
	SE	28.9	*	0.03	0.03	0.8	*	<0.01	<0.01	6.0	14.3	0.03	0.01	9.2	0.8	0.01	0.01
	RP	111.6	*	*	*	169.7	*	*	*	88.0	123.6	*	*	188.7	169.7	*	*
All Areas	*N*	1531	45	0.56	0.54	210	43	0.12	0.09	336	534	0.38	0.16	66	3	0.02	0.02
	SE	204.2	23.1	0.01	0.01	31.4	9.5	<0.01	<0.01	67.7	113.1	0.01	<0.01	13.1	1.8	<0.01	<0.01
	RP	26.4	101.7	*	*	29.6	43.4	*	*	39.9	41.9	*	*	39.3	124.5	*	*

Totals may be inexact due to rounding error; asterisks denote unreported catch ; SE = standard error (Cochran 1977); RP is relative precision (=1.98*SE/estimate x 100); NA = standard error not calculated due to single sample (boating party); B denotes salmon caught while bottomfishing.

Coho Salmon

Statistical Area 55 comprised the largest portion, 52% (801 fish) of total estimated coho salmon harvest (Table 5). Area 53 comprised 32% (495 fish) and Area 54 comprised 8% (118 fish).

Catch and harvest rates for all statistical areas were 0.56 and 0.54 fish/rod hour, respectively (Table 5). Area 46 had the highest catch rate (1.04 fish/rod hour) and harvest rate (0.92 fish/rod hour (Fig. 10). Reported catch and harvest rates increased for all statistical areas combined, from a low of 0.16 fish/rod hour (SE<0.01) in June to a peak catch rate in August of 0.98 (SE=0.02) and a harvest rate of 0.92 (SE=0.02) (Fig. 10). Similarly, Area 55 catch and harvest rates peaked in August at 1.01 (SE =0.06) and 0.92 (SE = 0.06) fish/rod hour, respectively. Area 55 dominated coho harvest for all statistical areas in June but contributed less than half of total harvest during July and August.

Coho salmon catch and harvest generally increased from June through July for all statistical areas. Reported harvest peaked in August at 614 individuals, a four-fold increase from June and July harvest levels of 143 and 128 fish, respectively (Fig. 9).

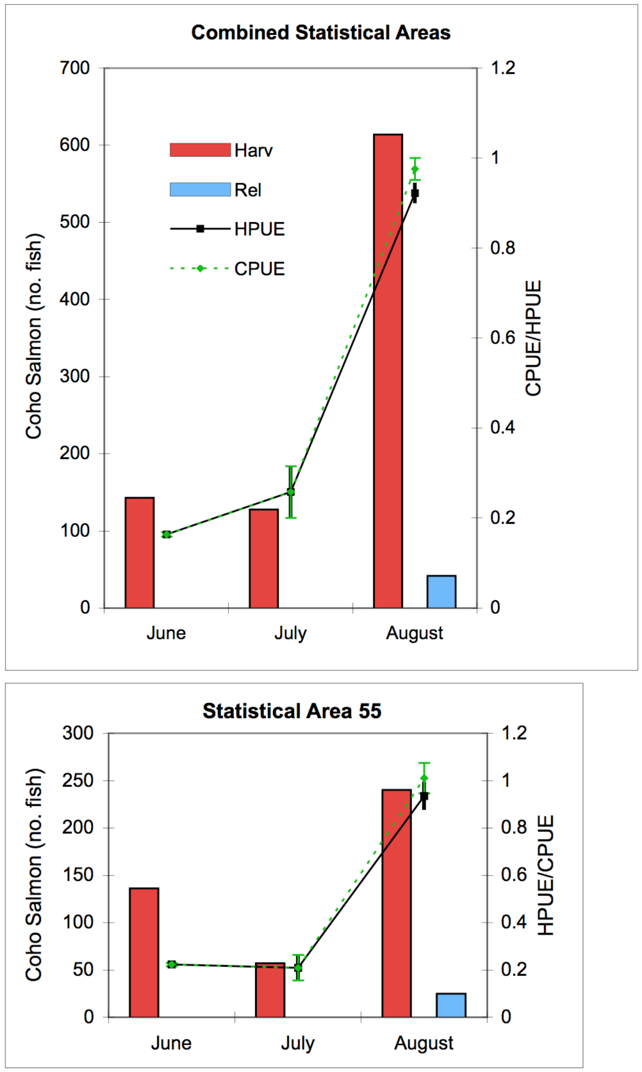

Figure 9. Reported numbers of coho salmon harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) in Statistical Area 55 and combined areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

King Salmon

Reported king salmon harvest decreased as the sampling season progressed, with an observed peak in June (109 fish) (Fig. 11). Area 55 accounted for 87% (183 fish) of the total king salmon harvested (Table 5). Areas 52 and 54 comprised 3% (7 fish) and 6% (13 fish), respectively.

Catch and harvest rates for all statistical areas were 0.12 and 0.09 fish/rod hour, respectively (Table 5). Area 55 exhibited the highest catch and harvest rates of 0.18 and 0.14 fish/rod hour, respectively. Reported CPUE and HPUE peaked in June at 0.18 (SE=0.03) and 0.13 (SE=0.02) fish/rod hour, respectively (Fig. 10). Harvest rates decreased 54% from the June peak to July and August values of ≤0.06 (SE=0.02) fish/rod hour.

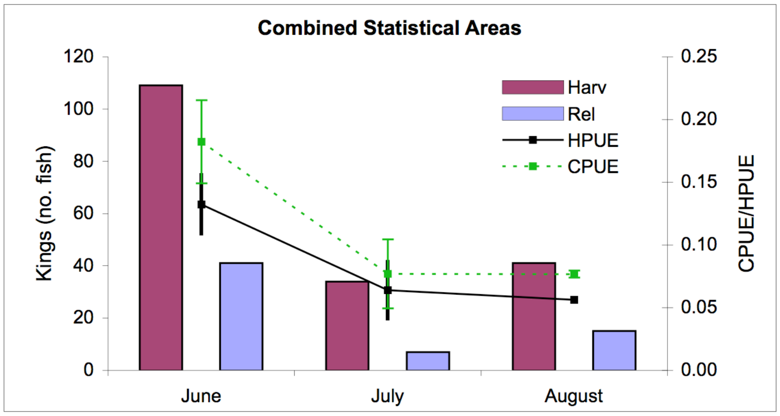

Figure 10. Reported numbers of king salmon harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) across all statistical areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Standard error is shown for HPUE and CPUE estimates.

Pink Salmon

Although a considerable number of pink salmon were harvested, more than 60% were released (Table 5). Most of the harvest (84%) occurred in Areas 53 and 55. Catch rates ranged from 0.02 to 1.46 fish/rod hour, with comparable harvest rates of 0.02–1.25 fish/rod hour. Catch peaked in July at 308 fish when more than 60% of catch was released (Fig. 11). The disparity between catch and harvest rates was similarly greatest during July.

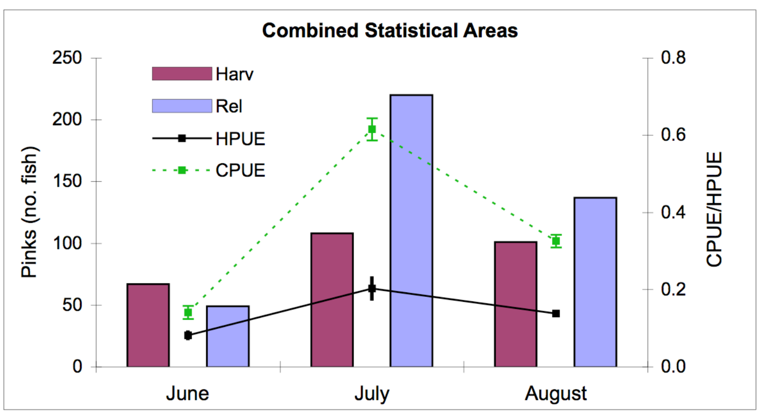

Figure 11. Reported numbers of pink salmon harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) across all statistical areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Chum Salmon

An order of magnitude fewer chum salmon were harvested, and very few were released (Table 5). Area 55 accounted for 76% of chum salmon harvest. Chum catch and harvest rates were $\leq$0.08 fish/rod hour.

Within-Park Salmon Catch

Only coho salmon were reported caught in Park waters. In Area 47, charter anglers harvested an estimated 8 fish and released 2.

Fishery-Independent Surveys to Estimate Halibut Catch and Effort

Halibut catch and effort data from the creel survey for Statistical Areas 46 and 53 were combined to increase sample size. The data were fit with a linear expression (R^2=0.57, n=51, b_o =0.2506, b= 2.0549) (Fig. 5). Despite a linear relationship between fishing effort and halibut catch, this relationship exhibits considerable variation between effort and catch.

Estimates of halibut catch and harvest using OWVAS aerial survey data were not attempted due to model variability, the difficulty of accurately ascertaining observed charterboat fishing methods, and small sample size as a result of our inability to subsequently intercept an adequate portion of OWVAS-observed charterboats during dock sampling.

A total of 18 Elfin Cove charterboats were documented as fishing (halibut or salmon) within Park waters during the 78-day aerial-survey sampling period. However, only four of these boats were subsequently intercepted during the creel survey. Although three boats observed fishing within Park waters during aerial surveys failed to subsequently report fishing there (Statistical Sub-Area 46-1), one boat did accurately report its fishing location within the Park (Area 47).

RESULTS 2

Gustavus Private & Charterboat Creel Survey

Stratification & Sampling

The sampling period ran from May 15 to September 15, 2003 and encompassed 123 days. More than 80% of days (102 days) within the sampling frame were sampled.

A one-way ANOVA comparing weekend with weekday strata effort showed no significant difference at $\alpha=0.05$ ($F=1.346$; $n=1578$; $p=0.213$). Thus, weekend and weekday strata were pooled for all statistical analyses and inference.

Total Fishing Effort

In comparison with private anglers, charter anglers accounted for most bottomfishing (81%) and salmon-fishing effort (84%) (Table 6). Charter anglers fished an estimated 18,622 rod hours, with 64% of that effort focused on bottomfish and the remaining 36% on salmon. Private anglers fished an estimated 4,066 rod hours, with 69% focused on bottomfish and 31% on salmon.

Salmon and bottomfishing effort for both private and charter anglers peaked in midsummer; salmon-fishing effort peaked strongly in August with a smaller peak in June, and bottomfishing effort peaked in July and early August.

Table 6. Distribution of estimated fishing effort across dock sampling sites by groups (charter or private) and fishing types (bottomfish and salmon) during the 2003 sampling period.

	Effort (rod hours)			Among fishing groups			Within fishing groups		
Dock	Bottom	Salmon	Total	Bottom	Salmon	Total	Bottom	Salmon	Total
Gustavus									
Charter	11,996	6,626	18,622	0.81	0.84	0.82	0.64	0.36	1.00
Private	2,806	1,260	4,066	0.19	0.16	0.18	0.69	0.31	1.00
Total	14,802	7,886	22,689	1.00	1.00	1.00	*	*	*
Elfin Cove									
Charter	3,219	2,731	5,950	NA	NA	NA	0.54	0.46	1.00
Total Effort	18,021	10,617	28,638						
Charter distribution by dock									
Gustavus				0.79	0.71	0.76			
Elfin Cove				0.21	0.29	0.24			

Asterisks indicate effort not reported; NA indicates calculation not applicable because of only one user group.

Bottomfishing

Estimated bottomfishing effort for *charter* anglers was 11,996 rod hours distributed over 14 statistical areas (Table 7). Area 46 accounted for 52% of this effort (6,220 rod hours), and Areas 28 and 29 comprised 27% and 17%, respectively.

Estimated bottomfishing effort for *private* anglers was 2,806 rod hours distributed over 10 statistical areas (Table 7). Area 28 exhibited the highest proportion (39%) of this effort, and Areas 29 and 46 comprised 35% and 19%, respectively.

Salmon Fishing

Estimated salmon-fishing effort for *charter* anglers was 6,626 rod hours distributed across 11 statistical areas (Table 7). Area 29 had the highest level of effort, 49% (3,234 rod hours), and Areas 26 and 55 accounted for 27% and 7%, respectively.

Estimated salmon-fishing effort for *private* anglers was 1,260 rod hours distributed across 9 statistical areas (Table 7). Similar to charter anglers, Area 29 had the highest level of effort, 56% (706 rod hours), and Areas 26 and 28 comprised 19% (235 rod hours) and 20% (250 rod hours), respectively.

Table 7. Distribution of estimated fishing effort (*N*=rod hours) by statistical area for bottomfish and salmon by charter and private anglers from Gustavus, Alaska during the 2003 sampling period.

Fishing	effort	Statistical Area																
		25	26	27	28	29	30	37	42	45	46	48	49	51	52	53	55	57	Total
Charter																			
Bottom-fish	*N*	29	*	*	3255	2064	7	*	19	4	6220	22	10	4	7	142	125	88	11,996
	SE	12.0	*	*	135.7	103.2	3.0	*	5.8	1.5	222.7	9.0	4.0	1.5	3.0	20.7	19.8	13.6	269.8
	RP	82.0	*	*	8.3	9.9	82.0	*	59.5	82.0	7.1	82.0	82.0	82.0	82.0	28.9	31.3	30.6	4.5
Salmon	*N*	*	1794	39	321	3234	*	130	*	*	22	*	*	324	112	113	479	55	6626
	SE	*	147.9	11.6	35.9	157.3	*	21.5	*	*	4.7	*	*	35.9	17.8	17.0	54.1	12.4	189.1
	RP	*	16.4	59.5	22.2	9.6	*	32.7	*	*	43.1	*	*	21.9	31.5	29.7	22.4	44.4	5.7
Private																			
Bottom-fish	*N*	*	22	31	1099	1003	52	34	*	*	539	*	*	7	*	14	5	*	2806
	SE	*	9.0	10.4	75.0	52.8	14.9	10.2	*	*	44.4	*	*	3.0	*	4.7	2.0	*	105.8
	RP	*	82.0	65.7	13.5	10.4	56.9	60.0	*	*	16.3	*	*	82.0	*	64.6	82.0	*	7.5
Salmon	*N*	*	235	*	250	706	5	11	*	*	*	*	*	*	19	12	14	7	1260
	SE	*	34.0	*	28.0	43.5	2.0	3.3	*	*	*	*	*	*	8.0	5.0	6.0	2.2	57.6
	RP	*	28.7	*	22.2	12.2	77.3	60.9	*	*	*	*	*	*	82.0	82.0	82.0	60.9	9.1

Asterisks denote catch not reported; SE = standard error (Cochran 1977); RP is relative precision (=1.98*SE/estimate x 100).

Within-Park Fishing Effort

Only 347 rod hours (excluding Area 51) of fishing effort were estimated for Park waters (Table 8). This accounted for about 1.5 % of total estimated effort, with the vast majority of that effort attributed to bottom-fishing. Salmon-fishing effort by *charter* anglers was comparable to bottomfishing effort by *private* anglers.

Bottomfishing

Charter anglers accounted for a total of 266 rod hours distributed across five statistical areas (Table 8). Area 29-1 had the highest level of effort for these anglers, 80% (212 rod hours), occurring within Park waters. Area 42 and and Sub-Area 46-1 comprised most of the remaining charter effort with 19 and 24 rod hours, respectively. Because bottomfishing effort and catch along the boundaries of Areas 29, 29-1, 46, and 46-1 may not have been reported accurately, estimates from these two areas should perhaps be combined for management purposes.

Private anglers accounted for only 16% of bottomfishing effort within Park boundaries. Total estimated effort for these anglers within Park waters was 52 rod hours in Area 30 (Table 8).

Salmon Fishing

Charter anglers accounted for all salmon-fishing effort within Park waters (29 rod hours in Sub-Area 26-1) (Table 8).

Table 8. Distribution of estimated fishing effort (*N*=rod hours) by statistical area *within* Park waters for bottomfish and salmon by charter and private anglers from Gustavus, Alaska during the 2003 sampling period.

Within-Park fishing effort		Statistical Area						
		26-1	29-1	30	42	45	46-1	Total
Chartered								
Bottomfish	*N*	*	212	7	19	4	24	266
	SE	*	26.4	3.0	5.8	1.5	10.0	32.1
	RP	*	24.7	81.8	59.4	81.8	81.8	23.9
Salmon	*N*	29	*	*	*	*	*	29
	SE	1.2	*	*	*	*	*	1.2
	RP	8.1	*	*	*	*	*	8.1
Private								
Bottomfish	*N*	*	*	52	*	*	*	52
	SE	*	*	14.6	*	*	*	14.6
	RP	*	*	55.8	*	*	*	55.8

Asterisks denote catch unreported; SE = standard error (Cochran 1977); RP is relative precision (=1.98*SE/estimate x 100).

Halibut Catch

Charter anglers accounted for most (84%) halibut reported caught by both private and charter anglers in Gustavus. Charter anglers accounted for 83% of the estimated harvest and 86% of estimated releases. An estimated 4,556 halibut (distributed over 11 statistical areas) were harvested and 5,884 halibut (distributed over 9 statistical areas) were released by Gustavus charter anglers during the sampling period (Table 9). Statistical Area 46 accounted for 52% of total halibut caught, with an estimated harvest of 2,351 halibut and an estimated 3,038 released. Areas 28 and 29 had halibut harvest levels of 1,281 (28%) and 857 (19%), respectively.

Private anglers harvested an estimated 948 halibut and released an estimated 970 halibut during the sampling period (Table 10). Area 28 comprised the largest proportion of this catch, accounting for 39% of all harvested and 48% of all released halibut. Estimated halibut harvest from Area 28 was 368 fish, with an estimated 468 released. Areas 29 and 46 accounted for 33% and 23%, respectively, of estimated halibut harvest for all statistical areas.

Unlike reported releases, differences in peak harvest times were observed between charter and private anglers. Reported halibut releases for both charter and private anglers peaked in July with 1,785 fish and 474 fish released, respectively (Figs. 12 & 13). In comparison, charter harvest peaked in August at 1,401 fish while private angler harvest peaked a month earlier in July with 391 fish.

Charter angler harvest and catch rates exhibited similar temporal trends. Reported harvest rates increased from a low of 0.38 (SE=0.01) fish/rod hour in May to a high of 0.56 (SE=0.07) fish/rod hour in September (Fig. 12). Similarly, catch rates increased steadily from a low of 0.72 (SE=0.02) fish/rod hour in May to a peak in August of 1.11 (SE<0.01) fish/rod hour. A slight decline in halibut harvest rate was observed between August and September.

Table 9. Distribution by statistical area of estimated numbers (*N*) of rockfish, halibut, and lingcod harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) by charter anglers from Gustavus, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within–Park harvest (Sub-Areas 29-1 and 46-1; Fig. 3).

Statistical Area		Rockfish: Quillback Harv	Quillback HPUE	Black Harv	Black HPUE	Yelloweye Harv	Yelloweye HPUE	Other Non-Pelagic Harv	Other Non-Pelagic HPUE	All Rel	All CPUE	Halibut: Harv	Rel	CPUE	HPUE	Lingcod: Harv	Rel	HPUE	CPUE
25	*N*	*	*	*	*	*	*	*	*	*	*	10	18	0.96	0.33	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	4.0	7.5	NA	NA	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	82.0	82.0	*	*	*	*	*	*
26	*N*	*	*	*	*	*	*	*	*	*	*	6	*	NA	NA	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	1.6	*	*	*	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	53.9	*	*	*	*	*	*	*
28	*N*	*	*	*	*	*	*	*	*	*	*	1281	1780	1.13	0.55	1	*	<0.01	<0.01
	SE	*	*	*	*	*	*	*	*	*	*	50.7	98.9	<0.01	<0.01	0.5	*	NA	*
	RP	*	*	*	*	*	*	*	*	*	*	7.8	11.0	*	*	84.5	*	*	*
29	*N*	*	*	16	<0.01	*	*	*	*	19	0.01	857	880	1.02	0.49	*	*	*	*
	SE	*	*	3.7	<0.01	*	*	*	*	8.0	<0.01	37.2	46.1	<0.01	<0.01	*	*	*	*
	RP	*	*	47.1	*	*	*	*	*	82.0	*	8.6	10.4	*	*	*	*	*	*
30	*N*	*	*	*	*	*	*	*	*	*	*	5	*	1.00	1.00	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	2.0	*	NA	NA	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	*	*
42	*N*	*	*	*	*	*	*	*	*	*	*	11	36	2.32	0.65	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	3.3	12.7	0.34	0.01	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	60.9	69.5	*	*	*	*	*	*
45	*N*	*	*	*	*	*	*	*	*	*	*	4	*	1.00	1.00	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	1.5	*	NA	NA	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	*	*
46	*N*	*	*	8	<0.01	*	*	*	*	2	0.01	2351	3038	1.00	0.46	*	7	*	<0.01
	SE	*	*	3.0	<0.01	*	*	*	*	1.0	<0.01	82.1	130.2	<0.01	<0.01	*	1.4	*	<0.01
	RP	*	*	71.1	*	*	*	*	*	82.0	*	6.9	8.5	*	*	*	38.0	*	*
48	*N*	*	*	*	*	*	*	*	*	*	*	5	12	0.78	0.22	*	22	*	1.33
	SE	*	*	*	*	*	*	*	*	*	*	2.0	5.0	NA	NA	*	9.0	*	NA
	RP	*	*	*	*	*	*	*	*	*	*	82.0	82.0	*	*	*	82.0	*	*
49	*N*	*	*	*	*	*	*	*	*	*	0.06	6	6	1.25	0.63	*	*	*	*
	SE	*	*	*	*	*	*	*	*	*	0.01	2.5	2.5	NA	NA	*	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	82.0	82.0	*	*	*	*	*	*
51	*N*	*	*	1	<0.01	*	*	*	*	*	<0.01	*	*	*	*	*	*	*	*
	SE	*	*	0.5	<0.01	*	*	*	*	*	<0.01	*	*	*	*	*	*	*	*
	RP	*	*	82.0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
52	*N*	*	*	*	*	*	*	*	*	5	0.06	*	*	*	*	4	2	0.08	0.09
	SE	*	*	*	*	*	*	*	*	2.0	0.01	*	*	*	*	1.5	1.0	0.02	0.02
	RP	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	84.5	82.0	*	*
53	*N*	5	0.01	14	0.04	24	0.08	*	*	*	0.13	21	103	1.05	0.18	5	27	0.04	0.13
	SE	2.0	0.04	3.5	0.07	5.1	0.11	*	*	*	0.01	3.7	32.8	0.14	<0.01	1.4	6.7	0.02	0.01
	RP	82.0	*	47.9	*	41.6	*	*	*	*	*	35.7	63.5	*	*	59.3	50.4	*	*
55	*N*	1	<0.01	12	0.02	42	0.09	1	<0.01	6	0.11	*	11	0.17	*	11	23	0.01	0.09
	SE	0.5	<0.01	3.6	0.02	8.0	0.05	0.5	<0.01	1.8	0.01	*	4.0	0.07	*	3.3	5.1	<0.01	0.01
	RP	98.9	*	58.8	*	37.6	*	82.0	*	58.8	*	*	73.3	*	*	59.6	44.5	*	*
57	*N*	1	0.01	14	0.07	45	0.38	1	<0.01	24	0.57	*	*	*	*	4	66	0.01	0.54
	SE	0.5	0.02	5.1	0.20	7.1	0.26	0.5	<0.01	7.0	0.06	*	*	*	*	1.5	11.6	0.01	0.06
	RP	82.0	*	69.5	*	31.5	*	81.98	*	57.7	*	*	*	*	*	84.5	34.8	*	*
All Areas	*N*	7	<0.01	66	<0.01	111	0.01	2	<0.01	57	0.02	4556	5884	1.03	0.48	24	147	<0.01	0.01
	SE	2.1	<0.01	9.1	<0.01	11.5	<0.01	0.7	<0.01	10.8	<0.01	101.8	177.2	<0.01	<0.01	4.5	17.5	*	*
	RP	57.7	*	27.1	*	20.6	*	57.7	*	37.9	*	4.4	6.0	*	*	36.6	23.6	*	*

Totals may be inexact due to rounding error. Asterisks denote unreported catch; SE = standard error (Cochran 1977); NA = standard error not calculated due to single sample (boating party) or unreported effort; RP is relative precision (=1.98*SE/estimate x 100).

Table 10. Distribution by statistical area of estimated numbers (*N*) of rockfish and halibut harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) by private anglers from Gustavus, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within-Park harvest (Sub-Areas 29-1 and 46-1; Fig. 3).

Statistical Area		Rockfish								Halibut			
		Quillback		Black		Yelloweye		All					
		Harv	HPUE	Harv	HPUE	Harv	HPUE	Rel	CPUE	Harv	Rel	CPUE	HPUE
26	*N*	*	*	*	*	1	0.01	*	0.01	7	14	1.00	0.33
	SE	*	*	*	*	0.5	<0.01	*	<0.01	3.0	6.0	NA	NA
	RP	*	*	*	*	82.0	*	*		83.0	82.0	*	*
27	*N*	*	*	*	*	*	*	*	*	16	13	1.13	0.50
	SE	*	*	*	*	*	*	*	*	5.2	3.9	1.19	0.50
	RP	*	*	*	*	*	*	*	*	65.7	57.9	*	*
28	*N*	5	<0.01	*	*	*	*	*	<0.01	368	468	0.82	0.40
	SE	2.0	<0.01	*	*	*	*	*	<0.01	24.6	39.4	0.13	0.06
	RP	82.0	*	*	*	*	*	*	*	13.3	16.7	*	*
29	*N*	2	<0.01	17	0.01	*	*	11	0.01	317	297	0.70	0.39
	SE	0.7	<0.01	5.2	<0.01	*	*	3.2	<0.01	17.9	24.7	0.12	0.07
	RP	57.7	*	60.6		*	*	58.0	*	11.2	16.5	*	*
30	*N*	*	*	*	*	*	*	*	*	10	13	0.43	0.17
	SE	*	*	*	*	*	*	*	*	2.9	3.9	0.40	0.15
	RP	*	*	*	*	*	*	*	*	59.5	57.9	*	*
37	*N*	*	*	*	*	*	*	*	*	4	*	0.11	0.11
	SE	*	*	*	*	*	*	*	*	1.1	*	0.11	0.11
	RP	*	*	*	*	*	*	*	*	60.9	*	*	*
46	*N*	*	*	1	0.01	2	0.01	*	0.02	215	162	0.86	0.56
	SE	*	*	0.5	<0.01	1.0	<0.01	*	<0.01	15.7	18.2	0.18	0.13
	RP	*	*	82.0	*	82.0	*	*	*	14.5	22.4	*	*
51	*N*	*	*	*	*	*	*	*	*	4	*	0.50	0.50
	SE	*	*	*	*	*	*	*	*	1.5	*	NA	NA
	RP	*	*	*	*	*	*	*	*	82.0	*	*	*
53	*N*	*	*	*	*	*	*	*	*	4	2	0.56	0.33
	SE	*	*	*	*	*	*	*	*	1.5	1.0	NA	NA
	RP	*	*	*	*	*	*	*	*	82.0	82.0	*	*
55	*N*	*	*	*	*	*	*	*	*	4	*	0.75	0.75
	SE	*	*	*	*	*	*	*	*	1.5	*	NA	NA
	RP	*	*	*	*	*	*	*	*	82.0	*	*	*
All	*N*	7	<0.01	18	<0.01	4	<0.01	11	0.01	948	970	0.33	0.70
Areas	SE	2.1	<0.01	5.2	<0.01	1.1	<0.01	3.2	<0.01	35.0	53.9	0.02	0.02
	RP	57.7	*	56.8	*	60.9	*	58.0	*	7.3	11.0	*	*

Totals may be inexact due to rounding error. Asterisks denote catch not reported; SE = standard error (Cochran 1977); NA = standard error not calculated due to single sample (boating party); RP is relative precision (=1.98*SE/estimate x 100).

Private angler catch rates were considerably more variable compared with 0.36–0.38 fish/rod hour harvest rates over all statistical areas combined (Fig. 13). The relatively high variability observed for catch rates of private anglers among statistical areas during both August and September (see Areas 28, 29, and 46 in Fig. 13) was likely due to a small sample of anglers exhibiting widely varying fishing success.

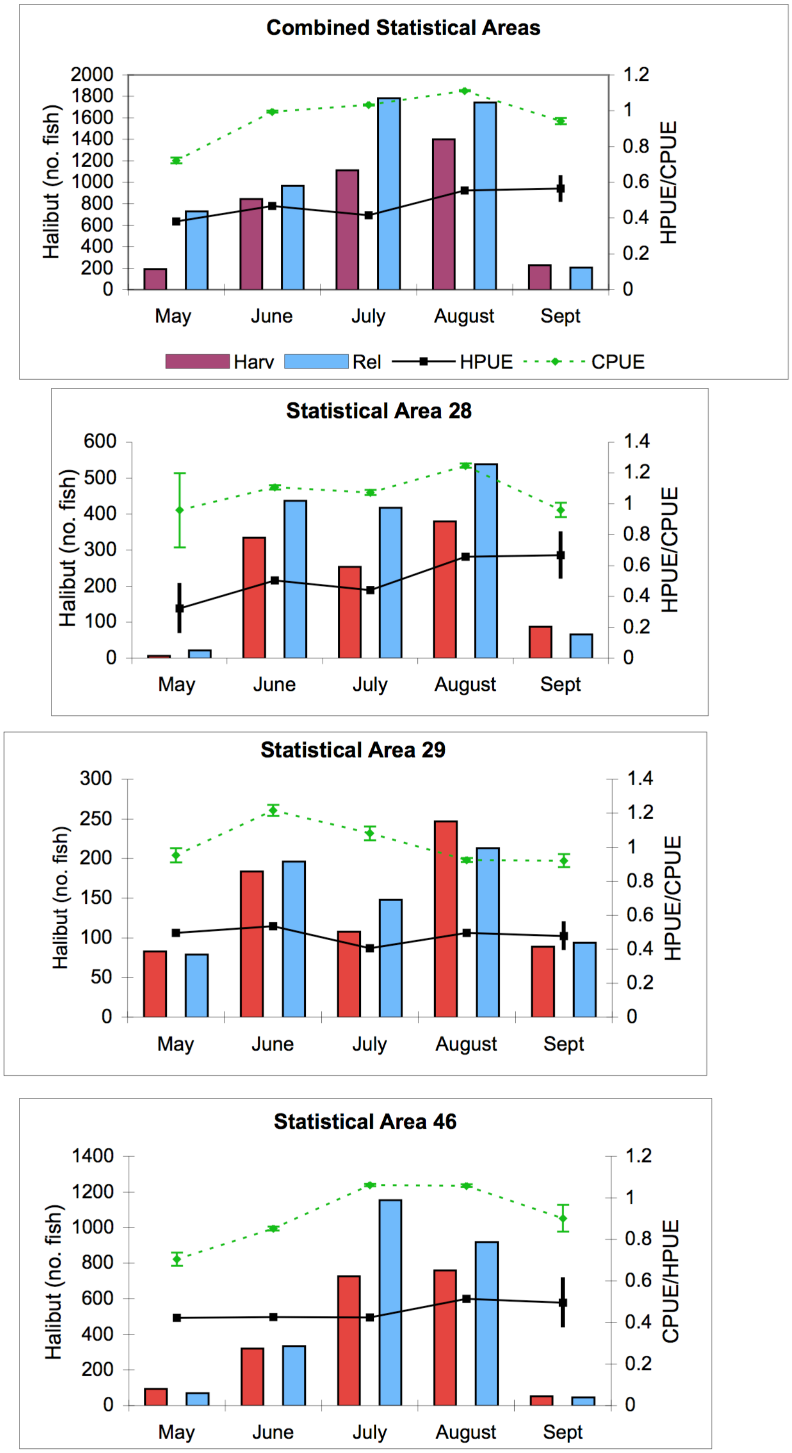

Figure 12. Reported numbers of halibut harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) in Statistical Areas 28, 29, 46, and combined areas for charter anglers from Gustavus, Alaska during the 2003 samping period. One standard error is shown for HPUE and CPUE estimates.

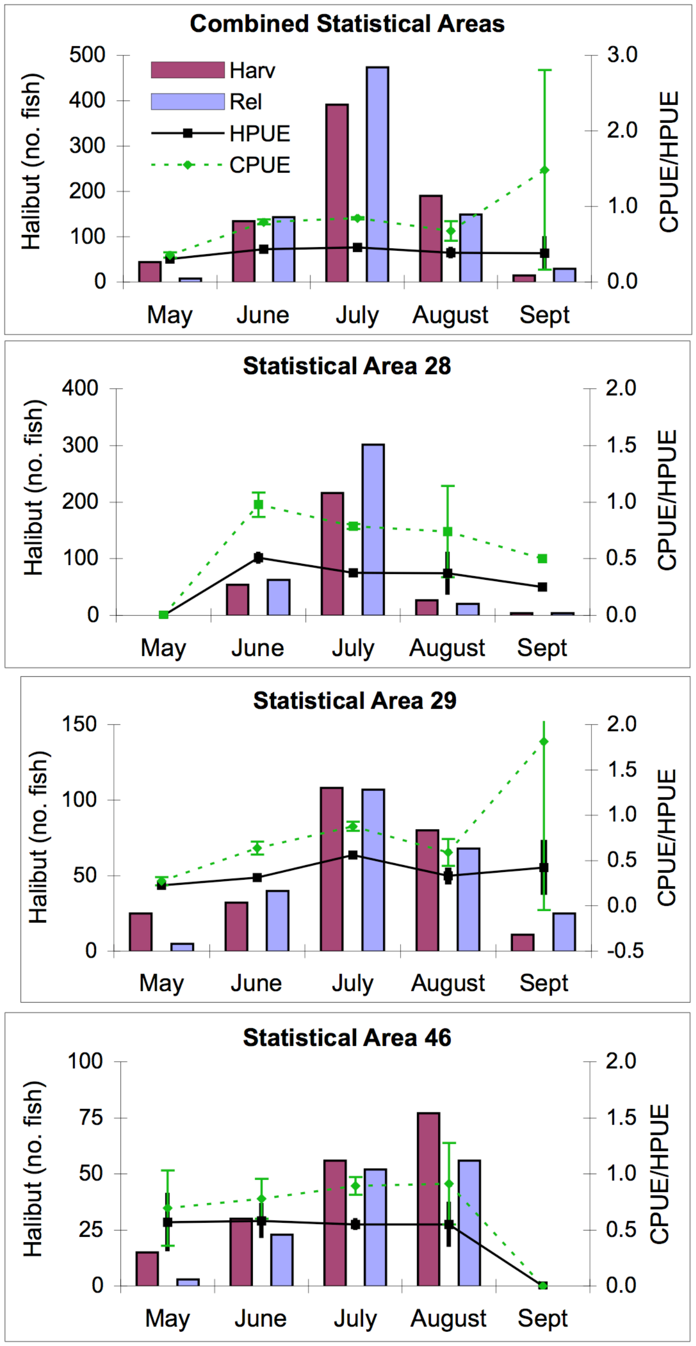

Figure 13. Reported numbers of halibut harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) in Statistical Areas 28, 29, 46, and combined areas by private anglers from Gustavus, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Within Park Boundaries

Charter anglers accounted for most (88%) halibut caught in Park waters, with an estimated 96 halibut harvested and 66 released (Table 11). Private anglers harvested an estimated 10 halibut and released 13. Charter anglers, as a group, fished in more statistical areas (4 areas total) than did private anglers (a single area). Sub-Area 29-1 had the highest estimated halibut harvested (80 fish) by charter anglers (Table 11). Area 30 accounted for all reported halibut caught in Park waters by *private* anglers.

Table 11. Distribution by statistical area of estimated numbers (*N*) of salmon and halibut harvested and released within Park waters by charter anglers from Gustavus, Alaska during the 2003 sampling period.

Statistical Area		Coho Salmon		Pink Salmon		Halibut	
		Harvest	Release	Harvest	Release	Harvest	Release
26-1	*N*	4	*	6	*	*	*
	SE	1.5	*	4.9	*	*	*
	RP	82.0	*	162.3	*	*	*
29-1	*N*	*	*	*	*	80	59
	SE	*	*	*	*	13.3	12.5
	RP	*	*	*	*	33.1	41.8
30	*N*	*	*	*	*	5	*
	SE	*	*	*	*	2.0	*
	RP	*	*	*	*	82	*
45	*N*	*	*	*	*	4	*
	SE	*	*	*	*	1.5	*
	RP	*	*	*	*	82.0	*
46-1	*N*	*	*	*	*	8	7
	SE	*	*	*	*	3.5	3.0
	RP	*	*	*	*	82.0	82.0
All Areas	*N*	4	*	6	*	96	66
	SE	1.5	*	4.9	*	16.1	12.8
	RP	82.0	*	162	*	33.2	38.2

Asterisks denote catch not reported; SE = standard error (Cochran 1977); RP is relative precision (=1.98*SE/estimate x 100).

Adjacent to Park Boundaries

Statistical areas adjacent to Park waters experienced halibut harvest from both private and charter anglers. Harvest by *charter* anglers in Area 46 peaked in July and August, with similar harvest levels both months (Fig. 12). Reported harvest by charter anglers in Area 46 was 727 fish in July and 758 in August, and reported releases peaked in July at 1,154 fish.

The large-magnitude halibut catch in Statistical Area 46 dominated the seasonal trend for all statistical areas combined (Fig. 12). An increasing seasonal trend in the number of halibut caught, harvested, and released—with a precipitous decline during September—is evident for this area. A much smaller and seasonally more variable contribution from Area 29 was evident. Interestingly, Area 28 exhibited a seasonal trend in catch and harvest that was quite similar to adjacent Area 29.

Although catch rates for *charter* anglers were temporally variable, harvest rates remained relatively stable within Areas 29 and 46 during the May–September period (Fig. 13). Both catch and harvest rates in Area 29 peaked in June at 1.22 (SE=0.04) and 0.54 (SE=0.01) fish/rod hour, respectively. Catch rates in Area 46 increased from a May low of 0.70 (SE=0.03) fish/rod hour to a July peak of 1.06 fish/rod hour and subsequently decreased 18% between August and September to 0.90 fish/rod hour in September. Conversely, harvest rates remained relatively stable throughout the sampling period for both statistical areas at between 0.4 and 0.6 fish/rod hour.

Seasonally, Area 28 harvest rates by *charter* anglers tracked catch rates fairly well, with the exception of September when catch rates declined (Fig. 12). In contrast with Areas 29 and 46, catch and harvest rates in Area 28 were most variable during May rather than September.

Private catch and harvest in waters adjacent to Park boundaries were greatest in Area 29 (Table 8). Halibut caught in Area 29 by *private* anglers peaked in July, with 108 fish harvested and 107 fish released (Fig. 13). Harvest rates peaked in July and September at 0.56 (SE=0.04) and 0.42 (SE=0.30) fish/rod hour, respectively; and catch rates peaked in July at 0.88 (SE=0.05) fish/rod hour and in September at 1.81 (SE=1.86) fish/rod hour. High variability was associated with September catch and harvest rates.

Reported halibut harvest by private anglers in Area 46 peaked in August at 77 fish (Fig. 13). Halibut released in Area 46 peaked at 52 and 56 fish in July and August, respectively. Harvest rates in Area 46 for private anglers remained relatively stable throughout the sampling period (except during September), with a small peak observed in June at 0.52 (SE=0.26) fish/rod hour; and catch rates increased from a low of 0.69 (SE=0.34) fish/rod hour in May to a high of 0.91 (SE=0.36) fish/rod hour in August. Both harvest and catch rates declined to near zero in September due to reduced fishing effort.

Although catch and harvest rates by private anglers in Area 28 peaked in June, halibut harvest and release were greatest in July (Fig. 13). Both catch and harvest rates were highly variable in August and slightly less variable in June. Such high variability is typically associated with wide variability in catch (and harvest) among few anglers.

Lingcod Catch

Charter anglers accounted for all lingcod caught, with an estimated 24 lingcod harvested and 147 released (Table 9). Lingcod catch was distributed among seven statistical areas. Statistical Area 57 exhibited the highest catch (70 fish) although 94% of fish were released. This area accounted for 45% of all lingcod released. Area 55 exhibited the largest lingcod harvest (11 fish) and accounted for 46% of the total estimated lingcod harvest.

Lingcod catch and harvest rates for charter anglers were generally <0.10 fish per rod hour (Table 9). Area 52 exhibited the highest charter harvest rate at 0.08 fish/rod hour, whereas Area 48 reported the highest catch rate at 1.33 fish/rod hour.

Within Park Boundaries

Area 48 exhibited the highest catch rate (1.33 fish/rod hour) within the Park. Although only one charterboat trip was reported for that area, an estimated 22 lingcod were caught and released there.

Rockfish Catch

Very few rockfish were caught by Gustavus anglers. In fact, Gustavus charter and private anglers caught just over 280 rockfish (Tables 9 & 10), about one quarter of which were released. Similar to Elfin Cove anglers, yelloweye rockfish accounted for most (41%) of these with contributions by black rockfish (30%), quillback (5%), and other non-pelagic species (<1%). Harvest rates for yelloweye were similarly much higher than for other species.

Yelloweye Rockfish

Charter anglers accounted for most (97%) of the estimated 115 yelloweye rockfish harvested. All yelloweye harvest originated from outside Park waters in Statistical Areas 53, 55, and 57 (Fig. 3). Area 57 had the highest estimated harvest (45 fish), accounting for 41% of the total estimated harvest (Table 9). Harvest rates were highest in Area 57 (0.38 fish/rod hour) and substantially lower in Areas 55 (0.09 fish/rod hour) and 53 (0.08 fish/rod hour). *Private* anglers accounted for 4 yelloweye rockfish caught in Areas 26 and 46 (Table 10).

Other Rockfish Species

Black rockfish comprised 88% (66 fish) of the other rockfish species harvested by *charter* anglers (Table 9) across six statistical areas. *Private* anglers reported harvesting 18 black and 7 quillback rockfish (Table 10).

Released Rockfish

Charter anglers accounted for most (84%) released rockfish, although only 57 rockfish were reported released by charter anglers (Table 9). Area 57 accounted for the largest proportion (42%) of released rockfish by charter anglers. Statistical areas on the outer coast (Areas 53, 55, 57) exhibited the highest catch rates for rockfish released by *charter* anglers (Fig. 3), with Area 57 exhibiting the highest catch rate at 0.57 fish/rod hour (Table 9). *Private* anglers reported 11 rockfish released from Area 29.

Within-Park Rockfish Catch

No rockfish were reported caught in Park waters by charter or private anglers.

Salmon Catch

Coho salmon accounted for most (62%) reported salmon harvested by *charter* anglers, followed by pink (25%), chum (7%), king (5%), and sockeye salmon (<1%) (Table 12). These anglers reportedly retained 97% of coho caught, 44% of pink salmon, 75% of chum, 49% of king, and 100% of sockeye, and harvested an estimated 2,653 coho, 1,059 pink, 305 chum, 204 king, and 29 sockeye salmon.

Pink salmon accounted for half of the salmon harvested by *private* anglers, followed by coho (44%), chum (4%), and king (2%) (Table 13). These anglers retained 81% of their pink salmon, 99% of coho, 66% of chum salmon, and 61% of king salmon; harvested an estimated 404 pink, 351 coho, 35 chum, and 17 king salmon; and released an estimated 93 pink, 4 coho, 18 chum, and 11 king salmon (Table 13).

Table 12. Distribution by statistical area of numbers (*N*) of salmon harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) by *charter* anglers from Gustavus, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within-Park harvest (Sub-Areas 29-1 and 46-1; Fig. 3).

Statistical Area		Salmon: Coho Harv	Coho Rel	Coho CPUE	Coho HPUE	King Harv	King Rel	King CPUE	King HPUE	Pink Harv	Pink Rel	Pink CPUE	Pink HPUE	Chum Harv	Chum Rel	Chum CPUE	Chum HPUE	Sockeye Harv	Sockeye HPUE
26	*N*	481	4	0.23	0.22	74	82	0.10	0.06	201	158	0.22	0.10	145	87	0.17	0.13	11	<0.01
	SE	66.9	0.9	<0.01	<0.01	12.2	15.8	<0.01	<0.01	43.1	37.8	<0.01	<0.01	32.1	26.1	0.01	<0.01	1.9	<0.01
	RP	27.6	46.9	*	*	32.9	38.3	*	*	42.4	47.4	*	*	44.0	59.7	*	*	34.5	*
27	*N*	*	*	*	*	*	2	0.08	*	24	*	0.50	0.50	*	7	0.25	*	*	*
	SE	*	*	*	*	*	1.0	*	*	10.0	*	0.50	0.50	*	3.0	0.25	*	*	*
	RP	*	*	*	*	*	82.0	*	*	82.0	*	*	*	*	82.0	*	*	*	*
28	*N*	80	5	0.18	0.17	*	2	NA	NA	198	226	2.17	1.11	39	1	0.08	0.08	1	0.01
	SE	14.4	1.6	0.01	0.01	*	0.7	*	*	30.5	35.7	0.11	0.03	8.6	0.5	0.01	0.01	0.5	<0.01
	RP	35.9	64.6	*	*	*	57.7	*	*	30.6	31.4	*	*	44.30	82.0	*	*	82.0	*
29	*N*	1794	78	0.61	0.58	18	93	0.03	<0.01	387	711	0.48	0.21	86	8	0.03	0.03	13	0.01
	SE	123.6	11.0	<0.01	<0.01	2.2	10.6	<0.01	<0.01	36.2	77.0	<0.01	<0.01	10.4	1.9	<0.01	<0.01	1.7	<0.01
	RP	13.7	27.8	*	*	23.8	22.7	*	*	18.6	21.4	*	*	24.1	44.8	*	*	25.7	*
37	*N*	17	2	0.17	0.14	5	5	0.09	0.05	5	7	0.12	0.05	19	*	0.10	0.10	*	*
	SE	4.1	1.0	0.03	0.03	1.2	1.2	0.02	0.01	2.0	3.0	0.03	0.03	5.4	*	0.03	0.03	*	*
	RP	48.6	82.0	*	*	49.8	49.8	*	*	82.0	82.0	*	*	55.3	*	*	*	*	*
46	*N*	6	*	B	B	4	*	NA	NA	41	28	2.60	0.90	1	*	<0.01	<0.01	*	*
	SE	1.3	*	*	*	0.9	*	*	*	7.6	7.0	0.89	0.21	0.5	*	NA	NA	*	*
	RP	42.8	*	*	*	46.9	*	*	*	36.8	50.4	*	*	82.0	*	*	*	*	*
51	*N*	55	*	0.25	0.25	11	*	0.02	0.02	21	28	0.21	0.09	1	*	<0.01	<0.01	2	0.01
	SE	9.1	*	0.02	0.02	1.9	*	<0.01	<0.01	4.9	6.0	0.02	0.01	0.5	*	NA	NA	0.7	<0.01
	RP	32.4	*	*	*	34.5	*	*	*	47.0	43.3	*	*	82.0	*	*	*	57.7	*
52	*N*	*	*	*	*	12	*	0.10	0.11	*	*	*	*	5	*	0.06	0.06	*	*
	SE	*	*	*	*	2.2	*	0.02	0.02	*	*	*	*	1.6	*	0.01	0.01	*	*
	RP	*	*	*	*	35.9	*	*	*	*	*	*	*	64.6	*	*	*	*	*
53	*N*	19	*	0.16	0.16	6	*	0.11	0.11	54	14	0.86	0.76	2	*	0.03	0.03	*	*
	SE	3.5	*	0.02	0.02	1.3	*	0.03	0.03	12.1	3.6	0.13	0.08	0.7	*	0.01	0.01	*	*
	RP	36.2	*	*	*	42.8	*	*	*	44.2	49.8	*	*	57.7	*	*	*	*	*
55	*N*	194	5	0.48	0.45	70	21	0.24	0.20	128	165	0.77	0.27	7	*	0.01	0.01	1	<0.01
	SE	24.5	2.0	0.02	0.02	8.0	4.0	0.01	0.01	37.6	32.4	0.04	0.01	2.1	*	<0.01	<0.01	0.5	<0.01
	RP	25.0	82.0	*	*	22.7	38.3	*	*	58.4	38.9	*	*	57.7	*	*	*	82.0	*
57	*N*	6	*	0.23	0.23	5	4	0.12	0.08	*	2	0.10	*	*	*	*	*	*	*
	SE	2.0	*	0.10	0.10	1.2	1.1	0.03	0.02	*	1.0	0.04	*	*	*	*	*	*	*
	RP	67.4	*	*	*	49.8	60.9	*	*	*	82.0	*	*	*	*	*	*	*	*
All Areas	*N*	2653	94	0.43	0.41	204	209	0.08	0.04	1059	1340	0.55	0.25	305	104	0.06	0.05	29	<0.01
	SE	141.1	11.2	<0.01	<0.01	15.0	20.7	<0.01	<0.01	85.4	107.2	<0.01	<0.01	37.5	26.3	<0.01	<0.01	3.0	<0.01
	RP	10.6	23.7	*	*	14.6	19.7	*	*	16.0	15.8	*	*	24.4	50.3	*	*	20.7	*

Totals may be inexact due to rounding error; asterisks denote catch not reported; SE = standard error (Cochran 1977); B denotes salmon caught while bottomfishing; NA = standard error not calculated due to single sample (boating party); RP denotes relative precision (=1.98*SE/estimate x 100).

Table 13. Distribution by statistical area of estimated numbers (*N*) of salmon harvested and released, catch per unit of effort (CPUE; rod hours), and harvest per unit of effort (HPUE; rod hours) by *private* anglers from Gustavus, Alaska during the 2003 sampling period. Estimates for Areas 29 and 46 include within–Park harvest (Sub–Areas 29–1 and 46–1; Fig. 3).

Statistical Area		Salmon															
		Coho				King				Pink				Chum			
		Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE	Harv	Rel	CPUE	HPUE
26	*N*	14	*	0.17	0.17	10	4	0.17	0.09	6	2	0.09	0.07	25	14	0.23	0.18
	SE	3.5	*	0.02	0.02	2.3	2.4	0.03	0.01	1.5	1.0	0.01	0.01	5.7	6.0	0.03	0.02
	RP	47.9	*	*	*	47.6	132.8	*	*	48.8	82.0	*	*	44.5	82.0	*	*
27	*N*	*	*	*	*	*	*	*	*	*	*	*	*	2	*	*	*
	SE	*	*	*	*	*	*	*	*	*	*	*	*	1.0	*	*	*
	RP	*	*	*	*	*	*	*	*	*	*	*	*	82.0	*	*	*
28	*N*	22	*	0.12	0.12	*	*	*	*	340	12	1.74	1.69	1	*	0.04	0.04
	SE	2.8	*	0.01	0.01	*	*	*	*	48.9	5.0	0.12	0.12	0.5	*	0.01	0.01
	RP	25.4	*	*	*	*	*	*	*	28.5	82.0	*	*	82.0	*	*	*
29	*N*	306	2	0.45	0.44	1	4	<0.01	<0.01	51	66	0.18	0.09	6	2	<0.01	<0.01
	SE	26.8	0.7	0.01	0.01	0.5	1.1	<0.01	<0.01	6.2	10.3	0.01	0.01	1.3	1.0	<0.01	<0.01
	RP	17.4	57.7	*	*	82.0	60.7	*	*	24.2	30.7	*	*	42.8	82.0	*	*
30	*N*	*	*	*	*	*	*	*	*	1	*	2.00	2.00	*	*	*	*
	SE	*	*	*	*	*	*	*	*	0.5	*	2.00	2.00	*	*	*	*
	RP	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	*	*
37	*N*	*	*	*	*	1	*	0.17	0.17	*	*	*	*	*	*	*	*
	SE	*	*	*	*	0.5	*	0.17	0.17	*	*	*	*	*	*	*	*
	RP	*	*	*	*	82.0	*	*	*	*	*	*	*	*	*	*	*
46	*N*	1	*	*	*	*	*	*	*	*	4	*	*	*	*	*	*
	SE	0.5	*	*	*	*	*	*	*	*	1.5	*	*	*	*	*	*
	RP	82.0	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	*
52	*N*	1	*	0.06	0.06	*	*	*	*	*	2	0.13	*	*	*	*	*
	SE	0.5	*	NA	NA	*	*	*	*	*	1.0	NA	*	*	*	*	*
	RP	82.0	*	*	*	*	*	*	*	*	82.0	*	*	*	*	*	*
53	*N*	6	1	0.60	0.50	*	*	*	*	6	6	1.00	0.50	*	*	*	*
	SE	2.5	0.5	NA	NA	*	*	*	*	2.5	2.5	NA	NA	*	*	*	*
	RP	82.0	82.0	*	*	*	*	*	*	82.0	82.0	*	*	*	*	*	*
55	*N*	*	*	*	*	2	*	0.17	0.17	*	*	*	*	*	1	0.08	*
	SE	*	*	*	*	1.0	*	NA	NA	*	*	*	*	*	0.5	NA	*
	RP	*	*	*	*	82.0	*	*	*	*	*	*	*	*	82.0	*	*
57	*N*	*	*	*	*	2	4	1.25	0.50	*	*	*	*	*	*	*	*
	SE	*	*	*	*	1.0	1.5	1.25	0.50	*	*	*	*	*	*	*	*
	RP	*	*	*	*	82.0	82.0	*	*	*	*	*	*	*	*	*	*
All Areas	*N*	351	4	0.31	0.31	17	11	0.05	0.03	404	93	0.49	0.42	35	18	0.05	0.04
	SE	27.5	0.9	<0.01	<0.01	2.7	4.3	<0.01	<0.01	50.4	13.4	0.01	0.01	5.9	6.1	<0.01	<0.01
	RP	15.5	46.9			32.2	78.2			24.8	28.7			33.2	66.5		

Totals may be inexact due to rounding error; asterisks denote catch unreported; SE = standard error (Cochran 1977); NA = standard error not calculated due to single sample (boating party); RP is relative precision (=1.98*SE/estimate x 100).

Coho Salmon

Charter Catch

Charter anglers reported the highest coho salmon harvest (68%) in Statistical Area 29 (1,794 fish) (Table 12). A total of 78 coho were released in Area 29 by charter anglers. Anecdotal reports by anglers showed that a large portion (>70%) of the coho harvested from Area 29 was caught on Pleasant Island Reef, or “the reef” as referred to by locals. Coho harvest in Area 29 was larger than in Areas 26 and 55, which comprised 18% and 7% of the total harvest, respectively. Estimated coho harvest for Areas 26 and 55 was 481 and 194 fish, respectively. Coho catch and harvest rates for charter anglers were greatest in Area 29 with 0.61 and 0.58 fish/rod hour, respectively.

Reported coho salmon harvest for all statistical areas combined peaked in August with 1,421 fish harvested (Fig. 14). Areas 26 and 29 exhibited different harvest peaks, with Area 26 peaking in July and Area 29 peaking in August. Harvests for these two areas were almost an order of magnitude different, with Area 29 showing far greater harvest levels.

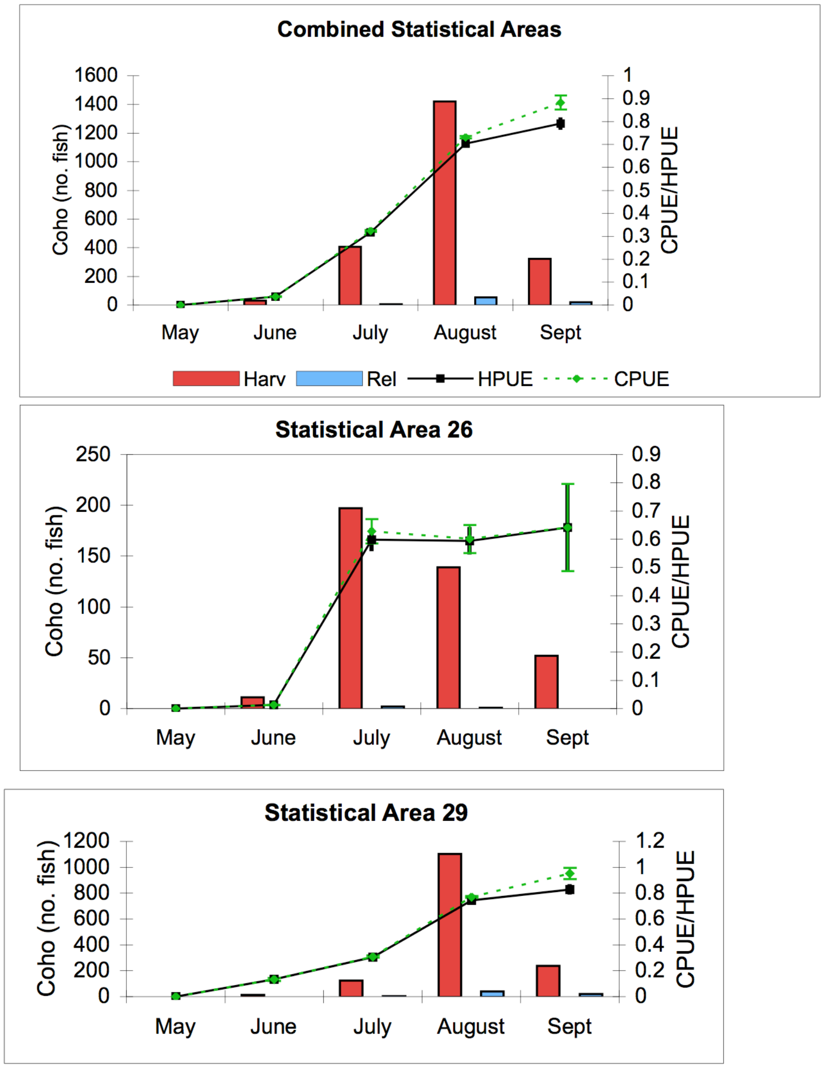

Figure 14. Reported numbers of coho salmon harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) in Statistical Areas 26, 29, and combined areas by charter anglers from Gustavus, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Private Catch

Private anglers also reported the highest coho salmon harvest (87%) in Area 29 (306 fish) (Table 12). Catch and harvest rates of 0.45 and 0.44 fish/rod hour, respectively, were associated with this area. Areas 26 and 28 comprised 4% (14 fish) and 6% (22 fish), respectively, of the total estimated coho harvest (releases of coho were not reported for these two areas). Area 53 exhibited the highest estimated catch and harvest rates for private anglers, with 0.60 and 0.50 fish/rod hour, respectively. These high rates were evident despite the fact that few fish (7 coho) were caught in this location.

King Salmon

Charter Catch

Area 26 accounted for the largest proportion (36%) of total king salmon harvested by charter anglers with an estimated 74 fish (Table 12). Areas 29 and 55 accounted for 9% (18 fish) and 34% (70 fish), respectively. Other statistical areas exhibited a king salmon catch of 12 fish or less.

Reported king salmon harvest for charter anglers peaked in June at 88 fish, with a reported 103 salmon released in August (Fig. 15). Many of these releases were king salmon smaller than the legal limit (28 inches). The number of released king salmon increased over the summer, but abruptly declined in September. King salmon harvest rates for charter anglers were highest in May at 0.12 (SE<0.01) fish/rod hour, declining in July to 0.07 (SE<0.01) fish/rod hour. Estimated catch rate increased from 0.15 (SE=0.01) fish/rod hour in May to a July peak at 0.20 (SE=0.01) fish/rod hour, and then subsequently declined to 0.01 (SE<0.01) fish/rod hour in September.

King salmon harvest and catch rates for charter anglers were highest in areas on the outer coast and in the Cross-Sound region (Table 12, Fig. 3). Harvest and catch rates were highest in Area 55 with 0.20 and 0.24 fish/rod hour, respectively.

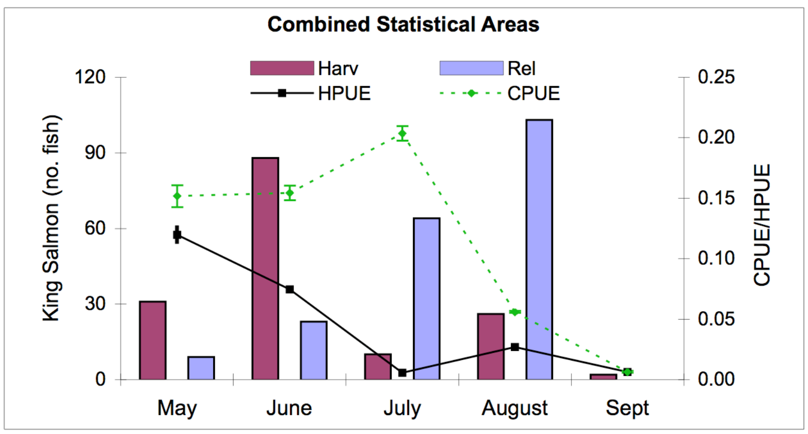

Figure 15. Reported numbers of king salmon harvested (Harv), released (Rel), harvest per unit of effort (HPUE; rod hours), and catch per unit of effort (CPUE; rod hours) across all statistical areas by charter anglers from Gustavus, Alaska during the 2003 sampling period. One standard error is shown for CPUE and HPUE estimates.

Private Catch

Private anglers harvested most (59%) of their king salmon from Area 26, although harvest consisted of only 10 fish (Table 13). Catch and harvest rates for Area 26 were 0.17 and 0.09 fish/rod hour, respectively. Area 57 had the highest estimated catch and harvest rates for private anglers at 1.25 and 0.50 fish/rod hour, respectively.

Pink, Chum & Sockeye Salmon

Charter Catch

Most of the reported pink, chum, and sockeye harvest occurred within three statistical areas: 26, 28, and 29 (Table 12). While more than half of all pink salmon caught were released, only one-quarter of chum was released. Maximum catch and harvest rates for pink salmon exceeded 1 fish/rod hour, while the highest rates for chum were typically one-quarter or less than this.

Private Catch

More than 70% of harvest reported for pink and chum salmon occurred within Areas 26 and 28 (Table 13). Few pink or chum salmon were harvested from other areas, with the exception of 51 pink salmon reportedly harvested from Area 29. In contrast with charter anglers, private anglers released only 19% of pinks and 34% of chum. Maximum catch and harvest rates were about 1.7 fish/rod hour for pink salmon, while comparative rates for chum were 11–13% or less.

Within Park Boundaries

Charter Salmon Catch

Pink salmon accounted for 60% (6 fish) of salmon harvested within Park waters in Sub-Area 26-1 by charter anglers (Table 11), while coho salmon comprised the remaining 40% (4 fish). Charter anglers did not release any salmon. Note that all within-Park coho and pink salmon were harvested only in Sub-Area 26-1.

Fishery–Independent Surveys to Estimate Within–Park Halibut Catch and Effort

Two different but complementary approaches were employed to estimate unreported halibut catch and harvest by Gustavus charter anglers within Glacier Bay National Park waters. We used the product of average halibut catch and number of vessels to estimate catch only for those charterboats observed fishing *within* Park waters during OWVAS aerial surveys. However, the estimate of catch and harvest for this relatively simplistic approach assumed that fishing effort for these vessels occurred entirely within Park waters and thus tended to overestimate catch and harvest for individual boats. To account for spatial variation in charterboat fishing effort, we employed a second but more complex approach. We estimated fishing effort as the product of average fishing effort for all vessels and number of OWVAS-observed charterboats. We subsequently used boat-based observations to weight fishing effort within Park waters. A catch vs. fishing effort regression was developed to estimate location-specific (i.e., Gustavus or Elfin Cove) catch. Finally, harvest for both approaches was similarly estimated from the product of catch and a sampling port-specific harvest/catch quotient.

Six charterboats were observed fishing *within* Park waters and nine boats *outside* Park waters during a 5-day boat-based sampling period to verify reported charterboat fishing location and effort. However, only five of the six charterboats fishing within the Park were identified. Survey observations showed that the five identified charterboats sighted within Park waters spent 80% of their non-running time *within* and 20% *outside* Park waters but within 1 mile of the Park boundary. All observed halibut effort in Statistical Areas 29 and 46 occurred east of a line running from Lemesurier Island to the Carolus River (Fig. 3).

None of the 14 identified Gustavus boats observed fishing within Park waters adjacent to Glacier Bay reported that their fishing activities occurred within Park waters. With only 14 boats observed during aerial surveys, it was difficult to provide halibut catch and harvest estimates for Park waters. Thus, to verify aerial survey methodology and evaluate whether estimates are within the same order of magnitude, two estimates are provided: One based on a simple random sample of vessels fishing within Sub-Areas 29-1 and 46-1 (the "simplistic" approach; equations 5.1–5.2) and a second methodology that assumes catch and harvest *within* Park waters is proportional to effort *outside* Park waters (the "more complex"approach; equations 6.1–6.5). Vessel counts using OWVAS observations are preliminary but should still provide a reasonable approximation of effort occurring within Park waters.

Gustavus creel survey catch and effort data for Areas 29 and 46 were combined. The data were fit using a least-squares linear expression (R^2=0.78, n= 98, b_0= 0.8407, b_1= 0.6555) and the *within-Park* halibut catch was estimated using equation 5.1 (Fig. 4). Results indicate a strong positive relationship between fishing effort and catch.

Both expansion methods produced halibut catch and harvest estimates of the same order of magnitude. Estimated halibut catches based on equations (5.1–5.2) for Gustavus charterboats fishing in Sub-Areas 29-1 and 46-1 combined were 184 fish caught (SE=23.30), of which 105 (SE=14.38) were kept, and 79 (SE=12.96) released. Estimated catch using the regression model described in equations (6.1–6.5) was 139 fish, with 79 harvested.

Anecdotal dock observations suggest that charter anglers and creel technicians likely misreported location when fishing along the boundaries of certain statistical areas and sub-areas (i.e., 29, 29-1, 46, and 46-1). Two explanations may account for charter angler misreporting at these locations: (1) Halibut catch, harvest, and effort were in such close proximity to the boundary between Areas 29, 29-1, 46, and 46-1 that the precise location of the catch was not clear; and/or (2) charter anglers chose to report catch, harvest, and effort statistics at the level of the larger statistical area (i.e., Areas 29 and 46) rather than at the sub-area (i.e., Sub-Area 29-1 and 46-1) level.

RESULTS 3

Comparison of Gustavus & Elfin Cove Creel Surveys

Fishing Effort

Not all Gustavus or Elfin Cove registered charterboats were observed during the survey period. Of the 29 boats licensed in Elfin Cove, 24 (83%) were included in the survey (Table 14). Similarly, 18 of the 27 (67%) charterboats licensed in Gustavus were observed during the creel survey.

Charterboats registered in Auke Bay, Sitka, Excursion Inlet, and Haines were also observed operating from Gustavus or Elfin Cove during the survey period (Table 14). These boats were irregular visitors to Gustavus or Elfin Cove.

Information from Alaska's Commercial Fishery Entry Commission on-line vessel licensing program provides an erroneous estimate of location-specific fleet fishing effort. The number of unique registered charterboats included in the creel surveys for Elfin Cove (24 boats) and Gustavus (18 boats) was not proportionately related to fleet fishing-effort levels. Despite the fact that Elfin Cove had two more registered charterboats than Gustavus, it accounted for only 24% of the total charterfishing effort, 21% of the total charter bottomfishing effort, and 29% of the total charter salmon-fishing effort (Table 6). Anglers in both communities spent about 65–70% of their time using bottomfishing techniques.

Table 14. Numbers of observed CFEC–licensed charterboats registered in Gustavus and Elfin Cove, Alaska during the 2003 sampling periods. Also shown are numbers of charterboats from other homeports operating from Gustavus and Elfin Cove during the same sampling periods.

Homeport	Elfin Cove	Gustavus	Haines	Auke Bay	Sitka	Excursion Inlet	Total boats
Gustavus	*	18	*	2	1	1	22
Elfin Cove	24	*	2	1	*	*	27

CFEC = Alaska Commercial Fishery Entry Commission; asterisks indicate no boats observed during creel survey.

Catch & Harvest

Halibut & Salmon

Despite fewer registered charterboats operating from Gustavus, charter anglers in Gustavus caught more halibut and salmon than private Gustavus anglers and Elfin Cove charter anglers combined (Table 15). Gustavus charter anglers harvested 2.6 times more halibut than Elfin Cove charter anglers and private Gustavus anglers combined. Similarly, Gustavus charter anglers caught 1.4 times more salmon than Elfin Cove charter anglers and Gustavus private anglers combined.

Groundfish

Groundfish catch comparisons between the two sampling sites were in marked contrast with those observed for salmon and halibut. Elfin Cove charter anglers accounted for 86% of lingcod harvest, 79% of the yelloweye rockfish harvest, and 62% of all other rockfish harvest (Table 15). Releases followed the same pattern, with Elfin Cove charter anglers accounting for 90% of all lingcod released, 91% of all rockfish released, and 100% of all dogfish. Retention rates for lingcod and yelloweye rockfish were comparable between charter anglers for both communities.

Within-Park Catch

Gustavus charter anglers accounted for most fishing effort, catch, and harvest that occurred within Park waters. When fishing within Park waters, Gustavus anglers generally occupied areas directly adjacent to Glacier Bay proper (Areas 29 and 46), most popularly Point Gustavus and Point Carolus. It should be noted that Gustavus anglers targeting bottomfish *outside* Park waters typically focused fishing effort on a submerged glacial moraine located directly east of Lemesurier Island and south of Glacier Bay proper.

Elfin Cove anglers were not observed fishing these areas; instead, they focused fishing effort in Dundas Bay and north of the Inian Islands. It should also be noted that effort, harvest, and catch levels for charter anglers from both port survey areas were very low when compared to *outside*-Park areas.

Table 15. Comparative harvest and release of salmon, halibut, lingcod, rockfish, and dogfish by charter and private anglers from Elfin Cove and Gustavus, Alaska during the 2003 sampling period.

	Salmon		Halibut		Lingcod		Yelloweye rockfish	All other rockfish		Dogfish
Dock sampling sites	Harv	Rel	Harv	Rel	Harv	Rel	Harv	Harv	Rel	Rel
Gustavus										
Charter	4,250	1,746	4,556	5,884	24	147	111	76	57	*
Private	807	125	948	970	*	*	4	25	11	*
Subtotal	5,056	1,872	5,504	6,853	24	147	115	101	68	*
Elfin Cove Charter	2,143	626	786	717	146	1,336	417	167	708	503
Catch Comparison (total charter + private)	7,199	2,497	6,289	7,570	170	1,483	532	268	775	503
Proportion Charter										
Gustavus	0.66	0.74	0.85	0.89	0.14	0.10	0.21	0.31	0.07	<0.01
Elfin Cove	0.34	0.26	0.15	0.11	0.86	0.90	0.79	0.69	0.93	1.00
Proportion Harvested										
Gustavus charter	0.71	*	0.44	*	0.14	*	*	0.77	*	*
Gustavus private	0.87	*	0.49	*	*	*	*	0.73	*	*
Elfin Cove charter	0.77	*	0.52	*	0.10	*	*	0.45	*	1.00

Asterisks indicate no data available.

RESULTS 4

Halibut Length & Weight Analyses

Gustavus & Elfin Cove

Halibut landed in Gustavus were generally larger than those landed in Elfin Cove. However, less than 50% of fish landed in Elfin Cove and Gustavus were smaller than the mean length (Table 16). Mean length of harvested halibut for charter anglers landed in Gustavus and Elfin Cove was 116 cm with a standard deviation (SD; Zar 1999) of 21.1 and 107 cm with an SD of 29.0), respectively. Mean length of halibut harvested in Areas 52 and 53 (combined) by charter anglers operating from Elfin Cove did not differ significantly[2] at the 95% level from that of halibut harvested in Area 28 (t=0.363, P=0.717, df=210) by Gustavus charter anglers.

Table 16. Length and weight statistics for halibut landed in Elfin Cove and Gustavus, Alaska by charter and private anglers during the 2003 sampling period.

		Mean				Median			Mode			Max
Location	*n*	Length	(SE)	RW	EW	Length	RW	EW	Length	RW	EW	RW
Elfin Cove Charter												
All Areas	*382*	107	1.48	35	26	100	28	21	79	13	10	363
Area 53	*162*	112	2.3	40	30	106	34	25	79	13	10	363
Area 46	*65*	114	3.8	42	32	109	36	27	132	68	51	254
Gustavus All Users												
All Areas	*1990*	114	0.47	42	32	112	40	30	97	25	19	376
Gustavus Charter												
All Areas	*1673*	116	0.5	45	34	112	40	30	122	53	40	
Areas 46 and 29 (combined)	*1191*	117	0.6	46	35	115	43	32	122	53	40	363
Area 28	*467*	114	0.91	43	32	111	39	29	97	25	19	376
Gustavus Private												
All Areas	*317*	102	1.12	29	22	99	27	20	97	25	19	190
Areas 46 and 29 (combined)	*186*	102	1.58	29	22	97	25	19	92	21	16	190
Area 28	*119*	101	1.71	28	21	99	27	20	102	30	22	149

RW = round weight; EW = eviscerated weight (head-off, gutted); SE = standard error (Zar 1999); n = number of fish sampled.

Mean round weight for halibut landed by Elfin Cove charterboats was 35 lbs (SD=0.5) while that for Gustavus charterboats was 45 lbs raw weight (not headed or gutted). Median length of halibut landed in Gustavus and Elfin Cove was 112 cm and 100 cm, respectively; and median round weight of halibut landed in Gustavus and Elfin Cove was 40 lbs and 28 lbs rw, respectively. The largest fish harvested in Elfin Cove weighed an estimated 363 lbs rw, and the largest fish harvested in Gustavus weighed an estimated 376 lbs rw.

Gustavus Length Analysis

There were monthly differences in the length composition of halibut harvested by *charter* anglers operating from Gustavus (Fig. 16). The greatest portion of small fish was harvested in September, and the contribution of large fish to overall halibut harvest was greatest in July. Overall, 50% of halibut harvested weighed about 110 cm or 30 lbs rw (20 lbs eviscerated). Boat and aerial-survey observations showed that 100% of the observed halibut effort (n=36) was in areas east of a line running from the northeasternmost point of Lemesurier Island to the headlands between the Carolus River and Salt Chuck.

[2] Equal variances were not assumed for the t-test (F=31.506,P<0.001) and a K-S test showed Elfin Cove length data to be not normally distributed (Z=2.257; N=382; alpha=0.05; p<0.001). Mann Whitney U-test results were similar to the t-test (Z= –0.890; p=0.373; N=750).

Length composition of halibut landed by charter anglers in 2003 varied significantly at the 95 % level between Statistical Areas 46 and 29 combined and Area 28 ($t= -2.833$, $P=0.005$, $df=1656$). The null hypothesis for all t- and Mann Whitney U-tests conducted was an assumption of equality between the test statistics (i.e., no difference between locations).

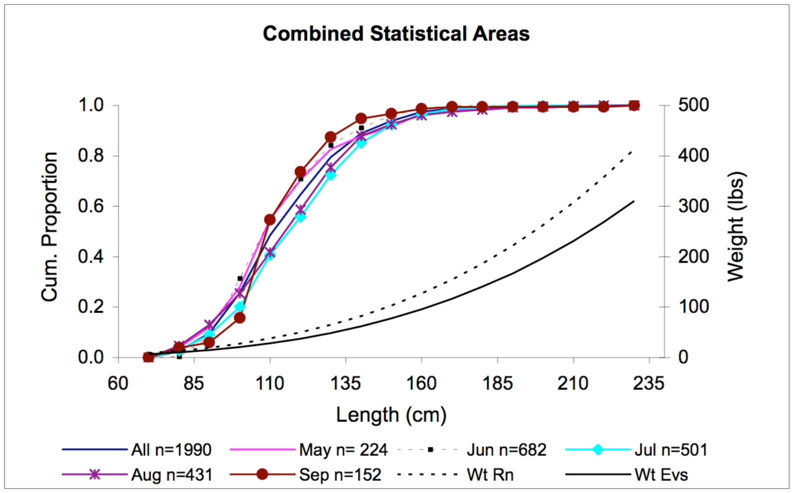

Figure 16. Length proportion of halibut harvested across months and all statistical areas by charter anglers from Gustavus, Alaska during the 2003 sampling period. The length-to-weight model described in equation 3.1 is provided for round weight (Wt Rn; including head and guts) and eviscerated weight (Wt Evs; headed and gutted). Both weights were calculated using the formula $w=al^{b}$, with parameters b=3.9 and $a=6.921x10^{6}$ for eviscerated weight and $9.0205x10^{-6}$ for round weight (Clark 1992).

Length data were not normally distributed for Areas 29 and 46 combined and Area 28, as indicated by Kolmogorov-Smirnov Goodness of Fit (K-S test) test results (Figs. 17 & 18). K-S statistical test results were $z=2.825$, $N=1191$, $alpha=0.05$, $p<0.001$ for Areas 29 and 46 combined; and $z=2.595$, $N=586$, $alpha=0.05$, $p<0.001$ for Area 28. T-test results should be considered valid because visual inspection of the length distribution approximated normality and sample sizes were large.

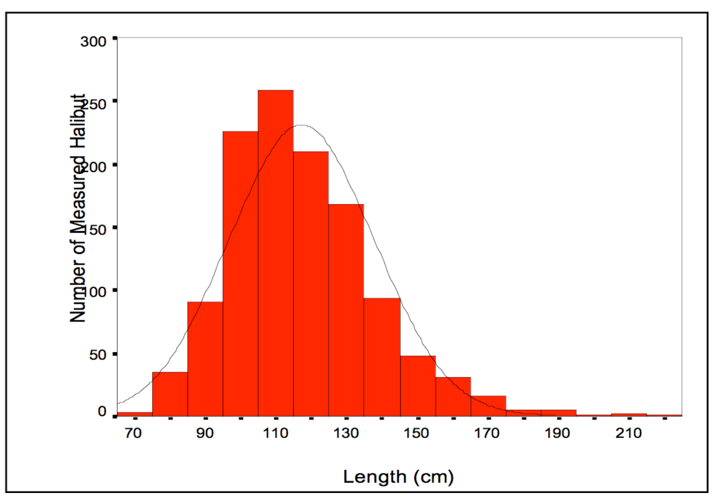

Figure 17. Distribution of length measurements and normal curve for halibut harvested in Statistical Areas 29 and 46 combined by charter anglers from Gustavus, Alaska during the 2003 sampling period.

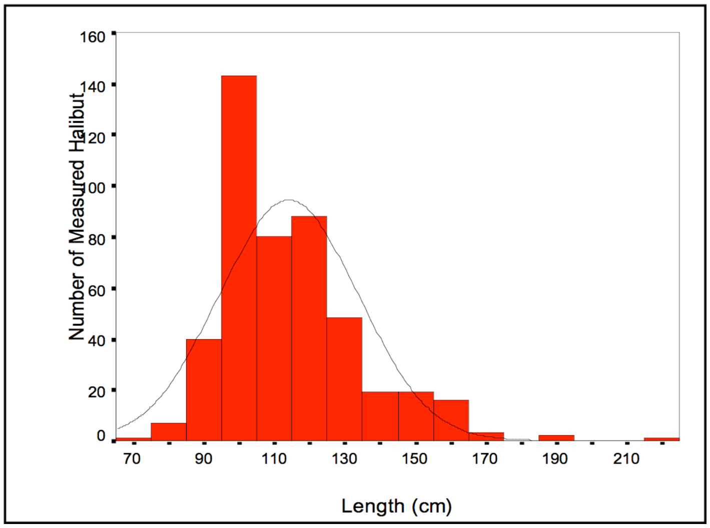

Figure 18. Distribution of length measurements and normal curve for halibut harvested in Statistical Area 28 by charter anglers from *Gustavus*, Alaska during the 2003 sampling period.

The combined harvest in Areas 29 and 46 was composed of larger halibut when compared with Area 28 (Fig. 19). Mean length for halibut harvested by charter anglers from Areas 29 and 46 combined was 117 cm (SE=0.59; 46 lbs rw), with a median of 115 cm (43 lbs rw) and a mode of 122 cm (53 lbs rw) (Table 16). Mean length for Area 28 was 114 cm (SE=0.91; 43 lbs rw) with a median of 111 cm (39 lbs rw) and a mode of 96.5 cm (25 lbs rw).

Mann Whitney U-test results were similar to the t-test results, showing that Areas 29 and 46 (combined) were significantly different from Area 28 at the 95% level (z= –6.556; N=1777, p<0.001). Sample sizes were not adequate to compare harvest in all other statistical areas by Gustavus charter anglers.

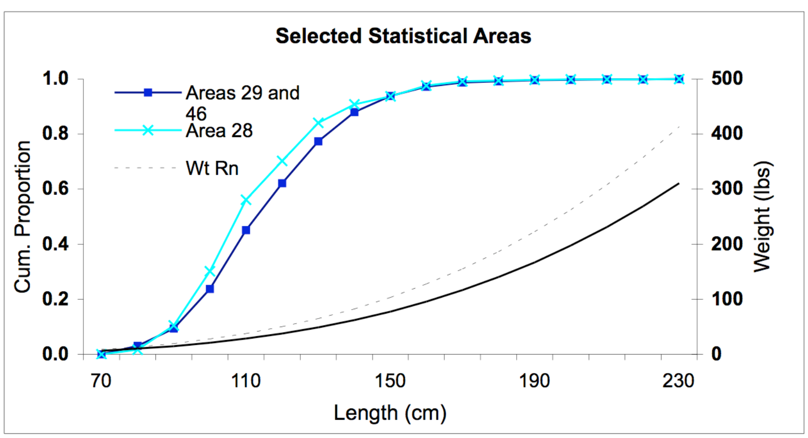

Figure 19. Length distribution of halibut harvested in Statistical Areas 29 and 46 combined and Area 28 by charter anglers from Gustavus, Alaska during the 2003 sampling period. The length-to-weight model described in equation 3.1 is provided for round weight (Wt Rn; including head and guts) and evis–cerated weight (Wt Evs; headed and gutted). Both weights were calculated using the formula $w=al^b$, with parameters b=3.9 and $a=6.921x10^{6}$ for evis–cerated weight and $9.0205x10^{-6}$ for round weight (Clark 1992).

RESULTS 5
Elfin Cove Rockfish Length & Age

Yelloweye Rockfish

Total lengths were obtained from a sample of 132 yelloweye rockfish caught by charter anglers from Elfin Cove (Fig. 20). Mean total length of harvested rockfish in Elfin Cove was 59.9 cm (SE=0.82) and median total length was 60.5 cm. Mean and median weights, estimated from equation 3.1, were 8.7 lbs and 9 lbs, respectively. The total length mode was 67 cm and weighed an estimated 12.5 lbs. The close proximity of the mean, median, and mode suggest rockfish catch was centrally distributed with a slight skew to the left.

Median age for harvested yelloweye rockfish, estimated from equation 3.2, was 48 years, with fish at estimated ages of 20–24 and 100+ years harvested at the greatest frequency (Fig. 21).

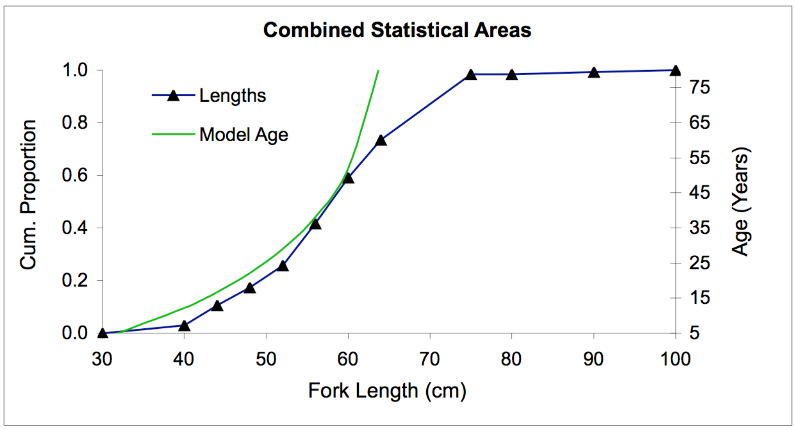

Figure 20. Estimated age distribution of yelloweye rockfish harvested across all statistical areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Age at length was estimated using the von Bertalanffy growth model as described by O'Connell et al. (2003). Fork length was estimated from total length using equation 3.3.

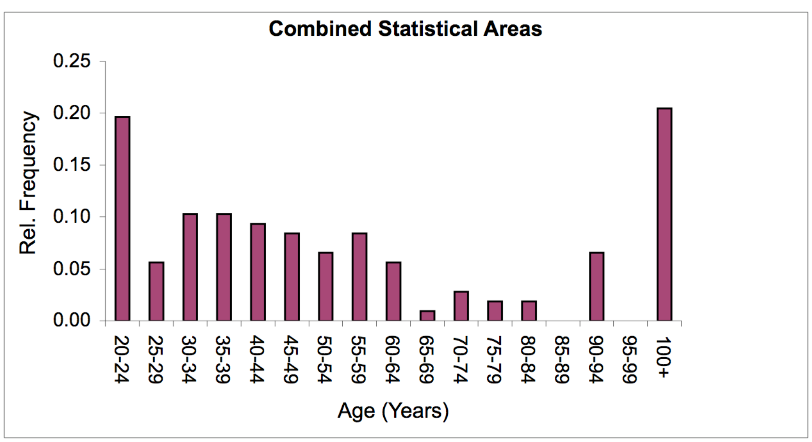

Figure 21. Estimated age distribution of yelloweye rockfish harvested across all statistical areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period. Age at length was estimated using the von Bertalanffy growth model.

Black Rockfish

Total lengths were similarly obtained from a sample of 72 black rockfish caught by charter anglers from Elfin Cove (Fig. 22). Mean total length of charter-harvested black rockfish in Elfin Cove was 46.5 cm (SE=0.68) and median total length was 46 cm. Mean and median round weights estimated from equation (3.3) were 3.8 lbs and 3.7 lbs, respectively. Total length mode was 41 cm with an estimated weight of 2.5 lbs. The close proximity of the mean, median, and mode suggest rockfish catch was centrally distributed with a slight skew to the right.

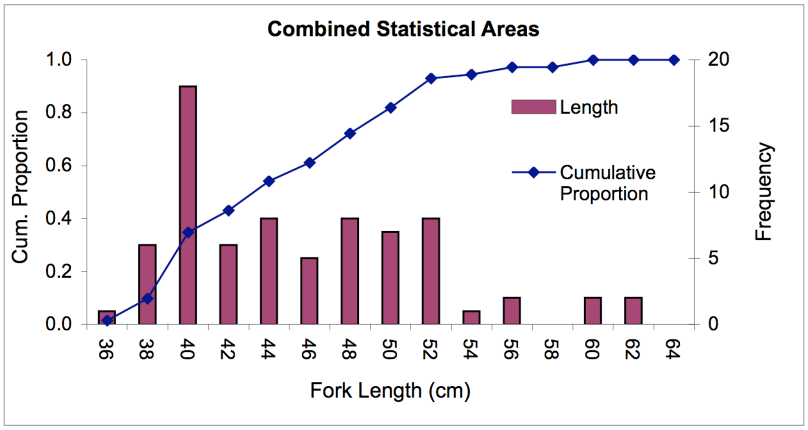

Figure 22. Cumulative proportion (by length) and length distribution for black rockfish harvested across all statistical areas by charter anglers from Elfin Cove, Alaska during the 2003 sampling period.

Other Rockfish

Sample sizes were not adequate to conduct length analysis for other rockfish species.

DISCUSSION & CONCLUSIONS

Sampling Problems

Only a small number of Elfin Cove charterboats observed during OWVAS aerial surveys were subsequently intercepted by dockside creel technicians. This occurred because charterboats observed during aerial surveys were often not encountered upon their return to Elfin Cove due to the stratified proportional allocation method employed to sample multiple docks. This could easily be remedied by radio-relaying OWVAS-observed charterboat identities to the Elfin Cove-based creel technician who could subsequently intercept these vessels upon their return. Our inability to realize and resolve this problem significantly hampered our ability to consistently survey vessels observed fishing *within* Park waters.

Another problem with our sampling regime was that sampling typically occurred during peak return times for anglers. The 1200–1900 h time period was sampled at the Gustavus dock because it was observed during a pilot study (Gasper et al. 2002) that >90% of Gustavus anglers returned to the dock during the sampling period. These types of assumptions should be periodically reevaluated in future studies by stratifying survey effort to assess angler returns outside these peak times. Furthermore, an adaptive sampling regime is necessary to assess costs vs. information gained by sampling outside peak angler return times in order to inform the overall sampling plan.

The short-term roving nature of aerial surveys presents a problem when attempting to assess how individual charterboats apportion their time among fishing locations (e.g., *within* vs. *outside* Park waters). Charter anglers are known to fish multiple locations throughout the day, yet a randomly selected (i.e., in terms of time of day) 1.5-h aerial survey would fail to account for this spatial and temporal variation. The use of multiple daily aerial surveys stratified by time and location could alleviate this problem. Temporal and spatial vessel-activity components could be assessed using this design. Focusing aerial survey efforts in high-use areas (Areas 29-1 and 46-1) and using an adaptive sampling strategy to compensate for angling behavior and weather could significantly lower costs. Alternately, a less costly approach might employ boat- or shore-based observers at strategic locations.

Relative precision of fisheries estimates *within* Park waters and some statistical areas was generally low due to small sample sizes and/or highly variable levels of effort, catch, and harvest. Increasing sampling effort would probably not increase the precision of estimates within these areas, particularly within Park waters, due to catch-location reporting error and/or low effort.

The sampling program did not account for boats originating from areas other than Elfin Cove or Gustavus, although other survey methods (Osterhoudt et al. 2004) employed at Bartlett Cove did. Anglers from Excursion Inlet, Hoonah, Pelican, and Juneau were infrequently observed at the Gustavus and Elfin Cove docks. Fishing pressure placed on Park and adjacent waters by transient boats from these communities is presumed to be small but is largely unknown. Assessing transient anglers may be very difficult without dock-intercept creel survey information from these vessel's homeports or roving surveys that would intercept transient vessels in the field.

Misreporting

Data collected during the aerial survey documented misreporting of effort, catch, and harvest, by Gustavus charter anglers. Misreporting was evident in Elfin Cove because all charterboats observed during both the aerial and dock surveys (n=7 boats) failed to report fishing within Park waters, despite direct documentation to the contrary during aerial surveys. Misreporting of halibut catch by Gustavus charter anglers was evidenced by the fact that the estimated halibut catch (based on aerial-survey data) was greater than creel census estimates for Statistical Sub-Areas 46-1 and 29-1. In fact, halibut catch and harvest reported by Gustavus charter operators during dock surveys underreported catch *within* Park waters by about 19% when compared with estimates generated independently using aerial-survey methodology. Moreover, all charterboats observed during both the aerial and dock surveys (n=7 boats) failed to report fishing *within* Park waters despite direct documentation to the contrary during aerial surveys.

Our estimates of unreported halibut catch *within* Park waters represent, at best, a minimum estimate. Within-Park halibut catch and harvest were underestimated because we failed to expand the few days of survey data when charterboats were being observed to account for the entire OWVAS sampling period. In other words, catch and harvest estimates reported for Gustavus charter anglers in this paper were based on only a few 1.5-hour aerial surveys of charterboats conducted during the June–September (105-day) 2003 season. These samples represent a very small component of the 48 total aerial-survey flights conducted during this period.

Lingcod closures from June 16 through August 15, 2003 (see ADFG Sportfishing Emergency Order No. 1-02-03) may have forced anglers seeking this species to fish *within* Park waters north of Icy Point during the closure; i.e., outside the Northern Southeast Alaska Inside/Outside (state/federal) groundfish areas. However, few charterboat trips north of Icy Point were reported given the associated cost and risk involved. Fuel costs and travel time to remote locations, combined with potential exposure to extreme weather and sea conditions with limited access to protected anchorages, can be self-limiting. The assumption that few charterboats ventured beyond Icy Point was supported by OWVAS survey results that documented only two charterboats fishing in the Icy Point area during 2003. However, areas north of Icy Point were outside the OWVAS survey area, and vessel use in this area remains undocumented.

The large reporting errors observed *within* Park waters suggest that catch, harvest, and effort estimates for these areas cannot be accurately obtained without complemented aerial and dockside surveys. Accurately determining effort and catch based on creel surveys or aerial observations alone is difficult at best, because neither method alone can provide completely reliable information on the spatial distribution of catch and fishing effort. Repeated, verifiable documentation of fishing location and target species is crucial. The use of a high-resolution digital camera to document the type of fishing (e.g., stationary bottomfishing or trolling) and/or the gear used (i.e., heavy rods and reels, lighter rods and downriggers) showed great promise for determining the species sought and providing spatial details on effort allocation and associated catch (i.e., *within* Park waters). If charterboat identity, as well as type and location of fishing activities, can be reliably captured using digital photography and GPS during aerial survey methods (Soiseth et al. 2005), it may be possible to match those observations with dockside creel survey results using access-roving methods outlined in Pollock (1994). Complementing a dockside creel survey with aerial survey methods as described would significantly improve the accuracy and reliability of effort, catch, and harvest data.

Catch & Harvest Rate Caveat

The use of sportfishery catch and harvest rates as an index of abundance has a higher risk of management error than standardized survey data or commercial data. This is partially due to the assumption that catchability (q) is constant over time and fishing ability among anglers is homogeneous (Bernard et al. 1998). Creel surveys cannot eliminate the biases associated with temporal changes in fishing behavior (i.e., technology advances). Thus, catchability fluctuates with time and among anglers (i.e., with an angler's fishing ability).

While relative catchability comparisons can be cautiously interpreted using catch rates, these data should not be used to directly indicate fish population abundance. Relative fish abundance comparisons can be made with caution among homogeneous angling groups (i.e., charter anglers) over short time periods (single fishing season). Comparing homogeneous users can reduce variability associated with the catchability constant. In other words, estimates of catch rate for anglers with similar fishing ability (i.e., charter anglers) will be less variable. While the rationale for constraining temporal comparisons of catch rate among user groups has been explained, spatial constraints are also often necessary to avoid direct comparisons across large or disconnected geographic areas. One final caveat is that neither sportfishery-derived catch nor harvest rates should be used to estimate fish population abundance because they do not necessarily represent true fish abundance.

Halibut Effort, Catch, Harvest & Possible Effects on Size Distribution

Halibut effort, catch, and harvest for both Elfin Cove and Gustavus were concentrated in relatively small close-proximity areas that were unique to either community. In other words, anglers from the two communities rarely used the same fishing sites and typically fished relatively close to homeports. Relative to Park waters, Gustavus charter anglers caught and harvested most (70%) of their fish directly east of Lemesurier Island and between Point Corolus and Point Gustavus in Statistical Areas 29 and 46. Elfin Cove anglers reportedly caught few halibut near Park waters with most (66%) of their harvest occurring in close proximity to Elfin Cove within Areas 53 and 55.

The large halibut catch (7,126 fish) in Areas 29 and 46 by Gustavus charter anglers should be of concern to Park fishery management because of the possibility of local depletion.[3] Local depletion problems have been reported by anglers fishing in high-use areas near the communities of Juneau, Homer, and Sitka (NMFS 2004). Unfortunately, no formal studies directly addressing local depletion of halibut have been conducted (to the authors' knowledge).

Local depletion information in Southeastern Alaska is derived from long-term harvest rate trends reported in ADF&G creel surveys (White & Jaenicke 2003). Long-term trends in sportfish harvest rates in the Juneau-area creel census show two important effects from local depletion: (1) During the period 1998–2000, harvest rates were near record low levels (White & Jaenicke 2003), and (2) during this time period, bottomfishing effort in the local Juneau area declined as anglers fished in more productive waters outside the Juneau area (White & Jaenicke 2003). Relative to the local depletion issue, ADF&G (White & Jaenicke 2003) reports that:

> "Given that Juneau area anglers are traveling to more remote fishing areas far more frequently than in the late 1980's (effort from the inside area[4] has declined 85% to 56% of the total Juneau area bottomfishing effort during the period from 1988–2003), there seems to be little doubt that localized depletion of stocks in Juneau's inside areas has resulted in a similar decline in bottomfish effort closer to Juneau."

Long-term trends in catch rates are not available for the Glacier Bay region. However, compared with other sportfisheries in Southeast Alaska, data from this study suggest a high abundance of halibut (in certain areas) given the high harvest rates (0.48 fish/rod hour for Gustavus and 0.54 fish/rod hour for Elfin Cove). The average harvest rate for Gustavus charter anglers in the Glacier Bay region was 18% lower than Sitka, 184% higher than Juneau, and 208% higher than Ketchikan (derived from data presented by White & Jaenickie 2003). The Glacier Bay region also has a significant commercial fishery that has substantially higher harvest rates than those observed in the recreational fishery. For example, between 1998 and 2002, commercial fishery harvest in the Glacier Bay region was between 2.5 and 3.5 million net lbs. (IPHC Statistical Areas 181–184 and 190; unpubl. IPHC data). It is not known if current commercial and recreational catch levels will cause local depletion of halibut directly adjacent to Glacier Bay proper.

The cautions noted under "Catch & Harvest Rates" in the Methods section of this report should be heeded when using sportfishery harvest rates to analyze halibut population abundance. These estimates are a good index when comparing similar sportfisheries over the short term, but caution is essential in inferring population abundance changes over the long term. Moreover, the reader should not assume that sportfish harvest rates are indices for the true population abundance of halibut. These indices provide only a relative comparison of abundance for halibut harvested in the sportfishery (assuming catchability is consistent among sampling sites).

Halibut length information may be a better measure of local depletion than harvest rates. Since larger halibut have been shown to maintain site fidelity among years (Hooge et al. 2001, Hilborn et al. 1995), evaluating local depletion without length data fails to account for shifts in population length-frequency distributions. As larger fish are removed at rates exceeding replacement, fewer large fish are caught and retained by anglers.

There are a variety of factors other than local depletion that may influence halibut size (e.g., environmental characteristics, population dynamics, and fishing behavior, to name a few). If the size distribution of halibut changes radically from surrounding areas, there may be local depletion issues. However, since there are no

[3] In this paper, local depletion refers to a long decline in the size and abundance of halibut within a small geographic area (i.e., a reef or glacial moraine). Local depletion typically occurs within close proximity to homeports due to frequent and consistent access to those areas by anglers.

[4] White & Jaenicke (2003) delineated fishing effort occurring in the Juneau area as "inside" and "outside" areas. Inside areas roughly refer to fishing that occurred east of Admiralty Island, southeast of Lincoln Island.

formal studies on sportfishery-induced local halibut depletion, the potential effects on the size distribution of halibut from localized sportfishing pressure is conjecture.

Length data collected in the Glacier Bay region showed that halibut harvested directly adjacent to the Bay proper were larger than other in areas of Southeast Alaska (White & Jaenicke 2003). The increased size of halibut caught within these areas could be attributed to spillover from Glacier Bay proper, preferred habitat within these locations (Geernaert & Trumble 2000), and/or possible migration corridors through these areas (Geernaert & Trumble 2000).

Spillover of halibut from Glacier Bay proper into surrounding areas provides a possible explanation for the greater halibut size distribution. The spillover hypothesis states that "…higher densities and greater average sizes of fish within a reserve will favor migration of adult fish into the surrounding water" (NRC 2001). Spillover of fish from protected areas has been shown to influence size distributions and abundance of fish in adjacent areas (Roberts et al. 2001).

Glacier Bay proper may be a protected area for halibut due to its large size (133,836 km^2) and low commercial fishing harvest.[5] Between 1998 and 2002, Glacier Bay contributed only 8% to the total commercial halibut harvest reported for northern Southeast Alaska (IPHC Statistical Areas 181–184 and 190; unpubl. IPHC data). Moreover, harvest in Glacier Bay proper declined during that period from a high of 360,408 fish in 1999 to a low of 248,452 fish (6% of the total harvest) in 2002. Effort similarly declined from 47 to 29 vessels during this same time period.

Spillover of fish from Marine Protected Areas (MPA) with characteristics similar to Glacier Bay (large area and relatively low harvest levels) are shown in the literature to have particularly strong impacts on species whose life-history traits include high site fidelity (NRC 2001). Halibut have been shown to maintain site fidelity among years during summer and spring (Skud 1977). Site fidelity and home range sizes <10 km^2 have been quantified in the literature by several studies: Geernaert and Trumble (2000) recovered 90% of tagged halibut within or adjacent to a 10-km^2 study site and concluded that some halibut have site fidelity among years off the coast of British Columbia; Hooge et al. (2001) used sonic tags to demonstrate that halibut *within* Glacier Bay National Park waters had relatively small home ranges; and studies conducted by the IPHC (Thompson & Herrington 1930, Skud 1977) have shown that a large portion of commercially legal halibut (about 7–8 years of age and 81.3 cm total length) return to the same feeding grounds each summer and have "high affinity for their release areas" (Geernaert & Trumble 2000).

Preferred halibut habitat or a migration corridor may provide other plausible explanations for the larger halibut observed at the mouth of Glacier Bay proper. Geernaert and Trumble (2000) suggested that "…high density on a spot could represent a temporary stop on a migration route or an area of preferred habitat that attracts halibut." The observed temporal change in size distribution of harvested halibut could support a migration hypothesis (Fig. 17). The data could be interpreted to mean that fewer small and large halibut are available to sport anglers by the end of the season. The reasons for the temporal shifts in harvested halibut size distribution are unknown because little information exists on the underlying population. Moreover, sportfishery data may not accurately reflect the population structure.

Further studies involving ecological, tagging, and aging work at the mouth of Glacier Bay and a control site (i.e., Point Adolphus) might elucidate halibut movement and population structure. Although continued collection of sportfishery data at the mouth of Glacier Bay proper would be beneficial for determining long-term trends in halibut size, it would not necessarily represent the actual size distribution of halibut in the Glacier Bay region because sample characteristics reflect angler catch. It would, however, provide a useful index of change within the sportfishery to supplement a fishery-independent study.

It should be noted that although this paper presents the spillover theory as a plausible hypothesis for the observed halibut size distribution, it does not provide a mechanism for spillover or establish that it is occurring. Other explanations for the observed halibut distribution (i.e., migration or optimal habitat) are plausible.

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[5] Commercial halibut fishing access within Glacier Bay proper is restricted by Federal regulation. Current permit holders meeting historical participation criteria are allowed to fish until they are no longer able (sunset program).

Lingcod Harvest

The Alaska Department of Fish and Game's closure of northern Southeast Alaska to lingcod harvest in 2003 from June 16 through August 15 (see ADF&G Emergency Order No. 1-02-03, April 15, 2003) likely affected charter harvest of this species. Charter harvest during 2003 was probably much reduced from other more typical years. This closure may have forced anglers seeking lingcod to fish *within* Park waters north of Icy Point in Statistical Areas 48 and 50, i.e., outside the Northern Southeast Inside/Outside groundfish areas. However, few charterboat trips north of Icy Point were reported given the associated cost and risk involved. Fuel costs and travel time to remote locations combined with potential exposure to extreme weather and sea conditions with limited access to protected anchorages can be self-limiting. The assumption that few charterboats ventured beyond Icy Point was further supported by OWVAS survey results that documented only two charterboats fishing in the Icy Point area during 2003. However, areas north of Icy Point were outside the OWVAS survey area and vessel use in this area remains undocumented.

Outside the closure, Elfin Cove charter anglers harvested the most lingcod, with catches reported within and adjacent to Park waters. Relatively large catches (50–465 fish) were reported in Areas 46, 47, and 53. In contrast, Gustavus charter anglers reported much smaller harvests (20–30 fish) for Areas 48 and 53. One charterboat reported releasing 22 lingcod during a trip to Area 48 along the Park's outer coast. Lingcod harvest by charter anglers from within-Park and adjacent waters during 2003 would have probably been much greater barring the ADF&G closure.

This species can be sensitive to overharvest because of its behavior and habitat, although females typically reach sexual maturity at 3–7 years of age and exhibit relatively high fecundity (Love 1996). Lingcod are often associated with rocky-reef habitat and are voracious predators. Hook-and-line anglers can therefore be quite successful at harvesting this species. Although few lingcod were reportedly caught within Park waters during 2003, typical harvest is undoubtedly much greater. However, local depletion at easily accessible reef locations may occur even at current, relatively low levels of harvest. Moreover, location misreporting for this species *within* the Park is largely unknown and these data would therefore represent minimum recreational harvest. Catch trends for this species should be closely monitored because lingcod may be sensitive to local depletion despite relatively early sexual maturity and high fecundity.

Rockfish Harvest & Release Mortality

Most (82%) rockfish were landed in Elfin Cove, with less than a quarter of the catch reported by Gustavus anglers. Yelloweye and black rockfish made up most of the harvest. Dusky rockfish harvest may have been underestimated due to confusion with black rockfish during identification. Relative to other statistical areas, harvest within and adjacent to Park waters was low, with most (51%) harvest on the outer coast in Area 55.

Nearly half (46%) of all rockfish releases occurred in statistical areas adjacent to Park waters (Areas 46, 29, and 53). Mortality rates and species composition of released rockfish are unknown or suspect due to misidentification. However, studies have shown that rockfish caught below 10 fathoms (60 feet) incur high mortality rates from gas embolism (Meyer 2002). The number of released rockfish caught below 10 fathoms by Gustavus and Elfin Cove anglers is unknown.

Release mortality and overfishing are concerns for local populations of non-pelagic rockfish such as yelloweye due to their high site fidelity, increased fecundity with age, slow growth, and late maturation (Love et al. 2002). The approximated median age for observed yelloweye rockfish in the Elfin Cove fishery was 44 years. Studies suggest that the timing of larval release is a critical determinant for young-of-year survival and that larval release times vary based on rockfish age (Eldridge et al. 1991, Parker et al. 2000). Thus, the selective capture of the larger, older, more fecund individuals truncates age distribution and alters a segment of the population that may determine recruitment success in some years (Berkeley & Markle 1999).

The median age estimate provided in this report should be viewed with caution because error abounds when using the von Bertalanffy growth equation to calculate age based on length measurements (Gulland 1969). Errors are associated with length measurement, the age-length model used, the total-to-fork-length conversion used (equation 3.3), overlap of ages for a given size range, geographical variation, and data beyond the models L_{inf}. The published L_{inf} parameter used in the model is based on a "best fit" of raw data by O'Connell et al. (2003), and length observations may reside outside the fitted model.

Median age is not intended to be an absolute or reliable measure of age for harvested rockfish in the Elfin Cove charterfishery. The intent of providing an age estimate for yelloweye rockfish in this report was to illustrate potential impacts of a sportfishery on yelloweye populations given their life-history characteristics. Future studies should consider the need to incorporate sex-specific age estimation through the collection of otolith samples to evaluate harvest effects on age class.

No age estimates were developed for black rockfish harvested in the Elfin Cove fishery because a published combined sex model was not available. Black rockfish populations are generally more robust with respect to overfishing due to their life-history characteristics and pelagic range (Love et al. 2002). However, like all rockfish species, populations can remain viable when fishing mortality rates are low, and overfishing results in long population recovery times compared with other teleost species such as salmon.

The sensitivity of yelloweye rockfish populations to overfishing has resulted in a National Marine Fisheries Service (NMFS) harvest strategy that has set commercial fishing mortality equal to natural mortality (F= 0.02) (O'Connell et al. 2003). Even with strict harvest guidelines, NMFS has recognized the need to spatially assess sedentary and spatially isolated species (such as yelloweye) to prevent localized depletion: "…fishing effort tends to be concentrated in areas of best [rockfish] habitat and high density and it may be that local overfishing occurs" (O'Connell 2003). This statement refers to yelloweye overfishing that may have occurred on the Fairweather Grounds, about 30 miles west of the outer coast of the Park (O'Connell 2003).

Future fishery assessment plans for rockfish should incorporate the complex intraspecific population structures (Gharrett et al. 2001) and regional biocomplexity[6] characteristics of rockfish. This will require harvest and bycatch assessments that recognize the biological and habitat characteristics of local rockfish populations. It may be necessary to accompany sportfish harvest information with a stock assessment of local rockfish populations to determine fishery-related impacts.

In summary**,** significant numbers of rockfish are being discarded in areas near Park waters, and the species composition of those discards is largely unknown due to logistical and identification issues.

Age distribution of the Elfin Cove yelloweye rockfish catch may be of concern to the Park if large numbers caught below 10 fathoms are being released (and suffer mortality) and/or harvest levels are high enough to affect local populations and cause harm to rockfish populations.

Without stock-assessment and commercial fishery harvest/bycatch information, it is impossible to determine sustainable harvest levels for rockfish. Therefore, future assessments should enumerate the composition of catch and age of rockfish in both the commercial and sport fishery, possibly by placing observers aboard charter and commercial boats; and a stock assessment of non-pelagic rockfish populations in the Glacier Bay region should be conducted, particularly of rockfish stocks that straddle Park boundaries.

Dogfish Release Mortality

The large number (503 fish) of dogfish released by charter anglers in Elfin Cove could be a potential management issue because release mortality and the population health for dogfish in the Glacier Bay region are unknown. Release mortality for dogfish is likely high if anglers in the Glacier Bay region consider them a nuisance species. This is a documented problem in Washington State and Yakutat, Alaska where dogfish are considered a nuisance by sport anglers (C. Tribuzio, pers comm. 2004). Dogfish are sometimes intentionally mutilated by fishers before release which can result in subsequent mortality. Large release mortalities are of management concern because dogfish are susceptible to overfishing due to their low fecundity, longevity, and late sexual maturation (male=20 years; female=35 years) (McFarlane & Beamish 1987). Sustainable fishing mortality for dogfish in the Glacier Bay region is unknown, which makes it an important future management and research topic.

[6] Biocomplexity refers to the genetic variability provided by localized populations to the population as a whole (i.e., some groups will have higher reproductive potential under certain environmental conditions) (Hilborn et al. 2003).

To determine sportfishery impacts on dogfish populations, post-release mortality for the Glacier Bay region could be assessed directly using empirical methods (i.e., sonic tagging) or indirectly by assessing angler attitude. Angler attitude questions should focus on the physical condition of released dogfish (i.e., cut-off fins) and if they are considered a nuisance species.

Salmon Harvest Within & Adjacent to Park Boundaries

Seasonal recreational salmon harvest within the Cross Sound/Icy Strait area is relatively small compared with historical year-round commercial harvest. Gustavus anglers (charter and private) harvested nearly 5,100 and Elfin Cove charter anglers harvested over 2,100 salmon during the 2003 summer season. Together, these anglers harvested over 4,500 coho, nearly 1,800 pinks, over 400 kings, and over 400 chum salmon. In contrast, commercial harvests for ADF&G District 114 (all of Cross Sound and Icy Strait including Glacier Bay proper) historically averaged 106,200 coho, 8,400 pinks, 6,600 kings, and over 2,000 chum annually during the 1985–1995 period (unpubl. ADF&G data). Thus, year-round commercial salmon harvests were historically 5 to 24 times greater than more recent seasonal recreational harvest.

Cross Sound is the migratory route for numerous salmon stocks returning to spawn in natal streams throughout northern Southeast Alaska. Thus, anglers from area communities are ideally positioned to take advantage of these returning stocks. Although migratory routes for Park salmon stocks are not known, most stocks probably arrive via the Cross Sound entrance. Numerous local breeding populations of salmon are thought to occur within more than 300 Park streams (Chad Soiseth, pers. com.).

Stock management generally does not adequately recognize the distinct geographical nature of local salmon populations. This is particularly problematic in mixed-stock fisheries when populations are harvested together and stock-specific harvest rates are not feasible. Specifically, mixed-stock fisheries can result in overharvest of small, week stocks when harvest rates exceed population productivity (NRC 1996, Knudsen 2000). Small populations, isolated both spatially and temporally during migration, could be overharvested using efficient harvest methods. This could have important population-viability implications if such stocks were overexploited over several successive years. Fortunately, however, hook-and-line fisheries associated with commercial trolling or recreational anglers are generally not considered particularly efficient.

The ability to reduce exploitation rates of stocks in years with weak runs is an important element of mixed-stock fisheries management in Alaska (Van Alen 2000). ADF&G monitors escapement returns to a few larger index streams in Southeast Alaska. However, both ADF&G and NPS lack reliable escapement information for most small and medium-sized streams. There is currently no evidence to suggest these populations are being overexploited. That said, absence of evidence is not evidence of absence.

Recently colonized (and/or small) salmon populations in streams emerging from glaciation may be susceptible to overharvest. The NPS currently lacks information on the long-term viability of Park salmon populations, particularly those in recently colonized streams. The NPS should consider the need and value of assessing long-term productivity of salmonids within a few key indicator streams. Methods outlined in this paper for assessing recreational harvest could be adapted to collect coded wire tags, genetic samples, or other materials from Park-originating fish provided they could be identified by recreational anglers and creel samplers.

RECOMMENDATIONS

1. Continue creel-sampling program and cooperation with ADF&G in Gustavus & Elfin Cove.

The creel-survey program provided important sportfishing catch, effort, and harvest information for the Glacier Bay region. Even with the large reporting errors for catch and effort *within* Park waters, the creel surveys in Gustavus and Elfin Cove elucidated important areas of localized fishing pressure.

Two areas that receive localized fishing pressure (mouth of Glacier Bay and the Inian Islands) are near Park waters. It is important to assess fishing activity in those areas because many species (halibut, salmon, rockfish, lingcod, and shark) caught by sport anglers have home ranges that likely encompass both *within*-Park and *outside*-Park waters. Furthermore, the relative use of *within*-Park and *outside*-Park waters by these species is largely unknown.

The creel survey was also beneficial for facilitating user involvement and increasing interaction between local users and Park management. Creel-survey technicians offered a convenient and non-threatening vehicle for charter and private anglers to communicate concerns about Park and state management, obtain regulatory and biological information, and facilitate involvement with management and monitoring.

Anecdotal data gathered by the UW-SMA and ADF&G creel technicians indicated that some anglers were frustrated with what they perceived as a non-transparent management process. Data collection that involves anglers may increase the legitimacy (from an angler's point of view) of future management actions taken by the Park and ADF&G. Moreover, joint cooperation between the two agencies insures that data is compatible with agency information needs and anglers are not asked to participate in duplicate studies.

2. Combine future creel-survey programs with aerial or other survey methods.

If the goal of future creel-survey programs is to assess *within*-Park harvest, then it is important to account for the high level of misreporting observed during this study.

This study found that all anglers surveyed by aerial and dock-intercept methods misreported fishing effort, catch, and harvest from *within* Park waters. Moreover, due to the high misreporting levels, it is unlikely that *within*-Park catch, effort, and harvest could be accurately assessed using only dock-intercept methods.

High levels of misreporting may have been due to some charter anglers not knowing (or not paying attention to) the location of Park boundaries outside Glacier Bay proper, by unpermitted charterboats operating *within* the Park, by avoidance of Park business-permitting requirements (i.e., fees and insurance requirements), or apprehension about providing creel census data to the NPS. Because the causes of misreporting were not studied in this report, the above-mentioned reasons are conjecture but are provided to aid future studies. Studies focused on the reasons for misreporting and methods to mitigate the problem would aide future fishery surveys and inform Park managers.

It may be possible to determine catch and harvest using aerial or boat-based surveys combined with dock-intercept methods. Analysis of OWVAS data suggested that photographs could be used to differentiate bottomfishing from salmon-fishing effort. If fishing effort can be differentiated, then catch and harvest can be enumerated using complemented aerial/dock- intercept methods as outlined by Pollock et al. (1994).

3. Conduct fishery-independent assessments of halibut size, movement, and local abundance within the Park and adjacent areas.

The size distribution of sport-harvested halibut in areas directly adjacent to Glacier Bay proper was larger than of sport-caught halibut in the communities of Juneau, Petersberg/Wrangell, Sitka, and Ketchikan. The size discrepancy among areas adjacent to Glacier Bay proper may be due to spillover effects from Glacier Bay proper, preferred habitat, and/or possible migration corridors.

A better understanding of Glacier Bay's influence on halibut stocks in the greater Glacier Bay region could improve local management by providing insight on the use of marine protected areas to manage and conserve local populations. The unusual size distribution of halibut near the mouth of Glacier Bay may indicate that it is important habitat for feeding, migration, or other life-history functions.

Future studies of halibut populations should be done using fishery-independent methods such as longline and tagging surveys. Collection of length data using fishery-independent surveys will reflect the halibut population better than sportfishery information because sportfishery data can vary due to changes in fishing behavior.

4. Incorporate age–length information for yelloweye rockfish into future creel surveys.

The determination of age at capture for yelloweye rockfish in the sportfishery is important because harvest pressure may be focused on the most fecund cohorts. This study anecdotally suggests that older cohorts are receiving greater harvest pressure by the Elfin Cove sportfishery. The median age for harvested yelloweye rockfish from Elfin Cove was estimated at 44 years, with ages 20–24 and 100+ making up a large portion of the catch. This pattern of sportfishing behavior has resulted in dramatic population declines up and down the U.S West Coast.

Future studies should analyze age-related structures (i.e., otoliths, scales, or stable isotopes). The age data will provide important management information on the age composition of yelloweye rockfish harvested in the sportfishery. The age estimates presented in this report are prone to large error and should be considered only an indicator for potential management concern and future research. Age-specific information would undoubtedly be used to better manage harvest of this species.

5. Incorporate fishery activity from transient anglers and other local fishing communities into future creel surveys.

Sportfish harvest and effort levels have not been assessed for anglers originating from more distant areas (e.g., other Alaska ports or areas outside Alaska) or other local communities (i.e., Pelican, Hoonah, and Excursion Inlet). Incorporating fishing activity from transient anglers and surrounding communities would increase the accuracy of sportfishing catch, harvest, and effort estimates for the Cross Sound/Icy Strait/Glacier Bay region of Southeastern Alaska.

A growing charter and lodge-based fishery is known to operate from Hoonah and Excursion Inlet (C. Soiseth, pers. commun. 2004). The city of Hoonah, in particular, has made strong efforts in recent years to attract more charter anglers with its Point Sophia cruiseship destination.

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APPENDIX TABLES

2002 Survey Data

Appendix Table A. Observed salmon– and bottomfishing effort (rod hours) by charter and private anglers from Gustavus and Elfin Cove, Alaska, across statistical areas, during the 2002 pilot study. Sub–Areas 28–1, 29–1, and 46–1 are within Park boundaries. Asterisks indicate no effort observed.

	Statistical Area										
Fishing effort	24	25	26	28	28-1	29	29-1	30	37	41	42
Gustavus											
Bottomfish											
Charter	35	4	79	797	16	3032	455	36	*	30	15
Private	6	*	12	512	*	707	108	20	6	*	*
Salmon											
Charter	29	*	344	610	9	2618	16	*	*	*	*
Private	*	9	103	67	*	835	*	*	*	*	*
Bottomfish : Salmon											
Charter	0.55	*	0.19	0.57	0.64	0.54	0.97	*	*	*	*
Private	*	*	0.10	0.88	*	0.46	*	*	*	*	*
Elfin Cove charter											
Bottomfish	*	*	*	49	*	*	*	*	*	*	*
Salmon	*	*	24	*	*	*	*	*	*	*	*
Bottomfish : Salmon	*	*	0	1.00	*	*	*	*	*	*	*
	44	45	46	46-1	51	52	53	54	55	56	57
Gustavus											
Bottomfish											
Charter	*	*	2350	*	*	*	334	36	8	77	*
Private	24	9	552	36	*	*	67	*	*	*	*
Salmon											
Charter	*	*	84	*	10	25	162	24	160	156	*
Private	*	*	22	*	*	*	46	*	*	*	*
Bottomfish : Salmon											
Charter	*	*	0.97	*	*	*	0.67	0.60	0.05	0.33	*
Private	*	*	0.96	*	*	*	0.59	*	*	*	*
Elfin Cove charter											
Bottomfish	*	40	105	52	42	4	389	46	330	*	*
Salmon	*	6	*	*	31	66	252	75	437	*	29
Bottomfish : Salmon	*	0.87	1.00	1.00	0.58	0.06	0.61	0.38	0.43	*	*

Appendix Table B. Observed numbers of halibut and lingcod harvested, released, and proportion retained (PR) by Gustavus, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Sub-Areas 25-1, 28-1, and 29-1 are within Park boundaries. Asterisks indicate no harvest observed.

Statistical	Halibut			Lingcod		
Area	Harv	Rel	PR	Harv	Rel	PR
24	12	11	0.52	*	*	*
25	13	17	0.43	*	1	*
25-1	1	2	0.33	*	*	*
26	23	23	0.50	*	*	*
28	241	259	0.48	*	1	*
28-1	8	7	0.53	*	*	*
29	981	1047	0.48	*	*	*
29-1	158	191	0.45	*	*	*
30	6	*	*	*	*	*
41	6	6	0.50	*	*	*
42	2	*	*	*	*	*
46	778	856	0.48	*	*	*
53	123	181	0.40	*	*	*
54	1	*	*	5	16	0.24
55	*	*	*	1	1	0.50
56	13	18	0.42	*	4	*
All Areas	2199	2418	0.48	6	23	0.21

Appendix Table C. Observed numbers of rockfish harvested by Gustavus, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Asterisks indicate no harvest observed.

Statistical	Rockfish harvest			
Area	Quillback	Black	Yelloweye	Other rockfish
24	*	*	*	*
25	*	*	*	*
26	*	*	*	*
28	10	*	*	1
29	1	2	*	2
30	*	*	*	*
41	*	*	*	*
42	*	*	*	*
46	6	1	*	*
51	*	*	*	*
52	*	*	*	*
53	1	1	2	*
54	*	*	11	*
55	*	*	*	8
56	1	*	4	*
All Areas	19	4	17	11

Appendix Table D. Observed numbers of salmon harvested, released, and proportion retained (PR) by Gustavus, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Asterisks indicate no harvest observed.

Statistical	Salmon											
	Coho			King			Pink			Chum		
Area	Harv	Rel	PR	Harv	Rel	PR	Harv	Rel	PR	Harv	Rel	PR
24	9	*	1.00	*	*	*	8	15	0.35	1	*	1.00
25	*	*	*	*	*	*	*	*	*	*	*	*
26	95	1	0.99	25	13	0.66	20	3	0.87	1	1	0.50
28	279	*	1.00	5	14	0.26	121	149	0.45	2	*	1.00
28-1	2	*	1.00	*	*	*	*	*	*	*	*	*
29	1994	27	0.99	70	68	0.51	277	769	0.26	29	1	0.97
29-1	9	*	1.00	*	*	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*	*	*	*	*	*
41	*	*	*	*	*	*	*	*	*	*	*	*
42	*	*	*	*	*	*	*	*	*	*	*	*
46	11	*	1.00	1	*	1.00	34	1	0.97	2	*	1.00
51	3	*	1.00	*	2	0.00	*	*	*	*	*	*
52	*	*	*	1	*	1.00	*	*	*	2	*	1.00
53	98	*	1.00	21	*	1.00	37	20	0.65	2	*	1.00
54	6	*	1.00	12	1	0.92	*	*	*	*	2	0.00
55	110	2	0.98	46	4	0.92	3	6	0.33	*	*	*
56	18	*	*	51	1	0.98	1	2	0.33	*	*	*
All Areas	2623	30	0.99	232	103	0.69	501	965	0.34	39	4	0.91

Appendix Table E. Observed numbers of halibut and lingcod harvested, released, and proportion retained (PR) by Elfin Cove, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Asterisks indicate no harvest observed.

Statistical	Halibut			Lingcod		
Area	Harv	Rel	PR	Harv	Rel	PR
28	1	8	0.11	*	*	*
29	*	*	*	*	*	*
45	9	*	1.00	*	*	*
46	21	5	0.81	*	8	0.00
46-1	9	*	1.00	*	*	*
47	*	*	*	*	*	*
51	9	10	0.47	*	2	0.00
52	*	*	*	*	*	*
53	76	19	0.80	*	8	0.00
54	5	3	0.63	*	4	0.00
55	102	121	0.46	15	83	0.15
57	*	*	*	*	*	*
All Areas	223	166	0.57	15	105	0.13

Appendix Table F. Observed numbers of salmon harvested, released, and proportion retained (PR) by Elfin Cove, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Asterisks indicate no harvest observed.

Statistical	Salmon											
	Coho			King			Pink			Chum		
Area	Harv	Rel	PR	Harv	Rel	PR	Harv	Rel	PR	Harv	Rel	PR
26	26	*	1.00	*	*	*	*	*	*	*	*	*
28	*	*	*	*	*	*	*	*	*	*	*	*
46	*	*	*	*	*	*	*	*	*	*	*	*
47	*	*	*	*	*	*	*	*	*	*	*	*
51	1	1	0.50	*	1	0.00	1	20	0.05	*	5	0.00
52	*	*	*	*	*	*	*	46	0.00	*	1	0.00
53	195	1	0.99	3	1	0.75	32	152	0.17	*	*	*
54	39	15	0.72	2	11	0.15	17	9	0.65	*	*	*
55	214	9	0.96	45	42	0.52	22	67	0.25	*	*	*
57	3	*	1.00	1	*	0.00	1	3	0.25	*	*	*
All Areas	480	26	0.95	58	48	0.55	73	297	0.27	*	6	0.00

Appendix Table G. Observed numbers of rockfish harvested, released, and proportion retained (PR) by Elfin Cove, Alaska charter anglers, across statistical areas, during the 2002 pilot study. Asterisks indicate no harvest observed.

Statistical	Rockfish Harvest				All Rockfish	
	Quillback	Black	Yelloweye	Other Rockfish		
Area	Harv	Harv	Harv	Harv	Rel	PR
46	*	*	1	*	*	1.00
47	*	*	*	*	*	
52	*	*	1	20	*	1.00
53	2	21	12	*	52	0.40
54	1	*	10	*	21	0.34
55	5	16	94	6	166	0.42
57	*	*	*	*	2	0.00
All Areas	6	37	118	26	241	0.44