NORTHERN SOUTHEAST INSIDE (CHATHAM STRAIT)

RELATIVE ABUNDANCE LONGLINE SURVEY

CRUISE REPORT

AUGUST 6-AUGUST 13, 1997

By Meg Cartwright and
Dave Carlile

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AUTHORS

MARGARET CARTWRIGHT
DAVID CARLILE

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TABLE OF CONTENTS

Page

AUTHORS 2
ACKNOWLEDGEMENTS 2
LIST OF TABLES 3
LIST OF FIGURES 3
APPENDIX 3
INTRODUCTION 4
OBJECTIVES 4
METHODS 4
  Survey Design 4
  Biological sampling 5
  Mark and Release 6
RESULTS 6
Scientific Personnel 7
Literature Cited 7

LIST OF TABLES

Page

Table 1*. Set and catch information for the 45 stations fished in the 1997 NSEI sablefish longline survey. 8
Table 2. Gear configuration of the fishing vessels chartered for the 1997 NSEI sablefish longline survey. 9
Table 3. Number of tagged fish released by station and statistical area in the 1997 NSEI sablefish survey. 9

LIST OF FIGURES

Page

Figure 1. Chatham Strait survey station locations. Numbered marks represent location of stations within each groundfish statistical area. Fish were marked and released at stations indicated by a circle. 10
Figure 2. 1997 NSEI survey sablefish catch per unit effort (fish/ hook) for each station. Numbers represent statistical areas (see Figure 1). 11
Figure 3. The proportion of total fish captured by bycatch species or group and station. The remaining proportion of fish is sablefish. For example, 52% of the fish caught at station 52 were sablefish and 48% other fish. 12

APPENDIX

Page

Appendix 1. Sablefish Maturity Codes 13
Appendix 2. Chatham Strait Sablefish Mark-Recapture Study, Project Operational Plan 15

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) conducts an annual longline survey in the Northern Southeast Inside (NSEI) subdistrict of the Southeast District to assess the health of the sablefish *Anoplopoma fimbria* stock targeted in the limited-entry state fishery. From August 6 to August 13, the Department performed the tenth-annual sablefish longline survey in the Chatham Strait portion of this subdistrict. The northern most station was located near Point Hepburn (Admiralty Island, latitude 57° 55.84", longitude 134° 47.65") and the survey extended several miles southeast of Cape Ommaney (Baranof Island, latitude 56° 05.2'longitude 134° 30.4'Figure 1).

OBJECTIVES

1. Estimate relative abundance of sablefish in the Chatham Strait portion of the NSEI subdistrict.
2. Collect biological samples and data including otoliths, length, weight, sex, and stage of gonad maturity from a subsample of fish.
3. Mark and release 4,000 to 6,000 marked sablefish from 22 of the 45 stations throughout the survey area.

METHODS

Survey Design

Three fishing vessels were contracted to conduct the 1997 survey in Chatham Strait. The F/V Ida June, F/V Charles-T and the F/V Kruzof fished 15 stations each in the northern, central, and southern Chatham areas respectively. The three boats fished for five days setting three to four sets/day. The F/V Kruzof and the F/V Charles-T, fished from August 7 to August 11. The F/V Ida June fished August 8 to August 12. The starting date of the survey was set to coincide with the first minimal tide of August. This time period was also selected as a balance between minimizing the amount of time between the survey and the fishery and maximizing the time between releasing (survey) and retrieving (fishery) marked fish. Because little is known about the movement of sablefish in and out of Chatham, the survey is conducted as close to the fishery opening as possible. Sufficient time between marking and recapturing tagged fish is necessary to promote mixing of marked and unmarked fish and to diminish the potential of hook "shyness" or "happiness" behavior.

A set of gear consisted of a flag, a buoy(s), an anchor, a running line, and 8-14 skates, about 1,100 baited hooks, and another set of running line, an anchor, buoys and a flag. Gear configuration was modified this year to parallel similar gear characteristics used by NMFS in the sablefish longline survey in the Gulf of

Alaska. Modifications included an increase in hook spacing (from 64 to 84 inches) and a change to 100% Illex squid bait. Approximately 12.5 lb. of bait was used per 100 hooks. Hook spacing varied from 78" to 84" with 76 to 125 hooks per skate and gangion length ranged from 7" to 12" (Table 2). Other gear characteristics are summarized on Table 2.

A total of 45 stations were surveyed including seven new stations in statistical area 345603 (Figure 1). Past surveys did not sample south of Patterson Point. Currently 25% of the commercial catch is landed from this southern area (Figure 1). One set of gear was deployed at each station. Sets were made in the same direction as the tidal current. A typical pattern of setting gear was to set two sets, wait three hours, pick up the first set, set the third (and sometimes fourth) set of the day and pick up the second and third (fourth) set in sequence. This allowed soak time to stay within the range of 3 to 11 hours to ensure gear fished on the bottom but presumably not long enough to "saturate" the gear with fish (Sigler, 1993). Haul-back direction depended on the tide, wind direction, and currents. The latitude, longitude, start and end depth, start time, compass heading, wind direction and speed, tide stage, bottom type, and sea condition were recorded for each set. The depth profile of the bottom was also recorded for each set using a recording fathometer. Tide speed was calculated using the tide stage and the 1997 Washburne's Tables (Washburne 1996) and Southeast Alaska Current Atlas (Washburne 1989). . The survey was conducted during a time period when the difference between high and low tides was minimal.

Catch and effort (number of hooks) data were tallied as the gear was hauled back on deck at each station. During the retrieval of each set, the species of each fish brought to the surface and the condition of each fishless hook (i.e. bated, unbaited, or broken) was recorded. Each skate was treated as a subsection within a set and tallied separately to allow estimation of variance within a set. This also allowed inclusion of selected subsections in the analysis of CPUE rather than excluding the data for an entire station if major gear snarls occurred within a subsection. By-catch was identified to species when possible including all rockfish *Sebastes* landed, spiny dogfish *Squalus aconthias*, arrowtooth flounder *Atheresthes stomias*, Pacific cod *Gadu macrocphalus*, walleye pollock *Theragra chalcogramma*, ratfish *Hydrolagus colliei*. Thornyheads *Sebastolobus* spp. and hagfish were not keyed to species and skates were identified as a longnose skate *Raja rhina* or other skate.

Biological sampling

We sampled every tenth sablefish for biological data including length (nearest cm), weight (nearest 0.1 kg), sex, and stage of sexual maturity. Stage of sexual maturity was coded according to a list of six descriptions of gonad conditions for each sex (Appendix 1). Otoliths were extracted and paired with the biological data and sent to ADF&G Commercial Fisheries Management and Development Division (CFMD) Coded Wire Tag (CWT) & Otolith Processing Lab in Juneau for age determination. Length measurements were taken on all rockfish caught from the set and on every fifth thornyhead. Other bycatch species were identified and released at the roller and were not sampled for biological data.

Mark and Release

This year, we implemented a mark/recapture study to evaluate the potential for obtaining an absolute abundance estimate of sablefish in Chatham Strait. The goal was to double mark between 4,000 to 6,000 sablefish distributed throughout the area fished by the commercial fleet. The primary mark was an upper caudal fin clip and the secondary mark was a T-bar tag with an individual number attached below the anterior dorsal fin (Figure 1 in Appendix 2). Fish were marked at 22 stations. The number of stations selected per statistical area was approximately proportional to the 1996 catch of sablefish (Appendix 2). Within each statistical area, marking stations were selected at random among the survey stations. All healthy sablefish were marked, tagged, and the tag number and the length to the nearest centimeter were recorded. Appendix 2 contains a detailed description of the mark release and recovery phases of the project.

RESULTS

Set information, CPUE, and biological data were collected from all 45 stations designated in the NSEI survey area. Due to their close proximity, similar depth and substrate type, Stations 1 and 2 were fished as one set (Figure 1). The first ten skates were designated Station 1 and the second ten skates as Station 2. The average depth fished was 315 fathoms ranging from 214 (Station 13) to 397 fathoms (Station 8; Table 1). Soak time ranged from 2.7 to 7.0 hours and averaged 4.0 hours. A total of 493 skates were set and of those, 454 were valid and used to calculate CPUE.

A total of 49,060 hooks were retrieved during the survey ranging from 922 to 1,217 hooks per station (Table 1). A total of 13,042 sablefish were caught. The overall CPUE (sablefish/hook) was 0.27 with a range between 0.10 (Station 58) and 0.50 (Station 39; Figure 1 and 2). Bycatch species included 261 halibut, 338 rockfish, 1433 thornyheads, 829 skates, and 260 "other" (Figure 3). The "other" category includes arrowtooth flounder, king crab, hake, Pacific Ocean perch, turbot, and Dover sole. High thornyhead catches were evident in the two most southern statistical areas of Chatham Strait, 345603 and 345631 (Figure 1). Other bycatch species catches showed greater variation between stations than between statistical areas (Figure 3).

Of the 584 sablefish sampled during the 1997 survey, the average length was 70 cm (±1.9, 95% confidence interval (CI)). ranging between 40 and 110 cm. The average weight was 3.9 kg (± 0.2, 95% CI) with a range from 0.7 to 16.8 kg. Fifty-one percent of the samples were males. Approximately 12 % of the sampled sablefish had not spawned previously indicating about three recruitments/100 hooks. Age data is not yet available.

A total of 5,600 tagged fish were marked and released at 22 predetermined stations and additional tags were released at Station 8 (Table 3). The number of marks released exceeded the minimal marking goal of 4,000 fish (Appendix 2). Marking goals proportionate to fishery effort by statistical area were met in all four targeted statistical areas except 345603 (Table 3 and Appendix 2). A less than 0.16 CPUE for some of the tagging stations in this statistical area prevented taggers from meeting the goal in this area.

A more detailed presentation of 1997 survey results will be compiled and reported in a forthcoming document.

SCIENTIFIC PERSONNEL

F/V Kruzof	Meg Cartwright	Crewleader
	Marc Pritchett	Fisheries biologist/crew
F/V Charles-T	Beverly Richardson	Crewleader
	Dave Carlile	biometrician/crew
F/V Ida June	Tory O'Connell	Crewleader

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Table 1*. Set and catch information for the 45 stations fished in the 1997 NSEI sablefish longline survey.

Location	Station**	Date	Start Latitude	Start Longitude	Average Depth	Number Sablefish	CPUE (fish/hk.)	2SE	Average*** Dr. Wt.(lb.)	Hooks per set
Patterson Pt	1	8/9/97	5631.20	13434.60	265	151	0.17	0.01	5.4	882
Patterson Pt	2	8/9/97	5631.95	13434.60	265	199	0.24	0.01		840
Patterson Pt	3	8/8/97	5635.20	13431.30	356	239	0.24	0.01	4.4	988
Gut Bay	4	8/10/97	5641.60	13434.80	371	324	0.27	0.01	4.7	1,217
Gut Bay	5	8/10/97	5642.30	13433.10	379	289	0.25	0.00	4.3	1,150
Washington Bay	6	8/7/97	5641.25	13425.47	234	226	0.21	0.01		1,101
Washington Bay	7	8/11/97	5641.70	13426.10	270	289	0.25	0.01	5.7	1,142
Gut Bay	8	8/10/97	5645.00	13433.20	397	254	0.21	0.01		1,211
Washington Bay	9	8/7/97	5645.53	13429.21	358	303	0.28	0.01		1,075
Hoggatt Bay	10	8/11/97	5647.00	13431.80	385	284	0.24	0.01	5.3	1,161
Kingsmill Pt	13	8/8/97	5650.55	13430.76	214	237	0.21	0.01		1,135
Red Bluff Bay	15	8/8/97	5653.01	13438.41	362	407	0.36	0.01		1,119
Yasha Island	16	8/8/97	5654.19	13433.75	357	309	0.28	0.01		1,111
Cascade Bay	18	8/9/97	5702.05	13442.68	344	323	0.29	0.01		1,122
Cascade Bay	19	8/11/97	5701.35	13443.95	350	289	0.25	0.01	7.0	1,134
Warm Springs	21	8/9/97	5707.52	13442.07	347	336	0.30	0.01		1,122
White Cliff	22	8/9/97	5710.07	13447.40	320	226	0.23	0.01		978
Wilson Cove	23	8/10/97	5711.30	13440.90	373	212	0.21	0.02	5.7	1,020
Pt Caution	24	8/8/97	5714.18	13440.72	300	352	0.39	0.01		912
Woody Point	25	8/10/97	5717.96	13439.94	256	409	0.38	0.01	5.0	1,075
Point Lull	27	8/10/97	5720.31	13444.78	388	308	0.34	0.01	6.3	897
Point Lull	28	8/8/97	5718.68	13442.71	303	219	0.26	0.02		851
Chaik Bay	29	8/8/97	5720.83	13436.96	291	405	0.47	0.00		861
Village Point	30	8/10/97	5721.27	13439.27	264	342	0.32	0.02	6.2	1,055
Pt Thatcher	32	8/11/97	5722.58	13446.04	361	280	0.29	0.01	5.7	955
Distant Point	33	8/9/97	5726.80	13441.55	299	341	0.36	0.01		943
Danger Point	35	8/11/97	5731.35	13442.07	304	327	0.30	0.01	5.2	1,103
White Rock	37	8/9/97	5732.47	13445.13	325	329	0.34	0.01		974
Parker Point	39	8/9/97	5734.73	13442.22	223	523	0.50	0.01	4.6	1,051
Basket Bay	41	8/10/97	5741.65	13452.54	305	199	0.19	0.00	5.1	1,075
S Passage Point	42	8/10/97	5743.91	13453.10	295	223	0.26	0.01	4.6	855
Fishery Creek	43	8/12/97	5744.43	13445.78	295	138	0.26	0.01		522
S Passage Point	44	8/10/97	5746.26	13448.76	278	189	0.23	0.01	4.4	829
S Passage Point	45	8/12/97	5747.07	13450.14	290	237	0.22	0.01		1,077
Fishery Point	46	8/13/97	5748.31	13448.64	260	183	0.17	0.01		1,052
Fishery Point	47	8/11/97	5750.97	13446.01	253	165	0.15	0.01	5.5	1,078
Fishery Point	49	8/11/97	5751.51	13447.17	274	234	0.30	0.01	5.0	792
Pt Hepburn	51	8/11/97	5756.49	13448.12	289	196	0.31	0.01	5.8	626
Pt Harris	52	8/9/97	5615.50	13427.30	394	202	0.17	0.02	6.6	1,161
Port Herbert	53	8/8/97	5625.20	13429.70	384	325	0.28	0.01	4.1	1,181
Port Armstrong	54	8/7/97	5618.40	13434.00	316	166	0.17	0.01	4.0	952
Pt Howard	55	8/7/97	5605.30	13430.50	286	232	0.29	0.01	3.6	795
Port Herbert	56	8/8/97	5626.17	13436.30	307	281	0.24	0.01	5.7	1,168
Pt Harris	57	8/9/97	5617.53	13424.80	389	260	0.24	0.01	6.3	1,082
Cape Ommaney	58	8/7/97	5608.10	13434.80	297	109	0.10	0.01	3.7	1,067
Average					315	268	0.27	0.00	5.19	45,497
Maximum					397	523	0.50		7.01	1,217
Minimum					214	109	0.10		3.60	522

*Data Varies From Survey Summary Due To Excluding Additional Invalid Sections.
**Stations 52 Through 58 Are New Stations Added South Of Patterson Pt. Stations 1 & 2 Were Fished As The Same Set.
***Average Dr. Lbs. Is Based On 63% Of The Round Wt. Of Fish Sampled.
Soak Time: 3-7 Hours
Bait: Illex Spp. Squid
Overall CPUE (Dr. Lbs./Hook) = 1.4

Table 2. Gear configuration of the fishing vessels chartered for the 1997 NSEI sablefish longline survey.

	F/V Ida June	F/V Charles-T	F/V Kruzof
Line type	5/16" gold	3/8" gold	3/8" gold
Anchor wt. (lbs.)	50	50	60
Hook spacing (in)	78	84	80-84
Gangion length (in.)	8	7	12
Skate length (fa)	100	150	150
Skate weights (lbs.)	2-3	4-7	5
Configuration	every skate end	every 2 skate end	every skate end
Running line length (fa)	150	50/100	150

Table 3. Number of tagged fish released by station and statistical area in the 1997 NSEI sablefish survey.

Station	345603	345631	345701	345731	Total
3		260			260
4		285			285
6		232			232
8		159			159
9		291			291
13		217			217
15		377			377
16		252			252
18			208		208
21			207		207
22			214		214
24			342		342
28			243		243
29			308		308
33			349		349
37				277	277
46				153	153
53	262				262
54	151				151
55	265				265
56	238				238
57	217				217
58	93				93
Total	1,226	2,073	1,871	430	5,600
% of Total	21.89	37.02	33.41	7.68	
Target %	26	32	33	9	

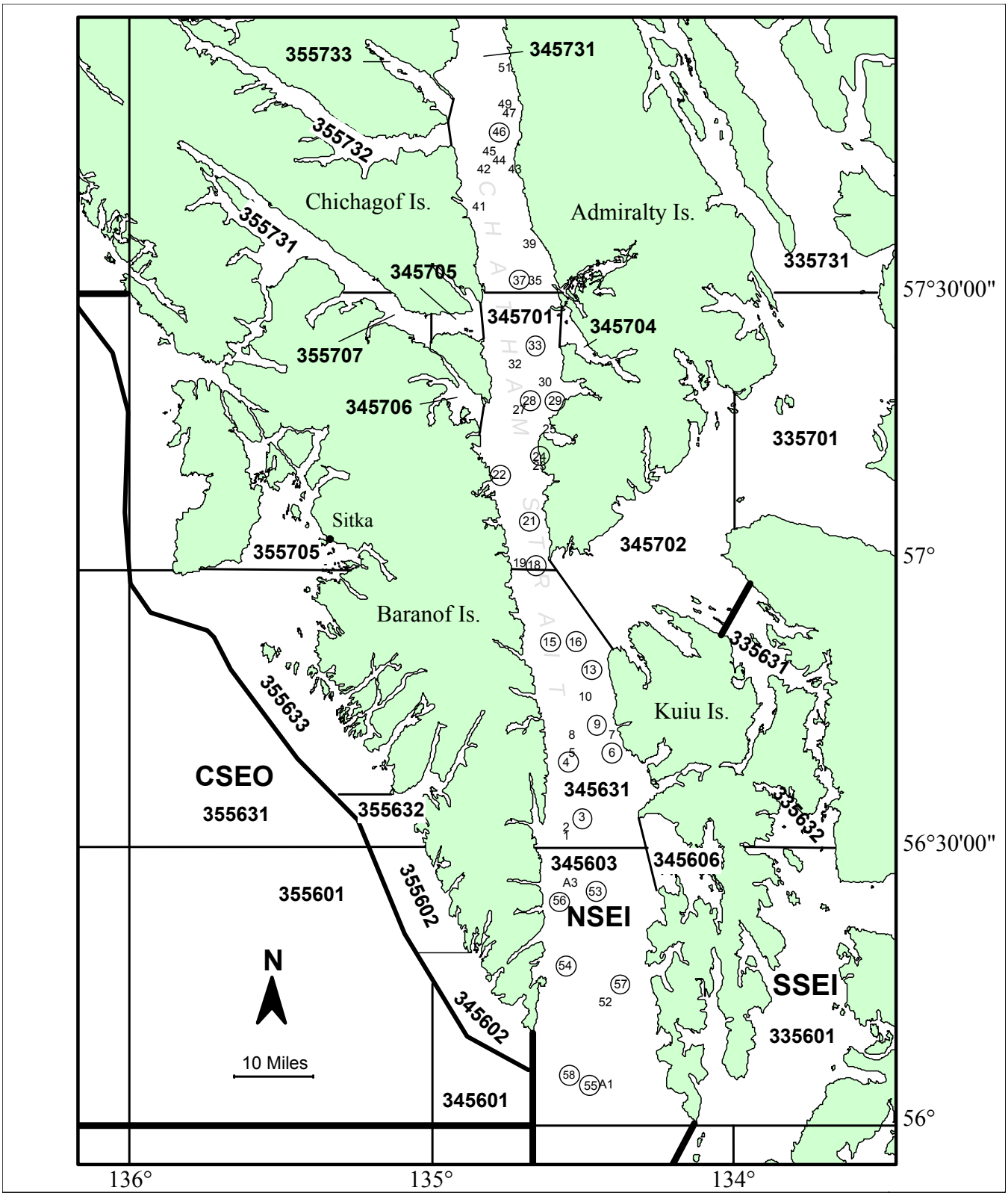


Figure 1. Chatham Strait survey station locations. Numbered marks represent location of stations within each groundfish statistical area. Fish were marked and released at stations indicated by a circle.

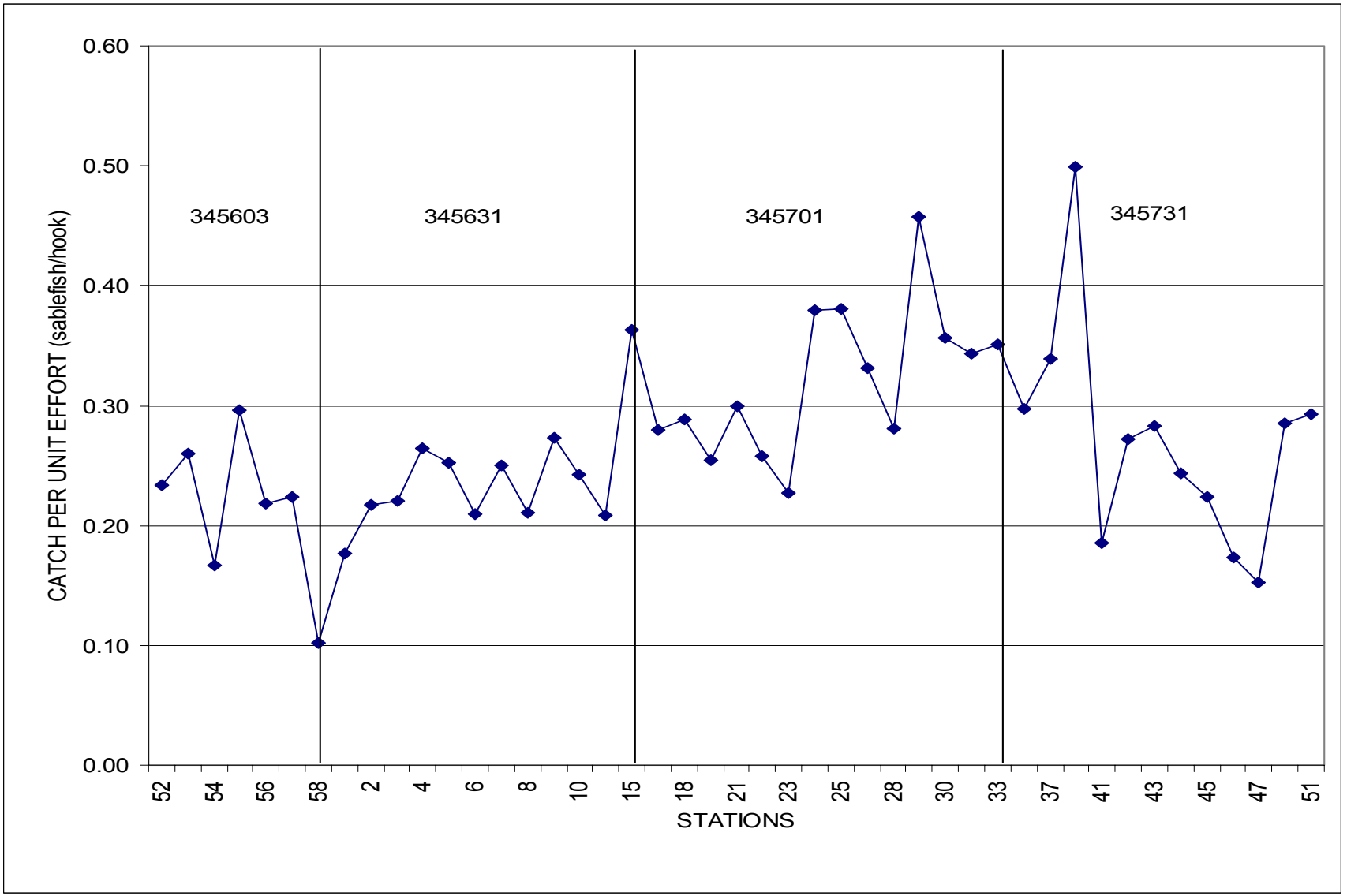


Figure 2. 1997 NSEI survey sablefish catch per unit effort (fish/ hook) for each station. Numbers represent statistical areas (see Figure 1).

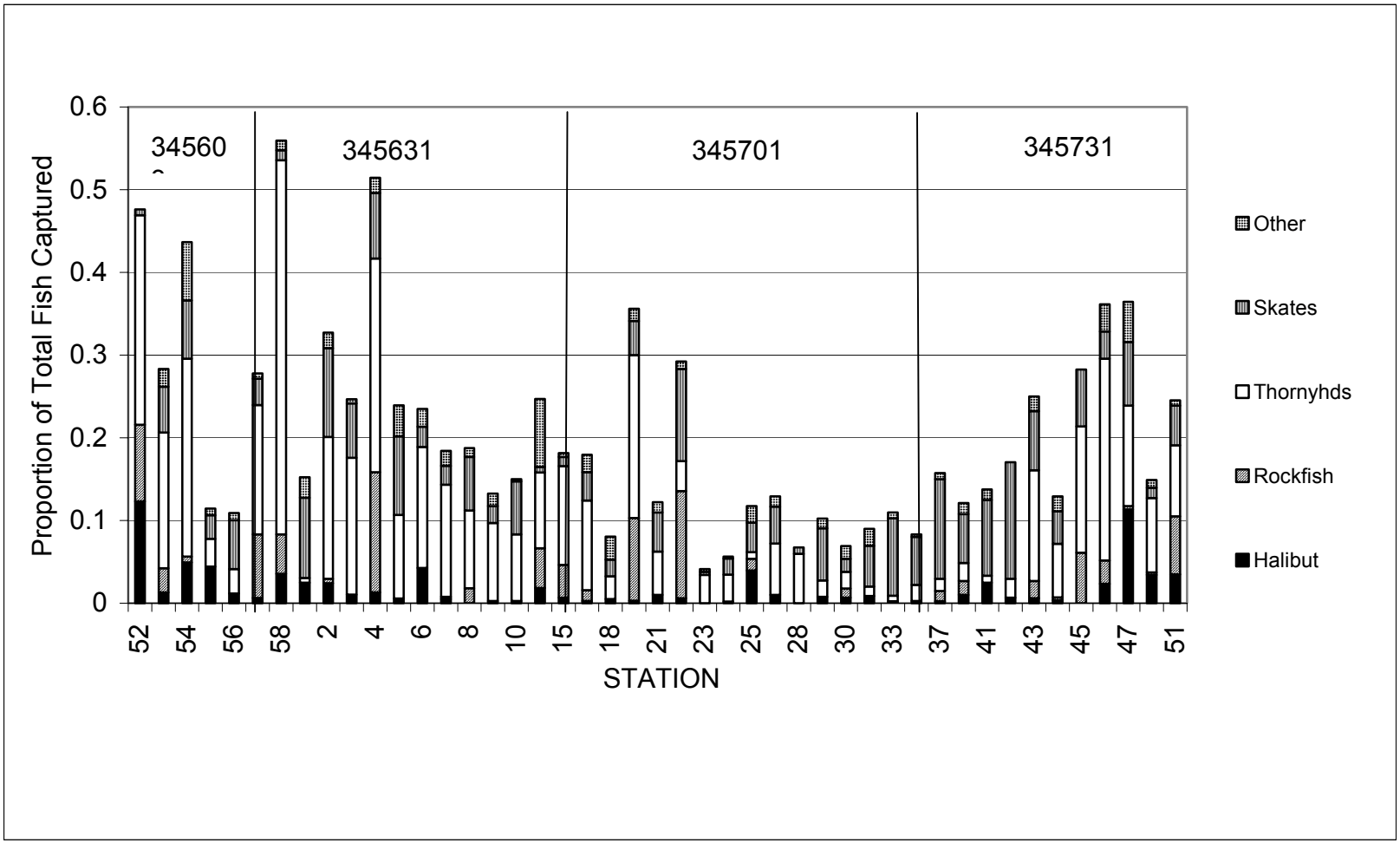


Figure 3. The proportion of total fish captured by bycatch species or group and station. The remaining proportion of fish is sablefish. For example, 52% of the fish caught at station 52 were sablefish and 48% other fish.

Appendix 1. Sablefish Maturity Codes

SABLEFISH MATURITY CODES			
MATURITY CODE	GONAD CONDITION	MALES (1) DESCRIPTION	FEMALES (2) DESCRIPTION
1	IMMATURE	Testes very narrow, parallel, flat and ribbon- like, almost clear in color. Longitudinal creases are easily discernable.	Ovaries appear as two narrow(slender) ovoids. May be vained.
			(It may be easiest to determine 2-1 from 2-2 while ovaries are intact in fish)
2	MATURING JUVENILE	Testes enlarging, not ribbon-like, with four discernable creases running full length. Light pink in color. Has not spawned before.	Ovaries enlarging, translucent and pinkish to clear: eggs not yet discernable. Has not spawned before. Will spawn coming year. More veined. Cloudy, but not necessarily throughout.
3	MATURE/ DEVELOPING	Testes large and white, each with four distinct lobes. No milt present.	Ovaries large and becoming white to yellowish white with developing eggs discernable and firmly attached.
4	SPAWNING	Testes very large and white, extruding milt freely under slight pressure or when cut.	Ovaries very large with large translucent eggs loose within ovary or extruding from he oviduct.
5	SPENT/ POST SPAWNING	Testes large, shriveled, often with wrinkles, and bloodshot. No milt present.	Ovaries shriveled and opaque, soft and flaccid, often reddish in color.
6	RESTING	Testes large and firm, light brown to off-white in color. No milt present. Has spawned previously. May have wrinkles.	Ovaries large, firm and opaque, not shriveled. No eggs discernable. Has Spawned previously. Noticeable folical structure
(Revised 1982, 1987, 1994, and 1997. Maturity code 6 (resting) added April 1994)			

Appendix 2. Chatham Strait Sablefish Mark-Recapture Study, Project Operational Plan

PROJECT OPERATIONAL PLAN

SABLEFISH MARK-RECAPTURE POPULATION ESTIMATION

by

Dave Carlile
Meg Cartwright

Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
Southeast Region
Juneau, Alaska

“And those who say, ‘I’ll try anything once,’ often try nothing twice, three times; arriving late at the gate of dreams worth dying for.”
- Carl Sandburg

INTRODUCTION

OBJECTIVE

To estimate the abundance, in numbers and/or biomass, of Chatham Strait sablefish in the Summer-Fall of 1997.

SAMPLING METHODS

Chatham Strait sablefish will be caught using longline gear, marked and released alive near their capture sites. Marked fish will be recovered from the commercial fishery during the September-October, 1997 Chatham Strait fishery. Several candidate population estimators based on single mark-recapture data will be evaluated to yield an estimate of Chatham Strait sablefish abundance, in numbers and/or biomass.

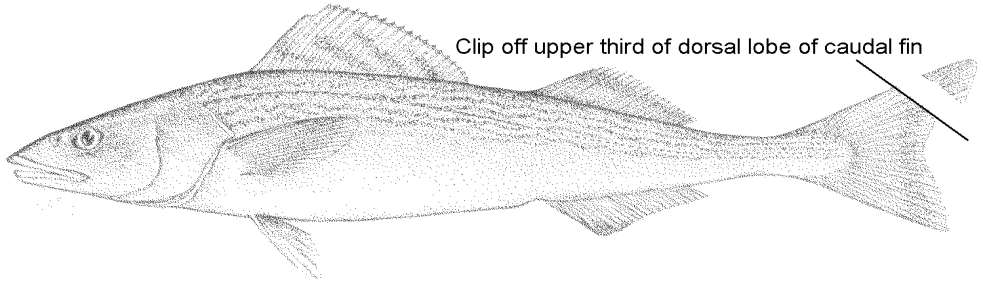
Candidate Marking Methods: Preliminary Evaluation

We conducted a pilot study to evaluate three different marking techniques during the May 1997 Clarence Strait sablefish longline survey including caudal fin clipping, freeze branding and PIT tagging. Fifteen sablefish were caught on longline gear, marked with one or more of the aforementioned marks and held on deck in a fish tote with circulating sea water for three days. Based on this pilot study we determined that clipping the caudal fin would be the most efficient method for marking sablefish for later "recovery" by port samplers. We determined that freeze branding would take too long for each fish, and the preferred site for branding, the flank, would necessitate turning over some of the fish in the processing plant to check for brands. Although we were readily able to detect PIT tags injected intramuscularly near the caudal peduncle of three test sablefish when the fish was held away from metal, in the presence of even non-ferrous metal like aluminum, the PIT tag signal was attenuated and the PIT tags were not detected by a hand-held detector. Since essentially all of the processing lines in the processing plants are constructed of aluminum and/or stainless steel, PIT tags do not seem an effective candidate for marking and detecting large numbers of fish, without modifying a portion of the processing line. In contrast, clipping the upper third of the upper lobe of the caudal fin was very quick, did not seem to impede the swimming ability or other behavior of clipped fish in a holding tank, seemed to heal sufficiently, and could be readily discerned in a fish processing line without having to turn the fish over. In addition, it is highly unlikely that the clipped fin would regenerate sufficiently in the 3-4 week period between fin clipping and potential recovery in the fishery, to render the clip undetectable by port samplers. Clipping a different fin, such as a pectoral fin, does not seem as efficient, since again some of the fish would need to be turned over on the processing line to check for the clipped fin.

Marking

For each sablefish the upper third of the dorsal lobe of the caudal fin will be clipped (Fig. 1). In addition to caudal fin clipping, we will tag each fin-clipped fish with an external T-bar . sequentially-numbered tag. Based on a long history of tagging, these types of external tags are known to be an effective method for tagging sablefish (e.g. Heifetz and Fujioka 1991).

Figure 1. Position of caudal fin clip for marking Chatham Strait sablefish in 1997.



The use of two marks on each fish (caudal fin clip and external tag) serves several purposes. The caudal fin clip will serve as the primary basis for the mark-recapture abundance estimate. This is the primary mark because of the very low likelihood of losing this mark and the apparent ease with which the mark can be identified by port samplers in processing plants. While the loss rate of external tags is low (e.g. Lenarz and Shaw, 1997) there is still some loss of this type of external tag. Although an estimator based on external tags can be corrected to account for tag loss, the use of a more permanent mark like a tail clip may obviate the need for any such correction and therefore theoretically should provide a more precise estimate of abundance. The main purpose of the external tag is to provide a backup abundance estimate if, for some unforeseen reason, the caudal fin clip is ineffective. In addition, by marking each fish with both a caudal fin clip and an external tag, we may be able to estimate the tag loss/non-reporting rate for external tags. This may be helpful for future mark-recapture estimates if we decide to rely solely on external tags. Also, external tagging, may provide an indication of movement among statistical areas (assuming we can adequately document catch locations from fishermen's logbooks). This movement data may supplement information from our sonic tagging study to indicate the likelihood of significant movement that may indicate violation of the assumption of closure during the four-week mark and recapture study.

Four thousand (i.e. $n_1 = 4{,}000$) sablefish will be double marked three weeks before the September 1, fishery opens. Marking should begin on or about August 7, and continue for 4-6 days. The approximate three week lead time is intended to allow mixing of fish prior to the fishery and allow tagged fish to recover from the trauma of marking. This will hopefully minimize any disparity in catch probability between marked and unmarked fish as a result of hook-happiness or hook-shyness of the marked fish.

Minimum 3-hour soaks will be used for each of up to four sets per boat per day will be made. Therefore it will probably be best to tag most or all of the fish from sets which have the shortest soak times. These presumably will be the earlier sets of the day for each boat. This should tend to increase the survival probability of the tagged fish, since they will have been on the longline gear for the shortest time and will tend to have lower incidence of sand flea infestation and other trauma associated with extended time hooked on the bottom. It will be imperative to minimize trauma to fish that will be marked to maximize their survival probability. Fish to be marked should not be gaffed to bring them aboard and hooks should be removed as gently as possible (e.g. no removal with crucifier). Any fish showing signs of excessive trauma such as amphipod (sand flea) injury, shark bites, gaff wounds, etc. should not be marked.

During initial catching, scientific crew will check each fish caught to determine whether it had been marked earlier during the marking phase.

The number of fish marked in each statistical area will be approximately in proportion to the 1996 catch of sablefish (Table 1). Depending upon the statistical area and the CPUE attained during early stages of the

1997 survey, the number of stations within a statistical area from which all sablefish may need to be marked will vary from one to nine (Table 1).

Table 1. Proposed apportionment of marked fish among NSEI Stat. Areas.

Statistical Area	% of 1996 sablefish caught in Stat. Area	Number of fish to mark in Stat. Area	% of fish to mark in Stat. Area	No. of complete sets to mark to achieve Stat. Area mark quota - **Assume CPUE = 0.2**	No. of complete sets to mark to achieve Stat. Area mark quota - **Assume CPUE = 0.12**
335701	0.4%	0	0%		
335702	0.3%	0	0%		
335732	0.1%	0	0%		
345534	0.1%	0	0%		
345603	**24.3%**	**1,048**	**26%**	5	8
345631	**30.0%**	**1,292**	**32%**	6	10
345701	**30.2%**	**1,300**	**33%**	6	10
345702	2.8%	0	0%		
345705	0.1%	0	0%		
345731	**8.3%**	**359**	**9%**	2	3
345801	0.1%	0	0%		
345803	3.2%	0	0%		
TOTAL	**100%**	**4,000**	**100%**	**19**	**31**

Assumes 7 additional stations (all in Stat Area 345603).

source: statmark.xls

Capture locations for fish to be marked have been chosen from among the randomly selected survey stations used for previous relative abundance indexing surveys (Fig. 2). Besides the stations surveyed in previous years, an additional 7 stations have been selected randomly in Statistical Area 345603 (Figure 2; Table 2). This statistical area has not been surveyed previously. These stations are being added for the mark-recapture study because 22% of the 1996 Chatham Strait catch was caught in this statistical area. To apply an abundance estimate to all of Chatham Strait, it will be most desirable to mark sablefish at locations throughout Chatham Strait.

Two or three scientific staff will be assigned aboard each of the three charter vessels. Two people will mark fish and the third person will record CPUE data for the survey (i.e. count hooks) and conduct biological sampling. Two people are needed to mark fish, one to hold the fish, the other to dip net, mark the fish and record tag numbers.

Table 2. Proposed supplemental Chatham sablefish sampling stations in Statistical Area 345603.

Proposed Station	Minutes of 134° W. Lon.	Minutes of 56° N. Lat.
52	27.5	14.5
53	29.3	26.1
54	36.2	15.1
55	30.4	5.2
56	36.1	25.4
57	24.6	16.1
58	34.9	6.8
Alternate 1	27.8	5.5
Alternate 2	35.0	18.3
Alternate 3	34.9	27.2

source: stamark.xls; 1997 Supplementary Stations

Recapture

Marked and unmarked fish will be captured in the September-October 1997 commercial sablefish fishery. Tallies of marked and unmarked fish and collection of external tags from fishermen and processing line workers will be done by port samplers. During port sampling we will examine a minimum of 138,000 (i.e. n_2 = 138,00) sablefish for marks. The mark and recapture sample sizes (n_1 = 4,000; n_2 = 138,000) are based on Robson and Regier's (1964) method of sample size determination. These sample sizes were chosen to promote an abundance estimate that is within +/- 20% of the mean, 90% of the time, assuming a preliminary estimate of abundance of eight million sablefish. The preliminary 8 million estimate of population size was generated from an age-structured model incorporating sablefish data from the Gulf of Alaska and Chatham Strait (M. Sigler, personal communication). To the extent that counts of fish checked for marks exceed 138,000 during the 7-10 day port sampling period, the precision of the abundance estimate will improve (Fig. 3). Figure 3 depicts 80% of the estimated number of sablefish landed at the ports in 1996. Only 80% of the estimate is accounted for because we will probably have insufficient port sampling to be able check every Chatham Strait sablefish that is landed at the plants in these ports. In Petersburg, a maximum of two plants will be sampled, but all processing lines will not be sampled, 100% of the time. Samplers will need breaks during the day, during which time mark checking may cease.

The 7-10 day port sampling period was chosen to promote attaining the minimum 138,000 fish checked for marks. In 1996 this number of fish was processed during the first two days of the fishery in two ports alone, Sitka and Petersburg (Fig. 4). Since the minimum port sample size can probably be attained at these two ports, they will likely be the only ports sampled.

Plants to be monitored in Sitka include Sitka Sound Seafoods (SSS) and Seafood Producers Cooperative (SPC). In Petersburg, we will monitor the (PFI) and perhaps Norquest plants. Depending on how the processing line is configured, as many as four (**??**) people may be required at some plants.

Assuming catch rates and ports of landing in 1997 are similar to 1996, the minimum 138,000 fish checked may be achieved within the first 4 – 6 days of the fishery. The additional 3 – 4 days planned for port sampling is designed to provide data from more days of landing, which will permit testing the assumption of equal catch probability (see "Abundance Estimation" section below).

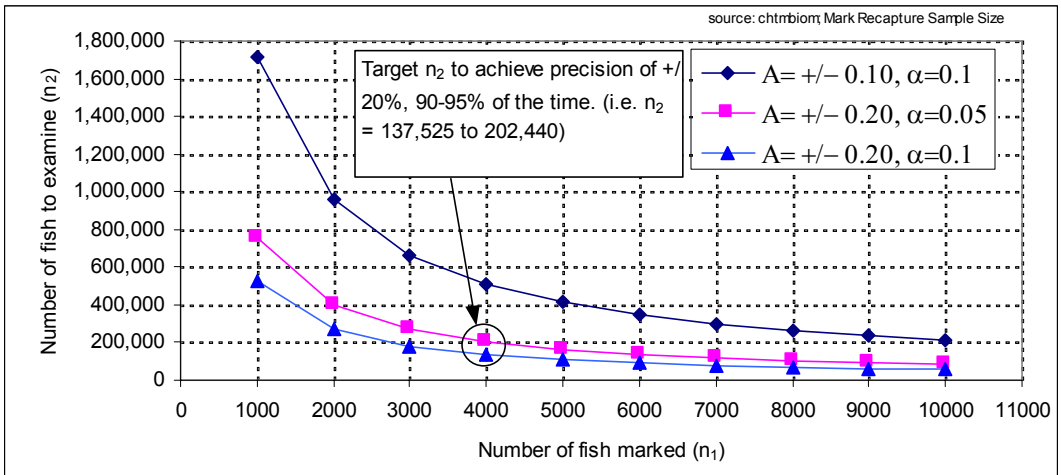


Figure 3. Estimated number of sablefish to check for marks to achieve specific levels of precision in abundance estimates.

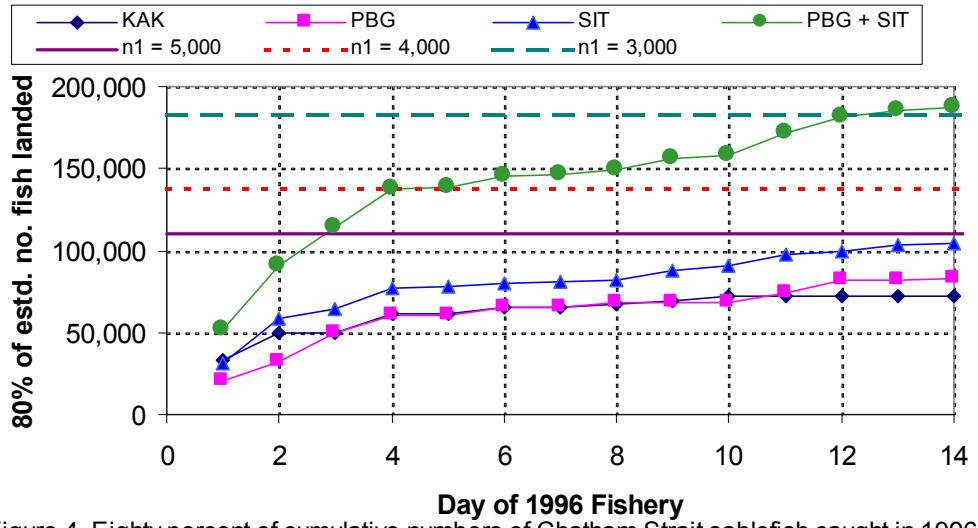


Figure 4. Eighty percent of cumulative numbers of Chatham Strait sablefish caught in 1996, by ports.

Daily counts of marked and unmarked fish recovered in the processing plants will be recorded. This daily accounting of marked and unmarked fish will serve multiple purposes. Recording marked and unmarked fish on a daily basis will provide multiple estimates of capture marked:unmarked ratios and allow a test of the critical assumption of equal capture probabilities (Skalski and Robson 1992). It may also allow us to use the alternative method of Paloheimo (Seber 1983; pp. 125 & bottom of page 565) to estimate abundance. If a test of equal capture probabilities indicates that the capture probability remains constant over time, a mark-removal estimator may be used as an alternative method of estimating absolute abundance (Table 3). This alternative estimator may provide an estimate with smaller sampling variance (Skalski and Robson 1982). Collecting data over the 7-10 day time period will also allow us to determine if the marked:unmarked ratio changes over time; a possible indication of initial hook-shyness or –happiness of marked sablefish earlier in the recapture phase.

Samplers will be positioned at a point in each plant to allow them to tally all sablefish that pass in the processing line and to check each tallied fish for caudal fin clips, without interrupting normal processing activities. Tallying all fish can be accomplished with the use of a hand counters (e.g. one click for each 10 fish counted). It may be necessary for port samplers to sample for up to 10 hours per day. Groundfish staff toured the major processing plants in Sitka and Petersburg to determine the optimum location for port samplers to tally fish and check for marks. At Sitka Sound Seafoods (SSS), the best place for the samplers will probably be at the outlet of the hoppers where fish are first dumped for initial grading after being removed from the holds of the vessels. The conveyor belts at this point move slowly enough that the SSS samplers should have the opportunity to count and tally each fish unloaded. At the Seafood Producers Cooperative (SPC) in Sitka, the best place in the processing line to tally and check for marked fish will be the conveyor belt, where headed fish move along in individual metal troughs. This would be a convenient spot to tally the fish and look for caudal fin clips. Based on preliminary information (Bev Richardson) about PFI and Norquest in Petersburg, the best places at these plants to tally and check for marks will be at the scales where individual fish are weighed for size grading.

In addition to port samplers checking fish for marks, external tags will be collected from vessel crews and processing line workers in the plants. It will be necessary to positively associate each tag with a vessel and the weight of the landing from that vessel, in case we need to rely on the external tags as the basis for the

abundance estimate, this is necessary because the value for n_2 would be the total weight of all fish checked for marks. Similarly, the estimate of abundance, $\hat{N}$, would be expressed in weight.

Abundance Estimation

Three abundance estimators are candidates for use in estimating abundance of Chatham Strait sablefish (Table 3). These estimators are appropriate for estimating abundance based on data from a single marking period followed by one or more subsequent recapture periods. The cost-effectiveness of marking sablefish only once and relying on the commercial fishery for recaptures of marked fish, precludes use of alternative estimators that rely on repeated marking periods wherein some marked animals may be captured and released more than once (e.g. see Pollock 1991).

If n_2 is based on external tags returned by vessel crew, the only variance estimator for abundance will be an empirical variance estimate based on the variance of several, individual abundance estimates applicable to groups of recoveries. For example, several, separate estimates of abundance may be generated for individual 2- or 3-day periods, using only the returned tags and landing weights for the 2- to 3-day periods. The variance among the individual abundance estimates would then be used as an estimate of variance for the overall abundance estimate. Similarly, the final abundance estimate would be the mean of the individual multi-day abundance estimates.

Skalski and Robson (1982) contrast the Lincoln-Petersen Index and the mark-removal method as candidate estimators to be used with single mark, multiple recapture data. They further emphasize the desirability of having more than one potential model to apply to mark-recapture data suggesting "It is…advantageous to conduct census procedures that yield capture data that conform to a number of models. The more diverse the estimators, the more likely that at least 1 may be valid (Skalski and Robson 1982)."

As indicated in Table 3, the candidate estimators have several assumptions in common. The assumptions the estimators have in common are listed below, along with discussion of the degree to which these assumptions may be met and/or methods for testing the assumptions.

Closed population – This assumption implies that the population does not increase or decrease between the marking and the recapture periods. That is, there are no additions to the population by recruitment or immigration, or losses from the population from emigration or mortality. This assumption will undoubtedly be violated. We will strive to minimize the effects of violating this assumption by limiting the time between the mark and recapture periods to a maximum of one month. Hopefully during this short time (relative to a full annual cycle), the changes in the population will be sufficiently small, relative to the size of the population, so as to minimize bias in the population estimate. A study conducted in Chatham Strait in the summer of 1996 suggests that the movement of significant numbers of sablefish out of Chatham Strait at the time of year the mark-recapture study will be conducted will probably be low. During a three-week period, the median distance moved by 19 sonic-tagged sablefish from their points of release was 4.4 km. This seems to be a small range relative to the over 230 km length of Chatham Strait (Fig. 2). Further reducing the opportunity for substantial, short-term emigration or immigration is the fact that Chatham Strait is a relatively confined body of water (e.g. compared to the Gulf of Alaska) which reduces the number of likely avenues for ingress and egress of sablefish. The main avenues of potential migration are the southern mouth of Chatham Strait and probably to lesser degree Icy Strait, Frederick Sound and the northern end of Chatham Strait. The fact that the mark-recapture study area will encompass the majority of Chatham Strait may further reduce the probable movement of significant numbers of sablefish from or into the study area.

Some limited violation of the closure assumption can occur without biasing the abundance estimates. Specifically, if only mortality occurs and the mortality rate is equal for marked and unmarked sablefish, then $\hat{N}$ (Table 3) estimates population abundance at the time of the marking sample. If recruitment only occurs, $\hat{N}$ estimates the population at the time of the recapture sample (Seber 1982, Skalski and Robson 1992). In practice, there is certain to be some mortality. Less clear is the magnitude of recruitment that may occur, if any, over the short span of this study. It may be possible to test for recruitment into the longline exploitable population by measuring lengths of sablefish during the marking and recapture periods. Sablefish will be sampled for lengths as part of the regular, annual relative abundance survey. However it does not seem sufficiently likely that any significant recruitment would occur during the one month of the study to justify the added effort of measuring lengths of sablefish during port sampling.

Equal and independent capture probabilities – This assumption means that each sablefish that encounters the longline gear during both the marking and recapture periods has an equal chance of being caught, whether they are marked or not. This assumption can be tested for the recapture period, using the daily counts of marked and unmarked sablefish accrued throughout the 7-10 day recovery period. The test is a chi-square test and is described by Skalski and Robson (1979 and 1982). As indicated previously the three week delay between marking and the fishery is intended to allow marked fish to recover from the marking process and minimize possible disparity in catch probability between marked and unmarked fish resulting from "hook-happiness" or "hook-shyness" of the marked fish. This assumption implies also that there is no marking-induced mortality or behavior modification that would compromise the equal catchability assumption. Observation of fin clipped fish kept in a live tank for three days during the 1997 Clarence Strait sablefish survey indicated no obvious ill-effects or aberrant swimming behavior of caudal fin-clipped sablefish.

No loss or non-reporting of marks – Loss or non-reporting of marks not accounted for in the estimation process will result in an upward bias in the abundance estimate. The caudal fin clip was chosen as the primary mark because of the extremely low probability of loss of this mark and the seemingly low likelihood of port samplers missing the mark in the processing lines. The caudal fin clip should be readily visible to port samplers regardless of how the fish is oriented in the processing line (e.g. laying on its left or right side). An informal check of one landing of sablefish at a Sitka processor and aboard a survey vessel in Clarence Strait (personal observation, D. Carlile) indicated an extremely low incidence (< 0.1%) of natural caudal fin injury that might be confused with the proposed caudal fin clip. In addition, it is highly unlikely that the clipped section of the caudal fin would re-grow sufficiently to render the mark unidentifiable in the maximum one months time elapsed between marking and recapture in the fishery.

Although the external tag (the secondary mark) may be lost or not reported by fishing crewmen or processing workers, a tag loss/non-reporting rate will be estimated based on comparison of numbers of caudal fin clips observed and tags turned in from individual landings (Seber 1982). This tag-loss rate may be used to correct the abundance estimates from the Lincoln-Petersen estimator based on weights of fish (i.e. $\boldsymbol{w_2}$ *;* see Table 1). If deemed desirable we may select catch from a subsample of boats from which to estimate the tag loss/non-reporting rate.

Random mixing of marked and unmarked animals - In addition to allowing marked sablefish to recover from the trauma of the marking operations, the three weeks between marking and the fishery is intended to allow time for marked and unmarked fish to mix. This may be the assumption most difficult to satisfy. Based on our movement studies, the median distance Chatham sablefish moved in three weeks was 4.4 km and the maximum distance from the release site was 8.8 km. Figure 2 shows the Chatham Strait study area with the potential distribution of marked fish over the study area. In this figure, the open circles are centered over the survey stations from which fish will be marked and have a radius equal to the median distance sonic-tagged sablefish moved from release sites during a 3-week period in the summer of 1996.

This figure is included to depict the potential for marked fish to distribute themselves over the study areas, and therefore presumably mix with unmarked sablefish, given the estimated median distance moved. Although much of the Chatham Strait area is covered by these ranges, there are gaps in the proposed coverage. To the extent that the catch in the fishery does not overlap the ranges depicted, the abundance estimate could be biased upward.

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SCHEDULES

Dates (1997)	Personnel	Activity
August 4-8	M. Cartwright T. O'Connell	Conduct annual survey and mark sablefish
	B. Richardson D. Carlile	
	Marc Prichett	
September 2-12	M. Cartwright T. O'Connell C. Brylinsky B. Richardson D. Holum D. Carlile Additional technicians	Port sample for marked sablefish

REPORTS

Dates	Author	Report
January 1998	M. Cartwright, D. Carlile T. O'Connell	Preliminary Results Report

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