Fishery Management Report No. 15-22

Southern Southeast Inside Commercial Sablefish Fishery and Survey Activities in Southeast Alaska, 2014

by

Jennifer Stahl,

Kristen Green,

Aaron Baldwin,

and

Kamala Carroll

May 2015

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY MANAGEMENT REPORT NO. 15-22

SOUTHERN SOUTHEAST INSIDE COMMERCIAL SABLEFISH FISHERY AND SURVEY ACTIVITIES IN SOUTHEAST ALASKA, 2014

by
Jennifer Stahl and Aaron Baldwin
Alaska Department of Fish and Game Division of Commercial Fisheries, Douglas
and
Kristen Green and Kamala Carroll
Alaska Department of Fish and Game Division of Commercial Fisheries, Sitka

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

May 2015

The Fishery Management Reports series was established in 1989 by the Division of Sport Fish for the publication of an overview of management activities and goals in a specific geographic area, and became a joint divisional series in 2004 with the Division of Commercial Fisheries. Fishery Management Reports are intended for fishery and other technical professionals, as well as lay persons. Fishery Management Reports are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone regional peer review.

Jennifer Stahl and Aaron Baldwin
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 3rd Street, Douglas, Alaska 99824, USA

and

Kristen Green and Kamala Carroll
Alaska Department of Fish and Game, Division of Commercial Fisheries,
304 Lake Street, Room 103, Sitka, Alaska 99835, USA

This document should be cited as:
Stahl, J., K. Green, A. Baldwin, and K. Carroll. 2015. Southern Southeast Inside Commercial Sablefish Fishery and Survey Activities, 2014. Alaska Department of Fish and Game, Fishery Management Report No. 15-22, Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

This report describes the status of the 2014 Southern Southeast Inside Subdistrict (SSEI) sablefish (*Anoplopoma fimbria*) stock located in Southeast Alaska in Clarence Strait and Dixon Entrance. The Alaska Department of Fish and Game (ADF&G) manages sablefish pot and longline fisheries in the SSEI Subdistrict by using commercial fishery and survey catch per unit effort (CPUE) data, fishery and survey biological data (age, weight, length, and maturity), and stock status trends of sablefish populations in surrounding geographic areas. ADF&G establishes the SSEI annual harvest objective (AHO) based on these data. This report summarizes the collection and analysis of data sampled during the annual longline survey and pot and longline fisheries in SSEI. A decrease occurred from 2013 to 2014 in the longline survey CPUE indices for all size classes of sablefish (0.67 round lb per hook to 0.61 round lb per hook) and for fish ≥520 mm fork length (0.63 round lb per hook to 0.65 round lb per hook); in addition, a small decline occurred in the longline fishery CPUE from 2013 to 2014 (0.33 round lb per hook to 0.30 round lb per hook). Recruitment has been observed in recent years for the SSEI fisheries; some of these new recruits were expected to have matured by the 2014 fisheries. However, a large proportion of immature fish were still harvested in these fisheries. ADF&G maintained the 2014 AHO of 536,618 round lb for the 2015 SSEI fisheries based mainly on modest decreases in the survey and fishery CPUE and slight improvements in the proportion of immature fish harvested. Concern continues for this fishery with lack of recruitment and future declines in spawning biomass in the adjacent Gulf of Alaska fisheries.

Key words: Clarence Strait, Dixon Entrance, Southern Southeast Inside, SSEI, sablefish, black cod, *Anoplopoma fimbria*, longline, pot

INTRODUCTION

Sablefish, also known as "black cod," are a valuable commercial species with an ex-vessel value of $4.8 million in Southeast Alaska state-managed fisheries in 2014. The Alaska Department of Fish and Game (ADF&G) manages commercial fisheries in the inside waters in the Southern Southeast Inside Subdistrict (SSEI) (Figure 1) and Northern Southeast Inside (NSEI) Subdistricts. This report discusses the stock status of sablefish in the SSEI Subdistrict where both pot and longline fisheries are allowed by regulation.

SABLEFISH LIFE HISTORY

Sablefish are a member of the Anoplopomatidae family and are distributed in the western and eastern North Pacific Ocean, with adults occurring in deep waters up to 2,740 m and young sablefish occurring in shallower nearshore waters (Mecklenburg et al. 2002). Sablefish are highly migratory; however, tagging data suggest that there may be 2 stocks in the eastern North Pacific: a northern stock that occurs from the Bering Sea to British Columbia and a southern stock from Washington to Baja California (Kimura et al. 1997). Stable isotope studies on juvenile sablefish indicate that stocks may be further divided with 3 different spawning stocks from British Colombia to Oregon (Gao et al. 2004). Genetic and morphometric data suggest differentiation between the northern and southern populations, but genetics do not indicate 2 discrete stocks in the eastern North Pacific (Tripp-Valdez et al. 2012).

Sablefish are long-lived, with a maximum reported age of 97 years for fish caught in Alaska waters (D. Anderl, National Marine Fishery Service (NOAA Fisheries); personal communication); however, few fish are caught in the Southeast Alaska commercial fisheries that are greater than 20 years of age (Mueter 2010). In the Gulf of Alaska, 50% of male sablefish are mature at approximately 57 cm fork length (FL) (5 year olds) while 50% of females are mature at 65 cm FL (6.5 year olds) (Sasaki 1985; Hanselman et al. 2013).

Sablefish spawn at depth in pelagic waters near the edge of the continental slope (Mason et al. 1983). Larvae ascend toward the surface with development (Sigler et al. 2001b). Juveniles

exhibit rapid growth (Sigler et al. 2001b) and reside in bays and nearshore waters for just over two years until they move offshore (Sigler et al. 2001a).

Both adult (Yang and Nelson 2000) and juvenile (Coutré 2014) sablefish are opportunistic feeders that consume teleosts and invertebrates species and scavenge on fish carcasses; yearling sablefish primarily feed on euphausiids (Sigler et al. 2001b). The diet of sablefish >60 cm in length has a greater composition of fish compared to smaller sablefish, which have a diet with more cephalopods, euphausiids, and shrimp (Yang and Nelson 2000). Juvenile sablefish are eaten by coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) (Wing 1985). Adult sablefish have been observed in stomachs of sperm whales (*Physeter macrocephalus*) in California (Kawakami 1980) and are depredated from longline fishing gear by both killer (*Orcinus orca*) and sperm whales in the Gulf of Alaska (Hanselman et al. 2013).

HISTORY OF THE FISHERY

Sablefish have been harvested in the internal waters in Southeast Alaska since the early 1900s, primarily as incidental catch in the halibut fishery (Bracken 1983). Directed fishing for sablefish fluctuated considerably prior to the 1970s (Bracken 1983), with high levels of harvest during World War I and World War II (Holum and Coonradt 2005). Since the 1970s, there has been substantial sablefish harvest due to high market prices (Sayer and Holum 2008). In 1985, 43 permit holders participated in the longline and pot fisheries with the implementation of limited entry. However, on average, only 28 permit holders fished in SSEI in successive years (1985–1996) (Holum and Coonradt 2005). In 1997, the equal quota share (EQS) system was initiated with each eligible permit holder given an equal portion of the annual harvest objective (AHO); a total of 35 permits, 30 longline and 5 pot, were authorized to participate (Holum and Coonradt 2005). As of 2015, 20 permit holders are eligible to fish in the longline fishery and 3 in the pot fishery. Four of the longline fishery permit holders are considered interim use; these permits are under review in order to determine if the permit holder qualifies for permanent status in this fishery. Not all authorized permit holders participate in the fishery each year. Typically, 1 SSEI longline permit holder does not fish while another harvests less than 25% of his EQS each year.

The SSEI longline fishery distribution has shifted over time from Clarence Strait to Dixon Entrance. Prior to the implementation of the EQS system in 1997, the short fishery opening restricted fishermen during unfavorable weather to Clarence Strait—an area in inside waters that is more sheltered than Dixon Entrance, which opens to the Gulf of Alaska. Since 2004, the fishery location has shifted further with an average of 43% of the harvest in Dixon Entrance (Figure 2).

Sablefish harvest in SSEI has been regulated since 1980 with guideline harvest ranges (approximately 198,000–794,000 round lb) based on historical catches (Bracken 1983). After the implementation of the EQS system in 1997, the AHOs were set annually based on SSEI fishery and survey catch per unit effort (CPUE), SSEI biological data, and sablefish stock status in other Alaska and Canadian waters (Table 1). The 1997 AHO of 790,000 round lb was lowered in 1998, with a 20% reduction to 632,000 round lb, but was raised the following year. The AHO was reduced again in 2000 and 2009. However, it remained above the historic low AHO set in 1998 until 2011 and was then lowered to 583,280 round lb. For the 2014 SSEI fisheries, the AHO was further reduced by 8% to 536,618 round lb, which was maintained for the 2015 AHO (Table 1).

Sablefish fisheries in Southeast Alaska are managed with seasonal openings to protect sablefish stocks during spawning periods. Sablefish fisheries were open year-round to fishing until the 1940s, when declines in CPUE and average weight prompted a December 1–March 15 closure to protect sablefish during the winter spawning season and to prevent incidental catch of halibut in early spring fisheries (Holum and Coonradt 2005). In addition, fishery openings were reduced to 7 days in the 1980s to prevent the guideline harvest limit (GHL) from being exceeded. The ability of the fishing fleet to harvest the GHL rapidly necessitated the implementation of a limited entry program. However, the GHL was still exceeded in some years (Figure 3), and the number of fishing days continued to decrease to as a few as 2 days in 1995 and 1996. In 1997, the EQS system was implemented and separate seasons were established for the longline (1.5 months) and pot fisheries (2.5 months). Prior to the establishment of separate seasons, conflicts occurred between the pot and longline fisheries, such as gear entanglement (Holum and Coonradt 2005). In 2000, the SSEI longline fishery was extended to the same length of the pot fishery. In 2015, the longline fishery will be opened from June 1 to August 15 and the pot fishery from September 1 to November 15.

SSEI fishery data are currently collected through a mandatory logbook program and fish tickets from each landing. In addition, permit holders are required to register prior to fishing in SSEI. Fishery data were initially collected through voluntary logbooks and skipper interviews. Logbooks became mandatory in 1997 and must include the following information by set: date, gear (type, hook spacing, number of hooks), location (start and end latitude and longitude), depth, and estimated weight for target and incidental catch (5 AAC 28.175). Permit holders must retain dead or visibly injured sablefish; sablefish that are not dead or injured may be released but must be recorded on a logbook (5 AAC 28.170). In addition, fishermen must record, by set, the tag number of any tagged sablefish that are landed (5 AAC 28.175). The State of Alaska requires a copy of each logbook to be returned with the fish ticket for each landing. Fish tickets are created by processing plant staff who are required to enter data into the State eLandings database. Fishermen are allowed to harvest a 5% overage, which is removed from their EQS in the following year; proceeds from overages that exceed 5% will be forfeited to the State of Alaska (5 AAC 28.170).

Rockfish (*Sebastes* and *Sebastolobus* spp.) are caught incidentally in the SSEI fisheries. Alaska administrative code (5 AAC 28.171) has required full retention and reporting for rockfish (*Sebastes* spp. only) caught in internal state waters since 2000 and since 2003 has limited catch of slope (*Sebastes* spp.) and thornyhead (*Sebastolobus* spp.) rockfish to incidental catch only. Proceeds from rockfish in excess of bycatch limits are forfeited to the State of Alaska; no profit can be obtained from rockfish harvested in the pot fishery (5 AAC 28.130).

HISTORY OF THE LONGLINE SURVEY

The ADF&G conducts annual longline surveys in the SSEI Subdistrict, which includes the waters of Clarence Strait and Dixon Entrance, to assess sablefish stock status. Annual surveys have been conducted since 1988 with the exception of 2005 due to budgetary constraints. In 2000, gear (hook spacing), bait (type and size), and soak time were standardized to specifications used on the federal longline survey to facilitate comparisons between federal and state waters. The hook spacing was 1.6–1.8 m from 1997 to 1999; in 2000 spacing was standardized to 2 m.

The SSEI survey was originally conducted in Clarence Strait in 3 statistical areas (325531, 315502, and 315432) and designed as a random stratified survey with each statistical area

considered a separate stratum. Survey stations were first added in Dixon Entrance in 1996; however, it is unclear what stratification design was intended for this area. In 2013, the SSEI survey was redesigned to reflect shifts in the commercial fishery harvest from Clarence Strait to Dixon Entrance (Figure 2) (Stahl et al. 2014). This change in the fishery distribution over time resulted in less overlap with the SSEI survey station distribution because few survey stations were located in Dixon Entrance (Figure 4). For the redesign, survey stations were proportionally allocated in relationship to the area of sablefish habitat by strata (Table 2), with statistical areas included in the design that had 3% or more of the commercial fishery harvest on average from 2003 to 2012. As a result, the northern Clarence Strait statistical area of 325533 was added as a new stratum, and the small eastern Dixon entrance statistical area 315401 was removed. The overall number of survey stations was decreased from 37 to 29 stations to maintain both the proportional allocation scheme by strata and to accommodate the additional time needed to survey the more exposed Dixon Entrance area (Figure 5). The intent of this survey redesign was to improve the spatial coverage of the survey relative to the fishery and to increase the minimum distance between stations (stations close together may not be independent if sablefish are attracted to bait at more than one station) while not significantly increasing the number of sablefish harvested in the survey.

BIOLOGICAL DATA

Biological data have been collected from sablefish in SSEI management area since the annual longline survey began in 1988. Sablefish samples have been collected from the SSEI commercial fisheries opportunistically since 1998 and on a regular basis in the longline fishery beginning in 2001 and the pot fishery in 2007. Sablefish are currently sampled for length, weight, sex, age, and maturity.

This report summarizes current stock status for the SSEI Subdistrict and includes biological, fishery, and survey data for 2014. The 2013 SSEI fishery and survey activities are summarized in Stahl et al. (2014).

METHODS

LONGLINE SURVEY

Survey Operations

The 2014 longline survey was conducted from the chartered commercial longline vessels F/V *Providence* and F/V *Viking Maid* from May 3 to 12, 2014 and was scheduled to correspond with the timing of previous surveys and favorable tides. The chartered vessels fished concurrently: the F/V *Viking Maid* fished 15 stations in the northern and middle of Clarence Strait and eastern Dixon entrance, while the F/V *Providence* fished 14 stations in southern Clarence Strait and western Dixon entrance.

A longline set was performed at each station surveyed in SSEI in 2014. Sets were performed in the same direction as the tidal current; however, haul direction depended on the tide, wind direction, and currents. Sets were soaked for 3–11 hours and consisted of 25 skates each with 45 #13/0 Mustad circle hooks with 2 m hook spacing. Hooks were attached to gangions that were secured to beckets tied to the groundline and were placed 38 cm from the groundline (the length of the gangion plus becket). At the end of each set was 150 fm (274 m) of running line with a 60 lb longline anchor, buoys, and a “high flyer” attached, and at the end of each skate was 5 m of

bare groundline with a 3 kg lead ball attached. Gear consisted of gangions composed of medium lay #60 nylon round braided twine, beckets of medium lay #72 nylon becket twine, and groundline of medium lay 1 cm nylon American Line SSR 100. Each year, all new hooks are attached to each skate prior to the survey. Bent, straightened, and missing hooks were replaced after each set, as the gear was baited. Squid (*Illex argentinus*) cut into 3.8–5.0 cm pieces were used as bait. Bait was thawed within 24 hours of use, and only the squid body was used (head and tentacles discarded).

Survey Design

The goal of the survey redesign in 2013 was to improve overlap in the distribution between the SSEI longline fishery and survey. The new design consists of 6 strata, 1 for each of the statistical areas in Clarence Strait (325533; 325531, 315502, 315432) and 2 for the Dixon entrance statistical areas, which includes 1 for western Dixon entrance (325401 and 325431) and 1 for eastern Dixon entrance (315431) (Figure 5). The number of stations for each stratum was proportionally allocated based on the area of sablefish habitat (Table 2). Stations were randomly located in each stratum within the delineated sablefish habitat while maintaining a minimum distance between random points of 5,400 m; this distance was set based on the average set length of 3,000 m and a bait odor of 1,200 m, which is the minimum distance sablefish can detect bait odor after one hour of soaking (Sigler 2000). Department staff worked with contracted fishermen during the 2013 survey to adjust sets prior to setting if there were problems with station locations (e.g., current direction, depth too shallow, or bottom feature that would make it difficult to set or retrieve gear). After the survey, department staff reviewed comments by contracted fishermen regarding station locations and noted 5 survey stations set in 2013 that were not in sablefish habitat or too close to underwater cables; as a result, these stations were replaced in 2014 with nearby survey stations that were fished prior to 2013. After the 2014 survey, comments were again reviewed; 1 additional survey station was noted as not located in sablefish habitat and will be moved for the 2015 SSEI survey.

The area of sablefish habitat was estimated for each stratum using bathymetry data and/or commercial fishery logbook data. Point bathymetry data were interpolated to a continuous surface and depths greater than or equal to 200 fm were selected as sablefish habitat for Clarence Strait in locations where bathymetry data were available; 200 fm is typically the minimum depth associated with sablefish catches in Chatham and Clarence Strait. For Dixon Entrance, bathymetry point data were unavailable and examination of fishery logbook data indicated sablefish in this area were caught in depths shallower than 200 fm. As a result, we delineated sablefish habitat in Dixon Entrance based on the presence of SSEI commercial fishery longline sets from 2003 to 2013.

Survey Data Collection

Set information was collected at each station and included date and time of set and haul, start and end latitude and longitude, deployment depth of each anchor and skate, haul back direction, wind direction and speed, and bottom substrate (Appendix A and B). Substrate was evaluated based on the skipper's interpretation of sounder information and whether any of the substrate was attached to fishing gear (i.e., mud on the anchors). Problems with gear or other factors potentially impacting CPUE (i.e., presence of sharks and whales) were recorded.

For each set, an observer performed accounting of all hooks; fish species were enumerated and hooks without fish were recorded as "bare," "bait," or "invalid," which included hooks that were

bent, broken, missing, or associated with a snarl. Fish breaking the water surface attached to a hook were identified to the lowest possible taxonomic group and tallied. All species other than sablefish, rockfish, and Pacific cod were immediately released. *Sebastes* rockfish were retained because their closed swim bladder may result in mortality from barotrauma. Shortspine thornyhead rockfish (*Sebastolobus alascanus*) were released immediately after sampling if fish appeared healthy; their open swim bladder allows more resilience to undergo pressure changes that occur during fishing. Halibut were retained only if the survey vessel skipper had halibut individual fishing quota. Additional information was noted for captured sablefish as follows. If sablefish were not landed but broke the water surface attached to a hook they were recorded as "lost." Sablefish less than approximately 45 cm were recorded as "small" and immediately released unless the fish was selected as a random biological sample. Non-marketable sablefish were released with the discard reason reported as "flea," "shark," or "not marketable;" sablefish with evidence of hagfish (*Eptatretus deani*) or orca damage were reported under the "not-marketable" discard category. Hagfish damage was indicated by presence of slime and/or tissue damage, and orca predation was indicated by bite marks or lips only remaining on hooks.

BIOLOGICAL DATA (SURVEY AND FISHERY)

In 2014, sablefish biological samples were collected at-sea during the longline survey and from longline and pot fishery landings in Sitka and Ketchikan. Sablefish were sampled randomly throughout fishery landings and systematically on the survey (first sablefish of each set and every 10th sablefish thereafter from the first 23 skates of each set) for fork length (nearest cm), weight (nearest 0.1 kg), sex, maturity, and otoliths. No otoliths were sampled from the pot fishery because only 3 pot fishery permit holders resulted in a high sampling rate for each landing. On the survey, additional fork length samples were collected from every 11th sablefish from the first 23 skates of each set. Sablefish sex and maturity were assessed for both males and females from visual observation of the gonads based on a 6-stage macroscopic maturity key (Table 3). Otoliths were cleaned, hand-dried, and sent to the ADF&G Age Determination Unit in Juneau for aging using the break-and-burn technique (Williams and Bedford 1974). In 2013, weights collected at sea were measured using Marel motion compensation scales; however, if seas were too rough to obtain repeatable weights during a haul, fish were not weighed. After sampling, all sablefish were cleaned and dressed to industry standards by ADF&G staff.

On the SSEI longline survey, biological data were also collected from *Sebastes* and *Sebastolobus* rockfish species. *Sebastes* rockfish were sampled for fork length (nearest cm), weight (nearest 0.1 kg), and sex, which was determined by examination of the urogenital papillae. *Sebastolobus* spp. were measured for fork length only and released alive. All rockfish were identified to the species level.

CPUE (SURVEY AND FISHERY)

A random stratified estimator was used to calculate CPUE for the SSEI survey from 1997 to 2014, weighting each stratum based on the proportion of sablefish habitat. Survey data prior to 1997 were excluded since the survey methodology for soak time had not yet been standardized.

Fishery CPUE was not estimated using a random stratified estimator. ADF&G staff apportions fish ticket pounds to each statistical area using logbook catch by set. Fishery data prior to 1997 were excluded because information was collected through interviews at port; consequently, data accuracy would be reduced compared to logbook data that was recorded immediately after

fishing at sea. Longline fishery gear types were pooled for CPUE analysis because a multiple regression indicated there was no significant difference between conventional fixed and snap-on gears. Longline fishery sets with killer whale depredation, auto-baiter problems, bad snarls, and clotheslining were excluded.

For the survey CPUE analyses, only valid skates were included that contained <12 broken, bent, or snarled hooks in a 45-hook skate, and skates with considerable killer whale depredation were excluded. The SSEI longline survey CPUE was calculated for 2 different sets of data: all fish sampled in the survey and fish ≥ 520 mm. CPUE analyses were performed for the subset of fish ≥ 520 mm to compare with the CPUE for the SSEI longline fishery; few fish < 520 mm are landed in the commercial longline fishery. The CPUE in round lb per hook for an individual stratum was calculated by multiplying the fish per hook for a stratum by the average weight of all fish sampled within that stratum. The CPUE for each stratum was then weighted (multiplied) by the proportion of sablefish habitat in that stratum relative to the total sablefish habitat in statistical areas surveyed in SSEI (Table 2). The overall CPUE for each year was then calculated by summing the weighted CPUEs for all strata. The CPUE for fish ≥ 520 mm was calculated in the same way, with the additional step of multiplying CPUE in round lb per hook for each stratum by the proportion of fish ≥ 520 mm for that stratum prior to weighting.

Fishery and survey CPUE were standardized for hook counts in order to account for variable hook spacing because sablefish catch per hook increases with hook spacing (Sigler and Lunsford 2001). In order to directly compare SSEI fishery and survey CPUE, all hook spacing was standardized to 1 m using the following formula:

$$N_{std} = N_{unstd}\, C_{\infty}\, (1 - \exp(-kh)),$$

with N = the number of hooks and h = hook spacing (Skud and Hamley 1978). This equation suggests that there is an increase in catch per hook with an increase in hook spacing but at a rate that is less than proportional to hook spacing. NOAA Fisheries performed hook spacing experiments to develop the following parameters in order to apply this equation to the directed sablefish longline fishery: $C_{\infty} = 2.2$ and $k = 0.57$. These experiments indicate that sablefish catch per unit hook is close to its maximum at a spacing of 4 m (Sigler and Lunsford 2001).

RESULTS

SURVEY

In 2014, a total of 5,780 sablefish were captured on the SSEI longline survey; of these, 5,568 sablefish were retained and sold. Approximately 2% of sablefish were lost before landing, <1% were discarded because they were too small, and approximately 1% were discarded due to shark, hagfish, orca, or sand flea damage.

In addition to sablefish, a total of 3,992 fish and 14 other marine invertebrates were caught and noted during the 2014 survey. Halibut was the most abundant non-targeted species and comprised 36% of the incidental catch; skates (*Raja rhina* and *Bathyraja* spp.) comprised a substantial portion of the incidental catch with 19%. Shortspine thornyhead rockfish comprised 14%, black hagfish 8%, and spiny dogfish (*Squalus suckleyi*) 7% of the incidental catch. Other species comprised ≤4% of the incidental catch and included, in descending order of catch (in numbers), Pacific cod (*Gadus macrocephalus*), arrowtooth flounder (*Atheresthes stomias*), spotted ratfish (*Hydrolagus colliei*), rougheye rockfish (*Sebastes aleutianus*), Dover sole

(*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), redbanded rockfish (*Sebastes babcocki*), walleye pollock (*Gadus chalcogrammus*), lingcod (*Ophiodon elongatus*), and yellowtail rockfish (*Sebastes flavidus*). The proportion of each fish species captured on the longline survey as incidental catch was consistent over time (2000–2014) for the majority of the species caught, with the exception of an increasing trend in the proportion of hagfish captured from 2000 to 2006, an increasing trend in the proportion of halibut captured in the last 3 years, and a declining trend in the proportion of dogfish captured, with the lowest proportions caught in the last 2 years since the survey was redesigned (Figure 6).

Length data were collected for shortspine thornyhead rockfish. The average fork length was 39 cm for the 505 shortspine thornyhead rockfish sampled.

FISHERY

In 2014, 23 permit holders were authorized to fish in SSEI fisheries, 20 in the longline and 3 in the pot fishery. One longline fisherman did not fish his permit in 2014. All 3 pot permits were fished; however, all fishing was performed using the same vessel. A total of 6 pot and 40 longline landings occurred with logbooks and fish tickets collected for each landing.

The SSEI commercial fisheries harvested a total of 494,830 round lb in 2014; the longline fishery harvested 425,465 round lb, with an ex-vessel value of $1,460,213, and the pot fishery harvested 69,365 round lb, with an ex-value $230,494.

The longline commercial fishery was distributed throughout Clarence Strait and Dixon entrance in 2014, with 30% of the harvest occurring in Dixon Entrance and 41% in the lower 2 statistical areas in Clarence Strait (315432 and 315502) (Figure 2; Figure 7). The proportion of harvest in Dixon entrance declined 45% (55% to 30% of harvest). The pot fishery was prosecuted in the middle of Clarence Strait (315502) and in Behm Canal (315531), with 60% of the harvest occurring in the middle of Clarence Strait (315502).

BIOLOGICAL DATA (SURVEY AND FISHERY)

In 2014, biological data were collected from sablefish in SSEI during the longline survey, longline fishery, and pot fishery. Length, weight, sex, and maturity data were collected from 553 sablefish from the SSEI longline survey, 550 from the longline fishery, and 501 from the pot fishery. Additional length data were collected from 541 sablefish on the longline survey for a total of 1,094 length measurements. Otoliths were collected from 544 sablefish on the longline survey and 549 sablefish from the longline fishery; no otoliths were collected from the pot fishery.

In 2014, the average size of sablefish was highest for the longline fishery (64 cm, 2.9 kg) and similar for the pot fishery (61 cm, 2.4 kg) and longline survey (59 cm, 2.2 kg) (Table 4). The length distribution of sablefish varied by sex and between the longline survey and longline and pot fisheries. The female length distribution was shifted to the right, with larger females caught compared to males (Figure 8). Females had a larger average size in the SSEI survey and fisheries compared to males; the average size of males (62 cm, 2.6 kg) and females (66 cm, 3.1 kg) was greater in the longline fishery than the longline survey and pot fishery, which had similar average sizes of males (survey—58 cm, 2.0 kg; pot fishery—58 cm, 2.1 kg) and females (survey—60 cm, 2.3 kg; pot fishery—62 cm, 2.6 kg). A larger proportion of females compared to males were captured on the longline survey (51%) and in the longline (55%) and pot (67%) fisheries. The

average age of sablefish sampled in 2014 on the longline survey was 7.2 years and 9.1 years in the longline fishery (Table 5).

In 2014, no strong year classes appeared to recruit to the survey or fisheries. A below long-term average[1] proportion of small fish were sampled in the 2014 SSEI survey (<500 mm) and pot and longline fisheries (<570 mm) (Figures 9). In addition, no new large year classes were visible in the length or age histograms for the survey or fisheries as with the 2010 and 2012 survey length histograms (Figures 10–12).

The distribution of sablefish by size varies from year to year across the SSEI Subdistrict (Figure 13). In 2014, as in most years examined, the majority of sablefish sampled on the survey were from the size class of 520–610 mm; this size class composed the largest proportion of lengths throughout most of the survey area in both 2013 and 2014 (Figure 13). However, in 2010, larger proportions of small fish (<520 mm) were caught across southern Clarence Strait and Western Dixon entrance; in 2011 and 2012, larger proportions of small fish (<520 mm) were also sampled in southern Clarence Strait but at fewer stations (Figure 13). Larger proportions of big fish (≥620 mm) were sampled in 2010 in northern Clarence Strait and in 2011 in a more limited area in northern Clarence Strait and in western Dixon entrance (Figure 13).

Macroscopic maturity data indicate that the majority of sablefish harvested in the SSEI survey and fisheries are immature, which includes fish that were classified as "immature" and "maturing juvenile." In 2014, the SSEI survey and fisheries had ≥65% immature females and ≥63% immature males (Table 6; Figure 14). The majority of mature fish had ovaries classified in the inactive state of "spent" or "resting" during the longline survey (95% females; 86% males). During the longline fishery the majority of mature females were spent or resting (63%); however, the majority of mature males were "mature/developing" (76%). In the pot fishery the majority of mature males (92%) and females (82%) were both "mature/developing" (Figure 14). No spawning females were observed in the fisheries or survey, and only a few males (≤1%) were observed spawning on the survey and in the fisheries (Figure 14).

CPUE (SURVEY AND FISHERY)

For the 2014 longline survey, less than 3% of skates (20 skates) were considered invalid and were removed from CPUE analyses; this included skates that were removed due to ≥12 broken, bent, or snarled hooks and those with killer whale depredation (skates 17–25 from station 119). Orcas were first observed on May 4th at station 119 during the hauling of skate 17 and remained in the area through the rest of this set and the hauling of the following set at station 120. There was minimal evidence of depredation at both stations with only four sablefish at station 119 and three at station 120 with signs of predation (i.e., only sablefish lips remaining on the hook or bite marks). However, CPUE at station 119 was generally lower for skates after orcas were observed; consequently, skates 17–25 at station 119 were considered invalid and removed from the analysis. All skates at station 120 were left in the analysis because CPUE was generally consistent across the set and scientific survey crew observed minimal evidence to justify excluding any skates from this set.

[1] Long-term averages were calculated for the entire data set available. Length data were available for the following years: for the longline fishery from 2001 to 2014, for the pot fishery from 1998–1999 and 2006–2014, and for the longline fishery from 1997–2004 and 2006–2014.

On valid skates, most hooks that did not catch anything were bare (57%); only a small proportion of hooks were invalid (3%; bent, broken, missing, or associated with a snarl) or had bait remaining (9%). The proportion of hooks that were bare ranged from 18% to 90% by station.

Longline fishery CPUE remained stable in recent years, with the 2014 estimate just below the 5-year average (Table 7; Figure 16); however, the CPUE indices for 5 of the last 6 years have remained below the 10-year average (Table 7). The pot fishery CPUE has been variable since 1997. The 2014 pot fishery CPUE (round lb per pot) was similar to the 2013 estimate and is below the 5-year average and above the 10-year average (Table 7).

Longline survey CPUE has generally been variable since 1997 (survey data prior to 1997 are excluded since the methodology for gear soak time was not standardized) (Figure 17). A large decline in survey CPUE occurred from 2006 through 2010; CPUE appeared to stabilize from 2011 through 2012 but declined in 2013 (Figure 17). In 2014, CPUE continued to decline for all indices; CPUE measured in round pounds or fish per hook for all fish or fish ≥520 mm (Table 7; Figure 17). The 2014 SSEI longline survey CPUE (all fish and fish ≥520 mm) was below the 5- and 10-year averages (Table 7).

The decline in the 2014 fishery CPUE (round lb per hook) was driven by decreases in CPUE in both lower Clarence Strait (315432) and the adjacent area of eastern Dixon Entrance (315401/315431); in all other areas the fishery CPUE increased (Figure 16). The survey CPUE remained stable in most areas with some decline in the middle of Clarence Strait (315502) (Figure 18).

DISCUSSION

FISHERY

The decline in the longline fishery harvest in Dixon entrance may have been related to weather, timing of other non-sablefish fisheries, and increased fuel costs in 2014. Generally fishermen did not fish in Dixon entrance when wind was above 20 mph and the wave height greater than 6 ft.

BIOLOGICAL DATA

The average size and age of sablefish differs among the SSEI survey and pot and longline fisheries, with the older and larger fish captured in the longline fishery (Table 4; Table 5). Longline fishermen are likely discarding small fish or targeting fishing locations with larger sablefish. The smaller average age and size of fish captured in the pot fishery compared to the longline fishery may be due to differences in selectivity between gear types.

In SSEI, recruitment generally declined since the late 1990s until 2008, when a new year class was first observed in the 2010 SSEI longline survey; no strong year classes have appeared since (Figures 9–12). In 2012, a small recruitment pulse was observed in the survey data length histogram (Figure 10); however, the proportion of small fish <500 mm was only average in size (Figure 9). In 2014, a below average proportion of small fish were observed in the SSEI survey and fisheries (Figures 9). In 2010, the strong incoming year class was observed in the survey length histogram, with 34% of the survey samples composed of small fish <500 mm (Figure 9–10). The following year above average proportions of small fish (<570 mm) were observed in the pot and longline fisheries (Figures 9); these influxes of small fish may appear later in these fisheries due to discards of small fish by the commercial fleet. This strong recruitment was also observed in the NSEI Subdistrict (Stahl and Baldwin 2013) and the Gulf of Alaska federal trawl

survey (Hanselman et al. 2013). The SSEI survey is considered to be a good indicator of future recruitment strength to populations in other areas, specifically Chatham Strait (Bracken et al. 1997). Clarence Strait sablefish have higher migration rates than sablefish tagged in other areas of the eastern Gulf of Alaska (Hanselman et al. 2014a), indicating these fish may contribute to other sablefish stocks. These fish are recovered over a broad geographic area, including Chatham Strait, the continental slope in the Gulf of Alaska, the Aleutian Islands, and along west coast of Canada (Figure 19). However, no tagging has been performed in Dixon Entrance where migration patterns may differ from Clarence Strait as indicated by variation in size classes in some years (Figure 13).

Historically, a greater proportion of immature fish are typically harvested in the SSEI commercial pot and longline fisheries than in the NSEI or Gulf of Alaska commercial fisheries. In the last 10 years, an average of 47% females and 56% males were immature in the SSEI longline fishery and 75% females and 56% males in the pot fishery. However, in recent years historic highs in harvest of immature fish have occurred, with an increase in the proportion of immature females from 2008 to 2012 in the pot fishery and 2008 to 2013 in the longline fishery and peak harvests of immature males in 2011 in the pot fishery and 2013 in the longline fishery (Table 6; Figure 14). Differences in trends between males and females are expected; males generally mature at a younger age and size than females. Harvest of immature males and females remains high in 2014 (Table 6; Figure 14). The high proportion of immature fish harvested in recent years may be due to recent recruitment to these fisheries (Figures. 9–12). Alternatively, high proportions of immature fish may be harvested in some years in the SSEI commercial fisheries due to changes in fishing patterns that may result in fishing in areas with higher proportions of immature fish. For example, in some years larger more mature fish are found in upper Clarence Strait while smaller immature fish may be found in Dixon entrance or lower Clarence Strait (Figure 13).

Some misclassification is possible with macroscopic maturity staging, especially for samples collected further away from the spawning season; however, examination of the maturity classifications by date sampled in relationship to the progression of the spawning season indicates the majority of classifications of sablefish in SSEI are accurate. It is possible that small ovaries from mature inactive ("spent" or "resting") fish and those from immature ("immature and "maturing juvenile") fish may appear similar to inexperienced samplers. However, ovaries from fish that have not spawned before will be translucent compared to opaque ovaries for mature individuals; in addition, some follicle structure from spawned oocytes (eggs) may also be noticeable in mature inactive ovaries (Table 3). An indication that misclassification rates may not be high in SSEI is that sablefish preparation for spawning progresses as sampling occurs closer to the winter spawning season, with fewer fish staged as inactive during the pot fishery that occurs in the fall (Aug. 15–Nov. 15) compared to the longline survey that occurs in May (Figure 15). If high rates of misclassification were occurring with inactive fish staged as immature, then a decline in the proportion of inactive fish as sampling occurs closer to the spawning season might not be observed. In 2014, the proportion of fish staged as inactive decreased as the proportion of "mature/developing" (stage when gonads become large with developing eggs or sperm) fish increased: the majority (95% females; 86% males) of mature fish sampled on the longline survey were at inactive stages and few (18% females; 8% males) mature fish were at inactive stages in the pot fishery (Figure 15). During the summer longline fishery (June 1–August 15), which occurs between the longline survey and pot fishery season, the majority (63%) of mature females were still inactive, but the majority (76%) of mature males were

"mature/developing" (Figure 15). The change in the proportion of mature inactive females (63% to 18%) between the longline fishery and pot fishery was more dramatic than for male sablefish (23% to 8%), with female preparation for spawning lagging behind males (Figure 15).

CATCH PER UNIT EFFORT

The longline survey CPUE has generally been declining since 2006 (Figure 17), and even though fishery CPUE has been fairly stable in recent years, biomass may be declining if fishing is concentrated in preferred habitat where fish are at higher densities (e.g.., Northeast Arctic cod, *Gadus morhua,* stocks declined while CPUE remained stable when fish concentrated in warmer waters during a cooling period of the Barents Sea [Nakken 2008]). In addition, a gulf-wide lack of recruitment has occurred since 2000, and spawning stock biomass in the adjacent waters of the Gulf of Alaska (GOA) is projected to decline in the near future (Hanselman et al. 2014b).

Black hagfish predation on bait may be reducing sablefish CPUE for both the SSEI fishery and survey. The high proportion of bare hooks observed on the SSEI survey may indicate black hagfish predation is high in this area. When hagfish are captured, the bait is absent or nearly gone from the hook the hagfish was caught, an indication hagfish can eat quickly. Gear soak time seems insufficient for the complete consumption of bait by sand fleas; if sand fleas were responsible for the bare hooks, then they would likely be observed attached to gear or fish and sand flea bites would be present on fish. In addition, there was evidence of hagfish in the SSEI area in 2014 with 327 hagfish captured on the 2014 survey and hagfish slime observed on longline gear during hauling. Furthermore, 39 sablefish were captured on the survey with hagfish damage and were not marketable; in the commercial fishery hagfish-damaged fish would be discarded, reducing fishery CPUE. The average proportion of bare hooks observed at each station was much higher in SSEI (57%) than in NSEI (22%) where no hagfish were captured on the 2014 longline survey. It is unknown why hagfish have not been captured in NSEI, but it is possible that SSEI is around the northern edge of their range. Black hagfish have not been documented north of SSEI (Mecklenburg et al. 2002). Fishermen may avoid areas with the highest hagfish predation; however, hagfish distribution is likely widespread in SSEI with high proportions of bare hooks observed at survey stations across Clarence Strait (31%–90%) and Dixon entrance (18%–85%). Although hagfish use soft substrate to burrow (Fernholm 1974; Hixon and Tissot 2007) it is likely they travel away from this habitat to reach longline gear. It is unknown how far they can travel, but it is probable they can detect bait from far away due to their extremely developed sense of smell (Sutterlin 1975).

Even though the CPUE for the last two years has been stable for the SSEI pot fishery, CPUE has been generally variable over time. This fishery has had limited participation (three to five permit holders); consequently, CPUE may be highly influenced by individual performance and limited spatial coverage and may not reflect abundance trends in the stock. In 2013 and 2014, the same vessel was used to fish all pot fishery permits, which may have resulted in less variability in CPUE between these years. In addition, the pot fishery CPUE may have greater sensitivity to recruitment than the longline fishery, because younger and smaller fish are typically harvested in the pot fishery compared to the longline fishery (Table 4; Table 5). This is demonstrated by the high pot fishery CPUE in 2012 that occurred with the influx of small fish to the area.

Both the survey and longline fishery CPUE in western Dixon entrance (325431/325401) have been higher and more variable than other areas, especially for the survey CPUE (Figure 16; Figure 18). Some of the variability in CPUE for Dixon Entrance may be explained by the

increased movements of fish in this area, as evidenced by the large differences in size classes observed in the survey stations in this area between 2010 and 2014 (Figure 13). The differences in the size classes of sablefish among the years are greater than interannual growth alone could explain, and are likely due to high levels of migration of different size classes of fish in and out of Dixon Entrance. However, some of the variability in the survey CPUE prior to 2013 may have been due to the low number of survey stations that were allocated in this area (Figure 4). Fishery CPUE may have been more stable in western Dixon entrance due to the high proportion of commercial fishery harvest in this area (Figure 7; Figure 16). With the 2013 survey redesign, the number of stations in western Dixon Entrance was increased (three to seven stations) in order to reflect the fishery distribution and the area of sablefish habitat available in this region. The 2013 and 2014 SSEI survey CPUE remained higher in western Dixon entrance than other areas; however, less variability in CPUE occurred between these areas (Figure 18). After a few years of data collection we will be able to determine if the increased number of survey stations in this area will continue to reduce the variability of CPUE or if this variability is characteristic of sablefish captured in this region. In addition, CPUE may be higher in western Dixon entrance due to lower hagfish predation in this area; only 25% of hooks were bare, on average, in western Dixon entrance compared to 45% in eastern Dixon entrance and 72% in Clarence Strait.

MANAGEMENT

For the 2015 SSEI fisheries, the department maintained the 2014 AHO of 536,618 round lb, which was an 8% reduction from the 2013 AHO. The department believes additional time may be necessary at this lowered harvest level to allow the stock to improve. Maintaining the 2014 AHO was based primarily on modest decreases in the department longline survey and longline fishery CPUE in 2014 and the slight improvement in the harvest of immature sablefish in the longline fishery (73% to 65% females and 67% to 63% males; Figure 3; Figure 14). Although, the SSEI longline fishery CPUE declined in 2014 it remains fairly stable overall (Figure 3; Figure 16). However, the decrease in the SSEI survey CPUE in 2014 continues a declining trend since 2011 (Figure 3; Figure 17). In the adjacent Gulf of Alaska (GOA) waters, an increase occurred in the 2014 federal longline survey abundance indices; yet these improvements followed historic lows (Hanselman et al. 2014b) (Figure 3; Figure 17). Moreover, there is concern that the spawning biomass in the GOA is expected to continue to decline in the near future (Hanselman et al. 2014b). The 2008 year class appears to be only average in recruitment strength in the GOA (Hanselman et al. 2014). It is uncertain how this recent recruitment will contribute to the spawning stock biomass in SSEI. In 2014, high harvest of immature female sablefish (≥65%) occurred in the SSEI survey and commercial fisheries (Table 6; Figure 14). However, by 2013, the proportion of immature female sablefish sampled on the federal longline survey had decreased to 14% (from the 64% in 2011) when the incoming recruitment was first observed in the area (Cara Rodgeveller, NOAA Fisheries, personal communication). The large proportions of immature fish in SSEI may indicate that the incoming year classes are more prevalent in this area and will have a greater than average contribution to the spawning stock biomass in SSEI versus the GOA once fully mature. However, there is still concern that these immature fish are being harvested before they are allowed to contribute to the spawning stock.

ACKNOWLEDGEMENTS

Thanks to the crew of the F/V *Providence* and F/V *Viking Maid* for their hard work during the SSEI longline survey.

REFERENCES CITED

Bracken, B. 1983. The history of the U.S sablefish fishery in the Gulf of Alaska, 1902–1982. Alaska Sea Grant Report 83-8.

Bracken, B. E., D. A. Gordon, and D. Carlile. 1997. Sablefish, *Anoplopoma fimbria*, stock assessment in the inside waters of Southeast Alaska. NOAA Technical Report NMFS 130: 195–206.

Coutré, K. M. 2014. Feeding ecology and movement patterns of juvenile sablefish in coastal Southeast Alaska. Master's thesis. University of Alaska Fairbanks, Fairbanks, Alaska.

Gao, Y., S. H. Joner, R. A. Svec, and K. L. Weinberg. Stable isotopic comparison in otoliths of juvenile sablefish (*Anoplopoma fimbria*) from waters off the Washington and Oregon coast. Fisheries Research 68: 351–360.

Hanselman, D. H., C. Lunsford, and C. Rodgveller. 2013. Chapter 3: Assessment of the sablefish stock in Alaska. Pages 267–376 [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, Anchorage.

Hanselman, D. H., C. Lunsford, and C. Rodgveller. 2014b. Chapter 3: Assessment of the sablefish stock in Alaska. Pages 283–424 [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, Anchorage.

Hanselman, D. H., J. Heifetz, K. B. Echave, and S. C. Dressel. 2014a. Move it or lose it: Movement and mortality of sablefish tagged in Alaska. Canadian Journal of Fisheries and Aquatic Sciences 75(2): 238–251.

Holum, D. D. and E. E. Coonradt. 2005. The Southeast Alaska Southern Southeast Inside sablefish fishery information report with outlook to the 2005 fishery. Alaska Department of Fish and Game, Fishery Management Report No. 05-26, Anchorage.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. 32: 199–218.

Kimura, D. K., A. M. Shimada, and F. R. Shaw. 1997. Stock structure and movement of tagged sablefish, *Anoplopoma fimbria*, in offshore northeast Pacific waters and the effects of El Niño-Southern Oscillation on migration and growth. Fishery Bulletin 96: 462–481.

Mason, J. C., R. J. Beamish, and G. A. McFarlane. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (*Anoplopoma fimbria*) off the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 40: 2126–2134.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, Maryland.

Mueter, F. 2010. Evaluation of stock assessment and modeling options to assess sablefish population levels and status in the Northern Southeast Inside (NSEI) management area. Alaska Department of Fish and Game, Special Publication No. 10-01, Anchorage.

Nakken, O. 2008. Fluctuations of Northeast Arctic cod catches: a review of possible sources. Resiliency of Gadid Stocks to Fishing and Climate Change. Alaska Sea Grant College Program AK-SG-08-01, University of Alaska Fairbanks.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22: 1–108, Far Seas Fishery Laboratory. Shimizu, Japan.

Sayer, A., and D. Holum. 2008. The Southeast Alaska Southern Southeast inside sablefish fishery information report with outlook to the 2008 fishery. Alaska Department of Fish and Game, Fishery Management Report No. 08-44, Anchorage.

Skud, B. E., and J. M. Hamley. 1978. Factors affecting longline catch and effort: I. General review II. Hook-spacing III. Bait loss and competition. International Pacific Halibut Commission. Scientific Report No. 64.

Sigler, M. F. 2000. Abundance estimation and capture of sablefish (*Anoplopoma fimbria*) by longline gear. Canadian Journal of Fisheries and Aquatic Sciences 57: 1270–1283.

REFERENCES CITED (Continued)

Sigler, M. F., and C. R. Lunsford. 2001. Effects of individual quotas on catch efficiency and spawning potential in the Alaskan sablefish fishery. Canadian Journal of Fisheries and Aquatic Sciences 58:1300–1310.

Sigler, M. F., C. R. Lunsford, S. A. Lowe, and J. T. Fujioka. 2001a. Alaska sablefish assessment for 2002. In stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fisheries Management Council, Anchorage, AK.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S. Yang. 2001b. Young of the year sablefish abundance, growth, and diet in the Gulf of Alaska. Alaska Fishery Research Bulletin 8(1): 57–70.

Stahl, J., and A. Baldwin. 2013. 2012 NSEI (Northern Southeast Inside Subdistrict) sablefish mark-tag survey. Alaska Department of Fish and Game, Fishery Data Series No. 13-29, Anchorage, AK.

Stahl, J. P., K. Carroll, and K. Green. 2014. Southern Southeast Inside commercial fishery and survey activities in Southeast Alaska, 2013. Alaska Department of Fish and Game, Fishery Management Report No. 14-39, Anchorage.

Sutterlin, A. M. 1975. Chemical attraction of some marine fish in their natural habitat. Journal of the Fisheries Research of Board. 32(6): 729–738.

Tripp-Valdez, M. A., F. J. García-de-León, H. Espinosa-Pérez and G. Ruiz-Campos. 2012. Population structure of sablefish *Anoplopoma fimbria* using genetic variability and geometric morphometric analysis. Journal of Applied Ichthyology 28: 516–523.

Williams, T., and B. C. Bedford. 1974. The use of otoliths for age determination. In: The ageing of fish. Proceedings of an international symposium. Editors T. B. Bagenal. Unwin Brothers Limited, Surrey, England.

Wing, B. L. 1985. Salmon stomach contents from the Alaska troll logbook program 1977–1984. NOAA Technical Memorandum NMFS F/NWC-91.

Yang, M. S., and M. W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. NOAA Technical Memorandum NMFS-AFSC-112.

TABLES AND FIGURES

Table 1.–Annual harvest objective, equal quota share, and reported harvest (round lb), along with ex-vessel value and effort for the directed commercial SSEI sablefish fishery since the equal quota share was established in 1997.

				Longline Fishery			Pot Fishery		
Year	Annual harvest objective	Total Harvest	Equal share quota	Harvest	Ex-vessel value	No. of permits	Harvest	Ex-vessel value	No. of permits
1997	790,000	725,067	23,200	608,786	$1,345,423	30	116,281	$256,981	5
1998	632,000	578,056	20,400	496,210	$699,656	29	81,846	$113,765	4
1999	720,000[a]	661,424	24,000	565,190	$1,006,038	26	96,234	$193,430	4
2000	696,000	590,815	24,000	494,528	$989,056	25	96,287	$187,760	4
2001	696,000	650,678	24,000	554,490	$1,064,621	25	96,188	$184,679	4
2002	696,000	650,339	24,000	554,074	$1,074,904	25	96,265	$212,746	4
2003	696,000	656,936	24,860	557,102	$1,286,906	24	99,834	$219,635	4
2004	696,000	648,845	24,860	550,472	$871,689	24	98,373	$158,986	4
2005	696,000	639,719	24,860	539,251	$1,127,483	24	100,468	$223,957	4
2006	696,000	624,832	21,750	537,812	$1,224,134	28	87,020	$210,605	4
2007	696,000	620,168	21,750	533,130	$1,306,573	28	87,038	$207,780	4
2008	696,000	618,033	21,750	531,866	$1,598,097	28	86,167	$256,300	4
2009	634,000	595,748	22,650	525,534	$1,553,838	25	70,214	$210,766	3
2010	634,000	558,633	23,400	488,449	$1,790,478	24	70,184	$258,553	3
2011	583,280	540,931	23,300	472,070	$2,309,949	22	68,861	$333,128	3
2012	583,280	521,825	25,360	445,678	$1,564,129	20	76,147	$198,906	3
2013	583,280	505,599	25,360	429,259	$1,117,189	20	76,340	$190,550	3
2014	536,618	494,830	23,331	425,465	$1,460,213	20	69,365	$230,494	3
2015	536,618		23,331			20			3

[a] An AHO of 696,000 round lb was intended by managers; however, a miscalculation occurred by the CFEC with an additional permit holder added after the AHO and EQS were released to the public. As a result, ADF&G increased the total AHO to 720,000 round lb to maintain the 24,000 round pound EQS.

Table 2.–The area and proportion of sablefish habitat by stratum. Proportion of sablefish habitat was used to weight the survey CPUE for each stratum.

Stratum	Sablefish habitat (km^2)	Sablefish habitat/total area
325533	177	0.06
325531	215	0.08
315502	484	0.18
315432	687	0.25
315431	492	0.18
325401/325431	694	0.25
Total	2,748	1.00

Table 3.–Macroscopic maturity used to assess maturity for male and female sablefish in Southeast Alaska.

Maturity Stage	Male description	Female description
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 veined.
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.
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.
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 the oviduct.
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.
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 follicle structure.

Table 4.–Average fork length (cm) of sablefish sampled in Southern Southeast Inside and Northern Southeast Inside.

Year	SSEI survey	SSEI longline fishery	SSEI pot fishery
1997	57	*No data*	*No data*
1998	57	*No data*	59
1999	57	*No data*	59
2000	58	*No data*	*No data*
2001	58	63	*No data*
2002	57	61	*No data*
2003	58	61	*No data*
2004	59	62	*No data*
2005	*No data*	63	*No data*
2006	61	66	61
2007	60	63	61
2008	62	66	63
2009	61	65	62
2010	57	64	61
2011	58	63	58
2012	58	63	58
2013	59	63	59
2014	59	64	61
Mean	59	63	60

Table 5.–Average age (years) of sablefish sampled in Southern Southeast Inside.

Year	SSEI survey	SSEI longline fishery	SSEI pot fishery
1997	9.2	*No data*	*No data*
1998	8.6	*No data*	*No data*
1999	5.8	*No data*	4.6
2000	8.2	*No data*	*No data*
2001	9.5	11.5	*No data*
2002	7.7	9.9	*No data*
2003	*No data*	8.3	*No data*
2004	8.2	9.2	*No data*
2005	*No data*	9.7	*No data*
2006	9.2	9.4	7.0
2007	8.5	9.7	7.2
2008	10.6	11.8	8.6
2009	10.9	10.7	7.1
2010	7.4	10.7	6.8
2011	8.2	10.6	*No data*
2012	6.8	8.4	*No data*
2013	7.8	8.9	*No data*
2014	7.2	9.1	*No data*
Mean	8.4	9.9	6.9

Table 6.–Percent of immature fish in the Southern Southeast Inside longline survey and fisheries.

Year	Percent immature females			Percent immature males		
	Survey	LL fishery	Pot fishery	Survey	LL fishery	Pot fishery
1988	49%	No data	No data	53%	No data	No data
1989	35%	No data	No data	21%	No data	No data
1990	34%	No data	No data	30%	No data	No data
1991	59%	No data	No data	37%	No data	No data
1992	54%	No data	No data	48%	No data	No data
1993	47%	No data	No data	50%	No data	No data
1994	53%	No data	No data	40%	No data	No data
1995	61%	No data	No data	46%	No data	No data
1996	54%	No data	No data	48%	No data	No data
1997	47%	No data	No data	62%	No data	No data
1998	71%	No data	No data	61%	No data	No data
1999	88%	No data	50%	74%	No data	47%
2000	67%	No data	No data	65%	No data	No data
2001	74%	27%	No data	77%	36%	No data
2002	72%	38%	No data	72%	52%	No data
2003	50%	42%	No data	67%	60%	No data
2004	52%	43%	No data	71%	65%	No data
2005	No survey	35%	No data	No survey	46%	No data
2006	39%	30%	75%	56%	45%	42%
2007	53%	40%	69%	61%	62%	45%
2008	41%	29%	54%	51%	59%	41%
2009	50%	30%	64%	48%	41%	51%
2010	64%	50%	73%	65%	55%	51%
2011	78%	60%	89%	61%	66%	80%
2012	83%	61%	96%	76%	58%	66%
2013	76%	73%	76%	69%	67%	59%
2014	73%	65%	76%	68%	63%	65%
1988–2014 average	59%	45%	72%	57%	55%	55%
2010–2014, 5-yr average	75%	62%	82%	68%	62%	64%
2005–2014, 10-yr average	62%	47%	75%	62%	56%	56%

Table 7.–Catch per unit effort (CPUE) for the longline survey and fishery in round lb/hook and for the pot fishery in round lb/pot from 1997 to 2014.

Year	Survey CPUE all fish	Survey CPUE ≥520 mm	LL Fishery CPUE	Pot Fishery CPUE
1997	0.49	0.40	0.36	33.0
1998	0.56	0.48	0.35	47.0
1999	0.78	0.65	0.44	77.2
2000	0.74	0.69	0.38	46.8
2001	0.58	0.54	0.31	41.3
2002	0.71	0.64	0.41	49.0
2003	0.80	0.73	0.45	69.9
2004	0.83	0.78	0.40	39.2
2005	No survey	No survey	0.51	32.1
2006	0.95	0.92	0.50	35.1
2007	0.77	0.70	0.49	38.2
2008	0.81	0.80	0.37	18.2
2009	0.75	0.71	0.31	19.1
2010	0.48	0.33	0.33	27.4
2011	0.79	0.73	0.38	51.0
2012	0.76	0.71	0.33	73.2
2013	0.67	0.63	0.33	44.4
2014	0.61	0.59	0.30	47.0
5-yr avg. (2010–2014)	0.66	0.60	0.33	48.6
10-yr avg. (2005–2014)	0.73	0.68	0.38	38.6
Overall average 1997–2014	0.71	0.65	0.39	43.8

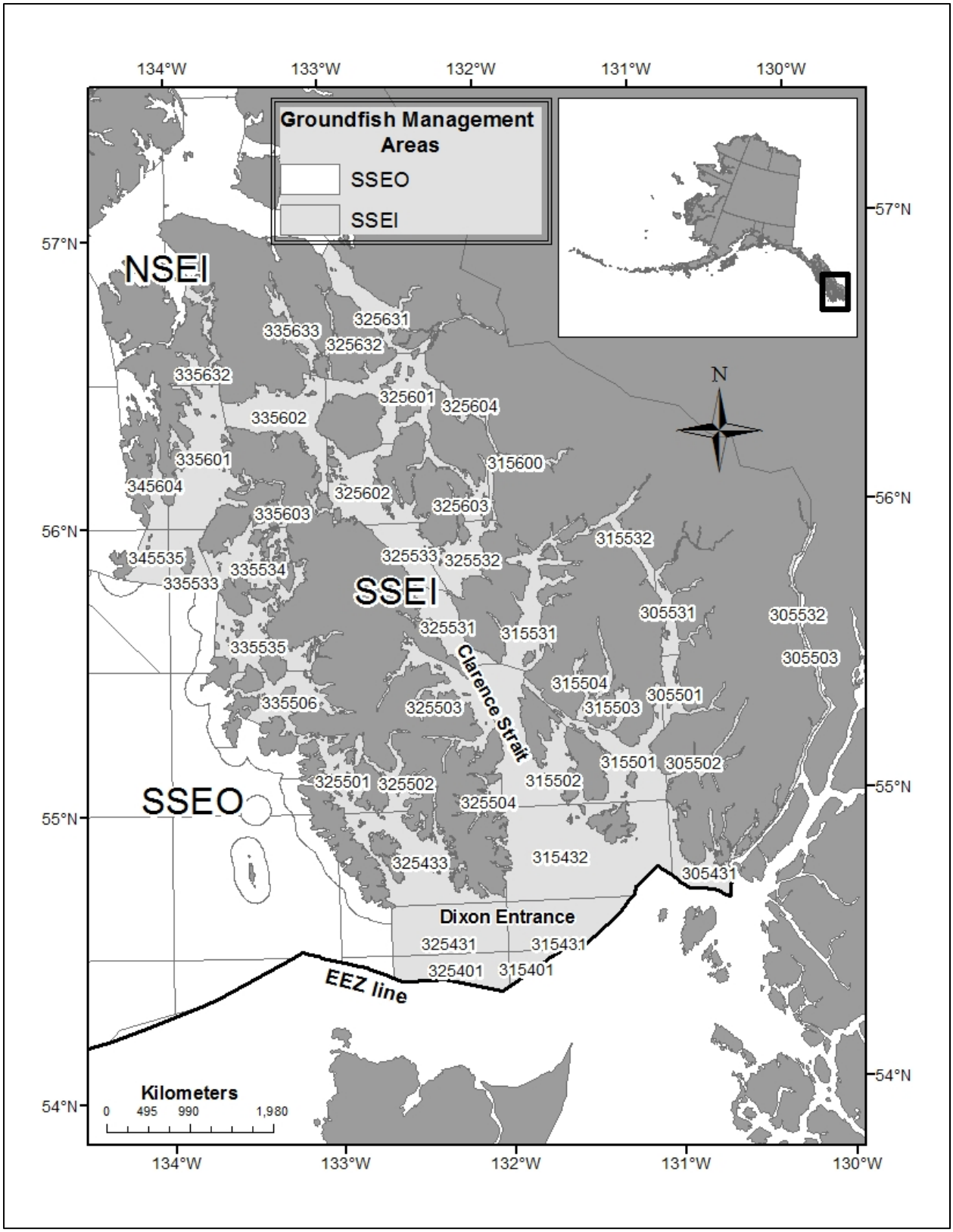

Figure 1.–Southern Southeast Inside Subdistrict with groundfish statistical areas open to fishing.

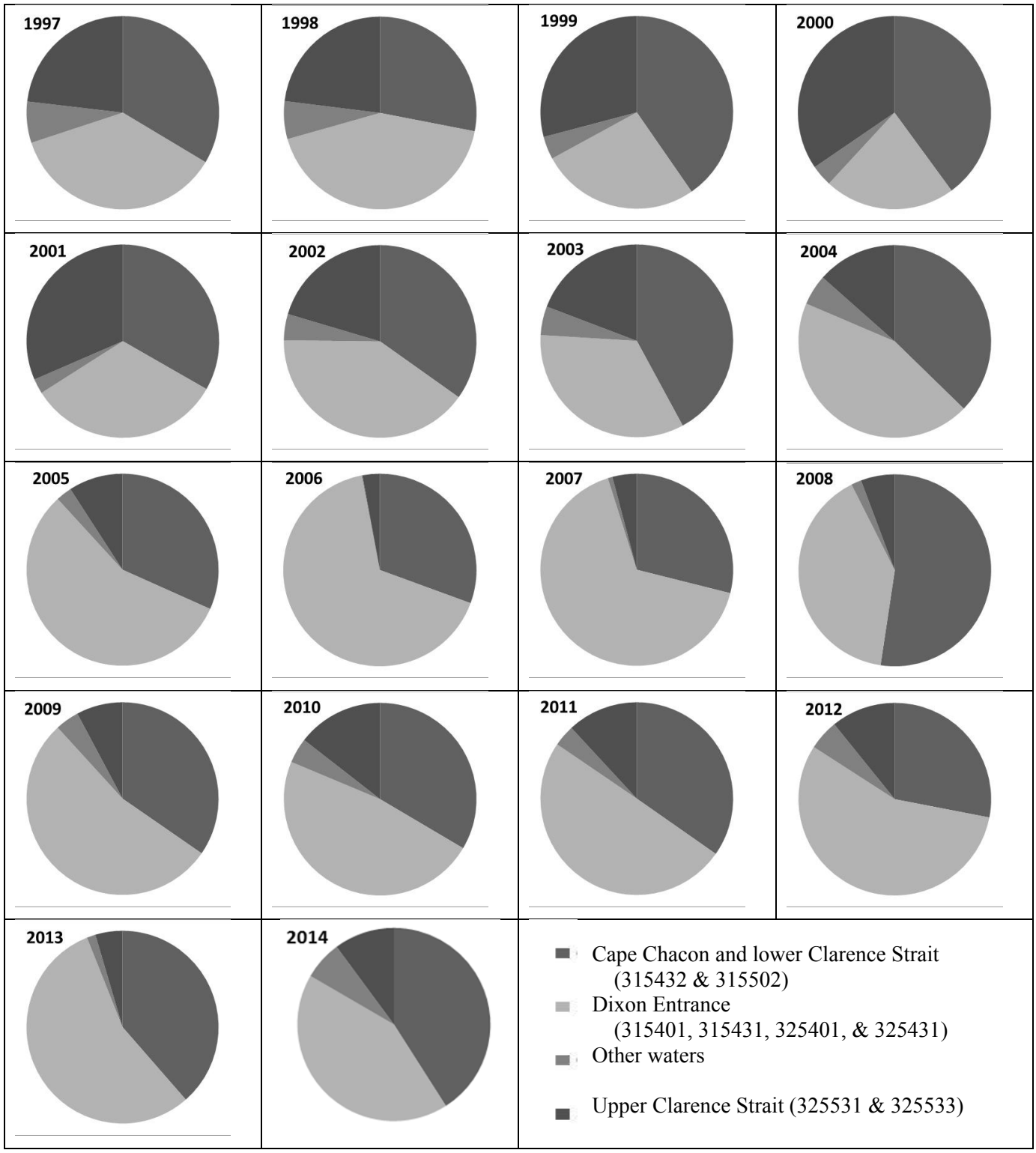

Figure 2.–Harvest distribution by area for the Southern Southeast Inside sablefish commercial longline fishery.

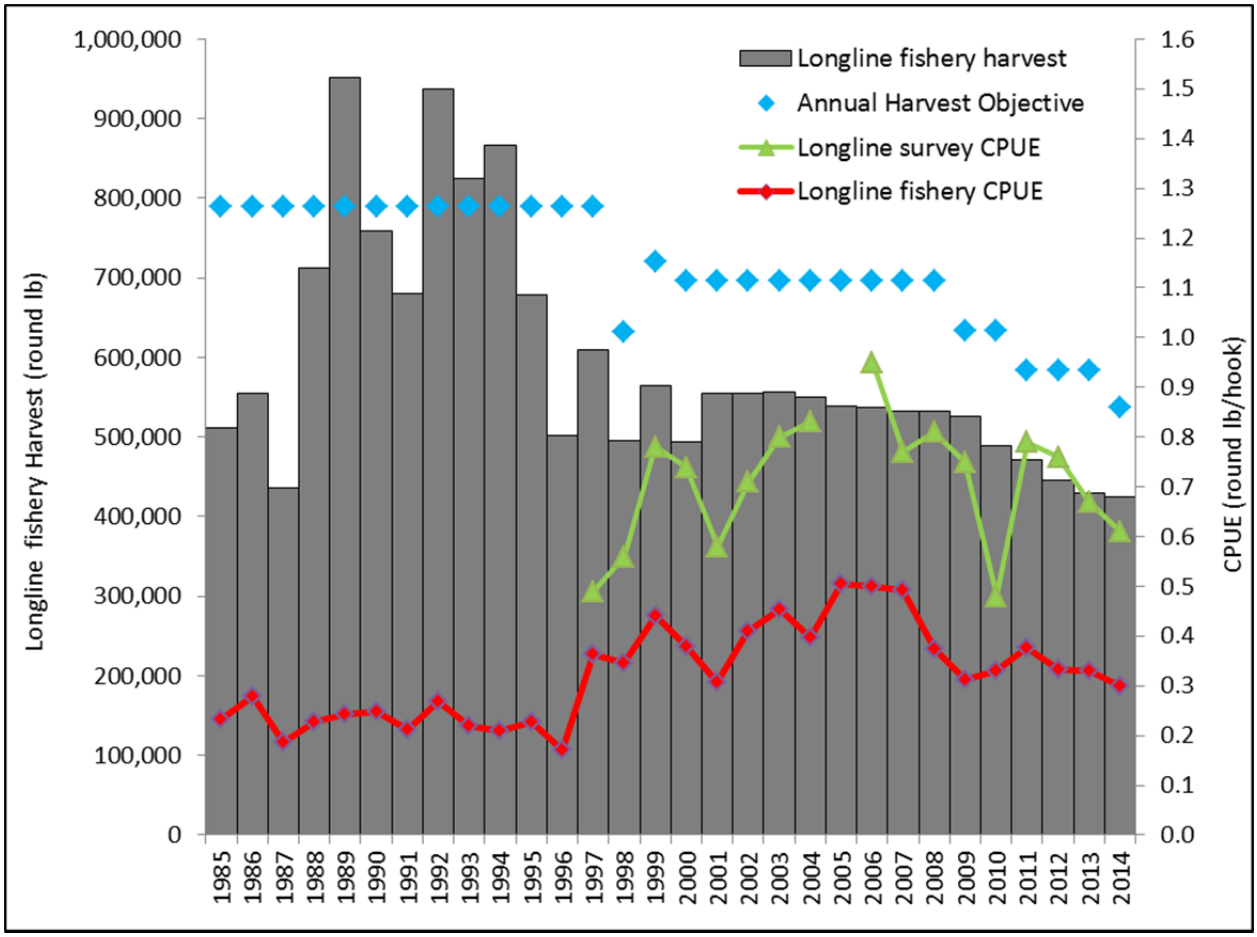

Figure 3.–Southern Southeast Inside longline fishery and survey catch per unit effort (CPUE) and longline fishery harvest with the annual harvest objectives. Survey CPUE is presented since 1997 when survey soak times were standardized. The 2013 and 2014 survey CPUE estimates exclude the stations that were moved in the following survey year.

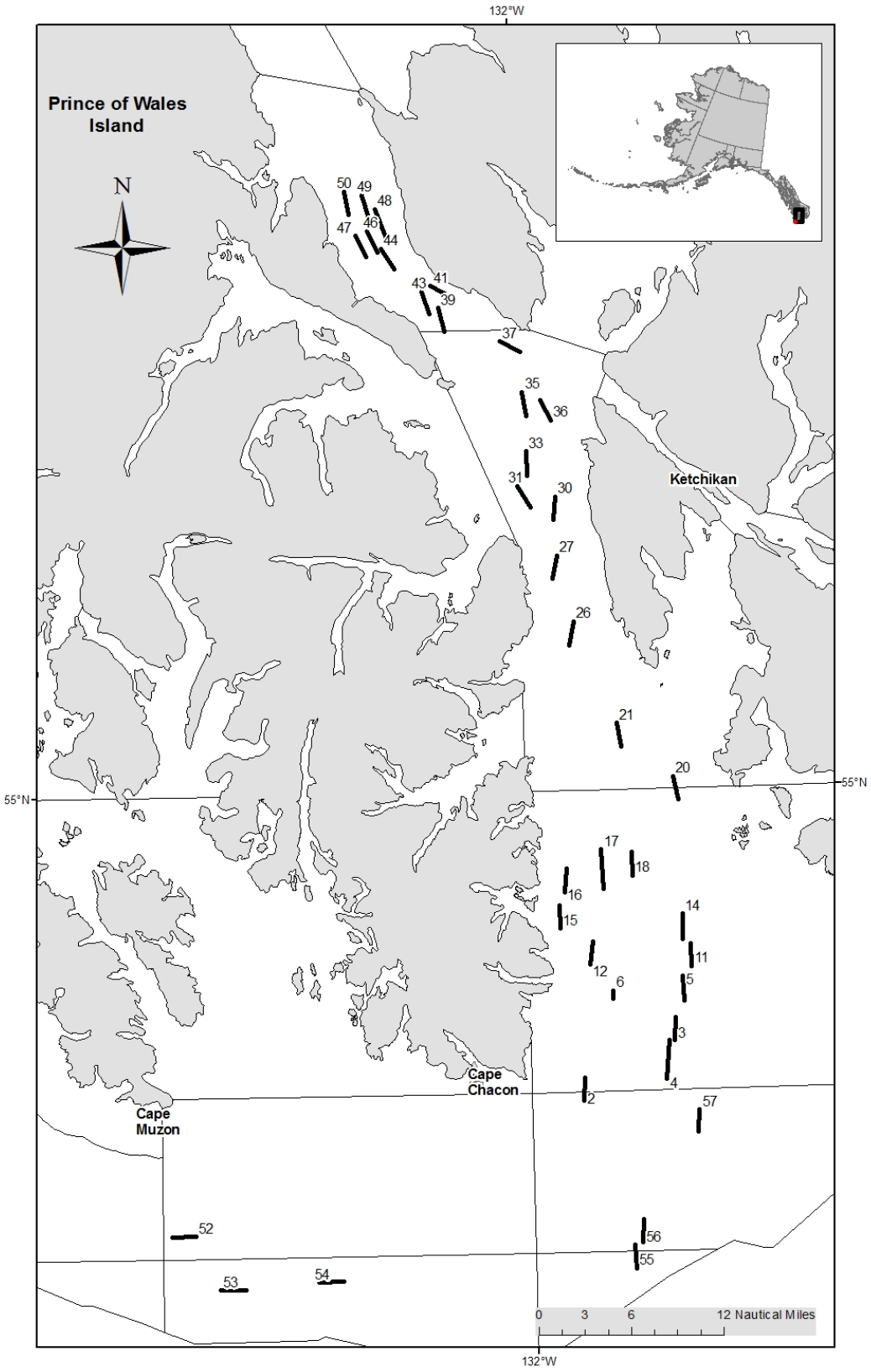

Figure 4.–Southern Southeast Inside longline survey stations fished prior to 2013 redesign.

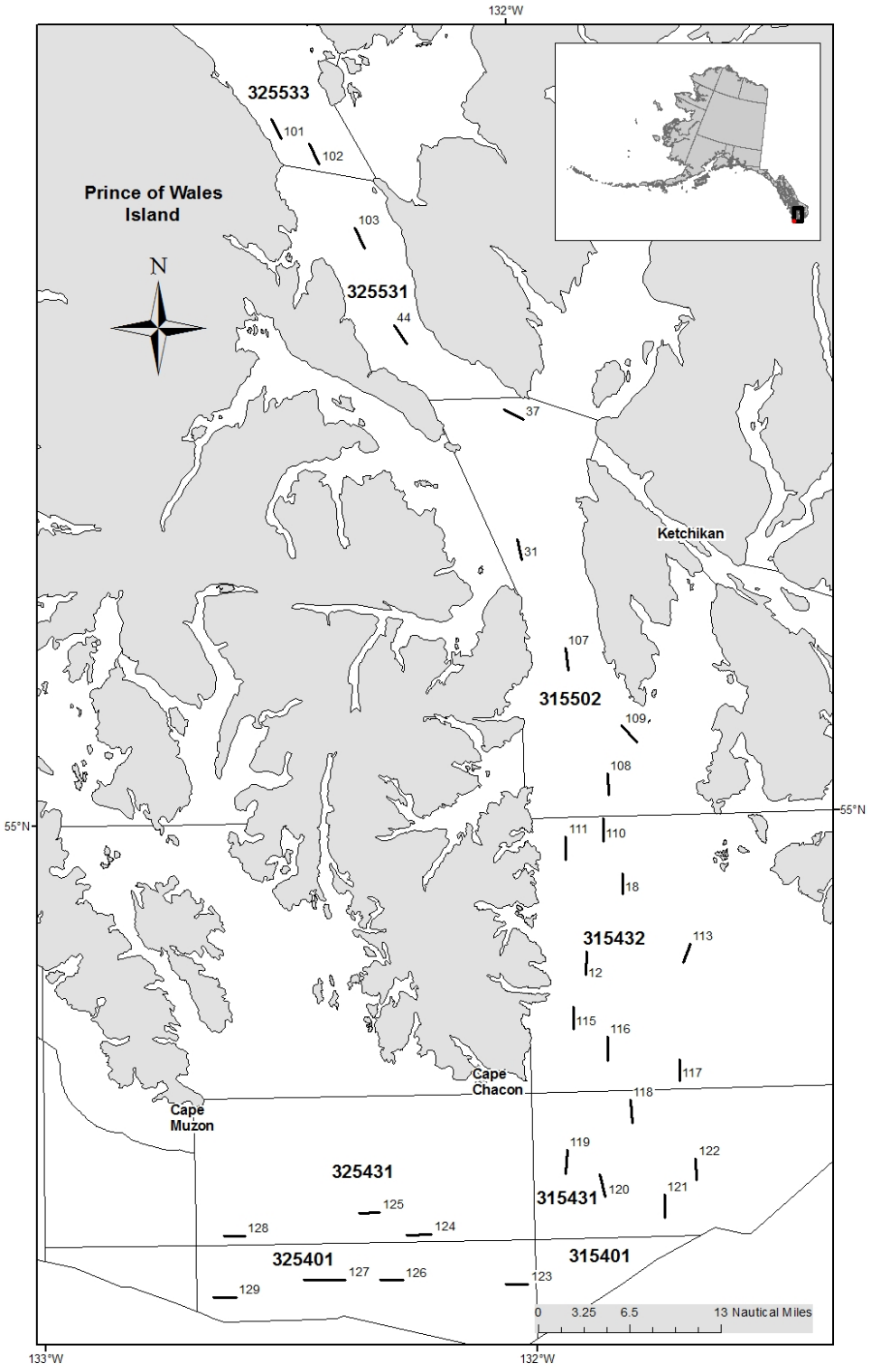

Figure 5.–Southern Southeast Inside longline survey stations fished during 2014 redesigned survey.

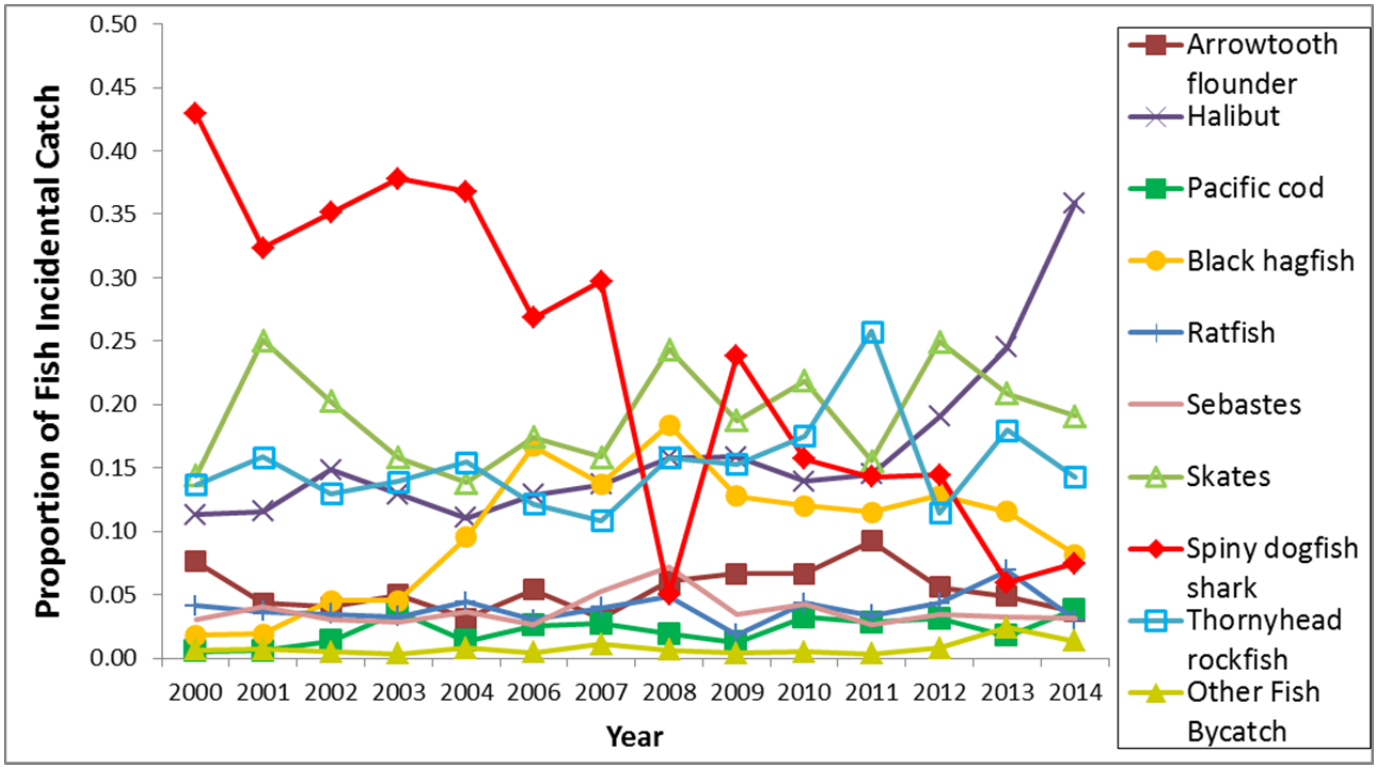

Figure 6.–Incidental catch of fish landed in the Southern Southeast Inside longline sablefish survey, 2000–2014.

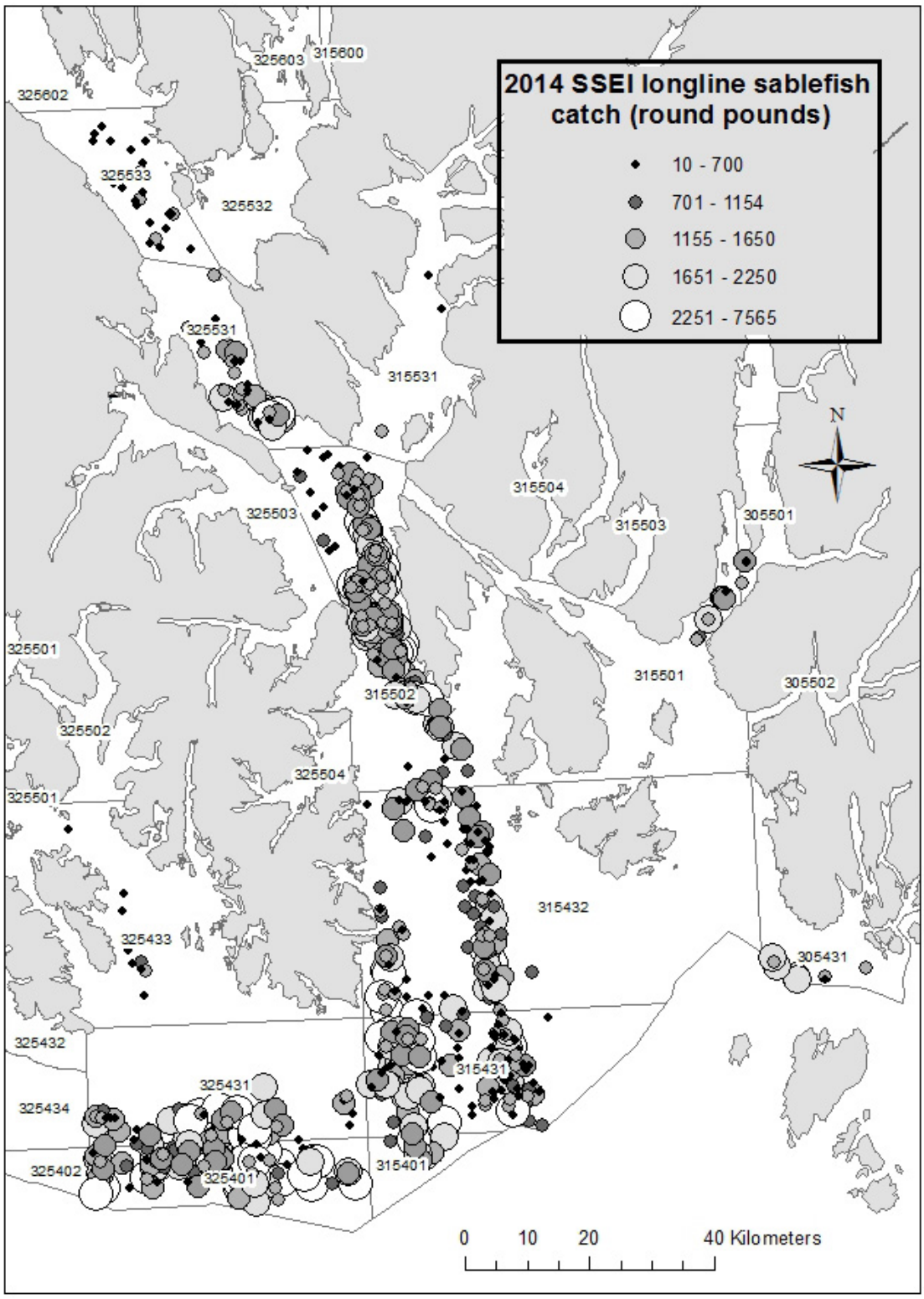

Figure 7.–Southern Southeast Inside 2014 commerical longline fishery catch in round lb and distribution by statistical area.

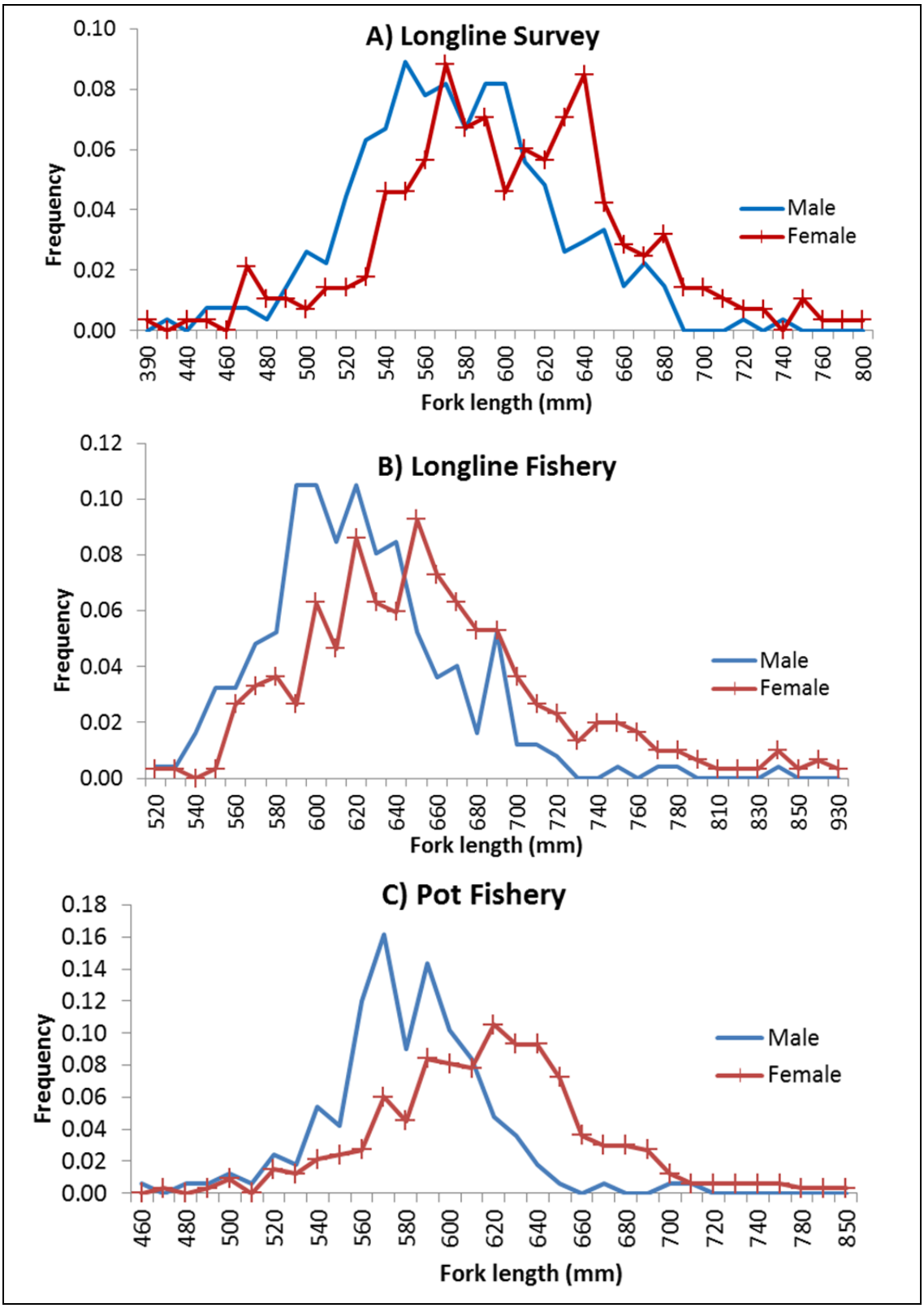

Figure 8.–The 2014 length frequencies of sablefish by sex for the A) longline survey, B) longline fishery, and C) pot fishery.

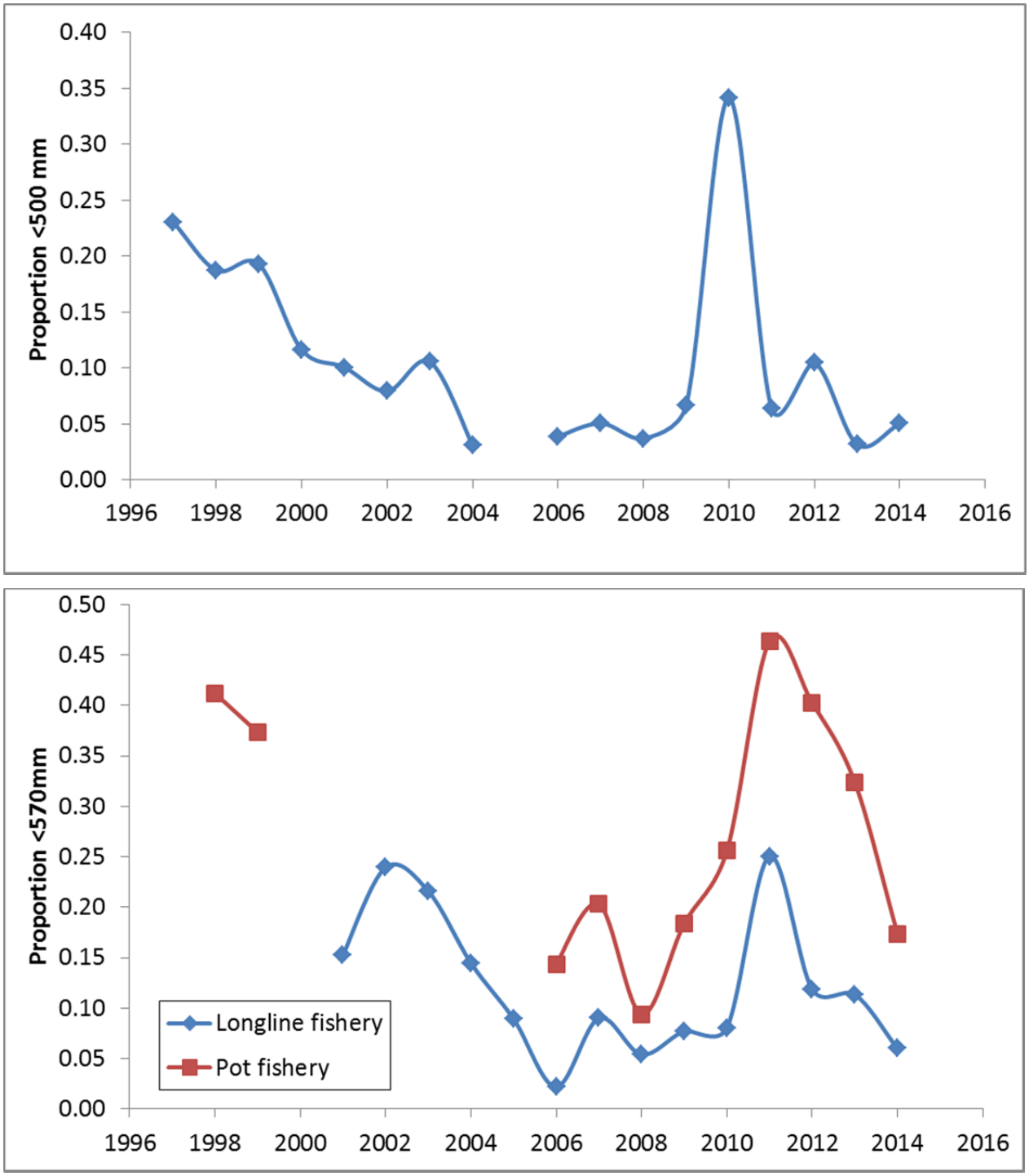

Figure 9.–Proportion of small sablefish recruiting to the Southern Southeast Inside longline survey (<500 mm; top) and SSEI fisheries (<570 mm; bottom) by year. No survey was performed in 2005, and no biological data were collected from the longline fishery before 2001 or from the pot fishery from 2000 to 2005.

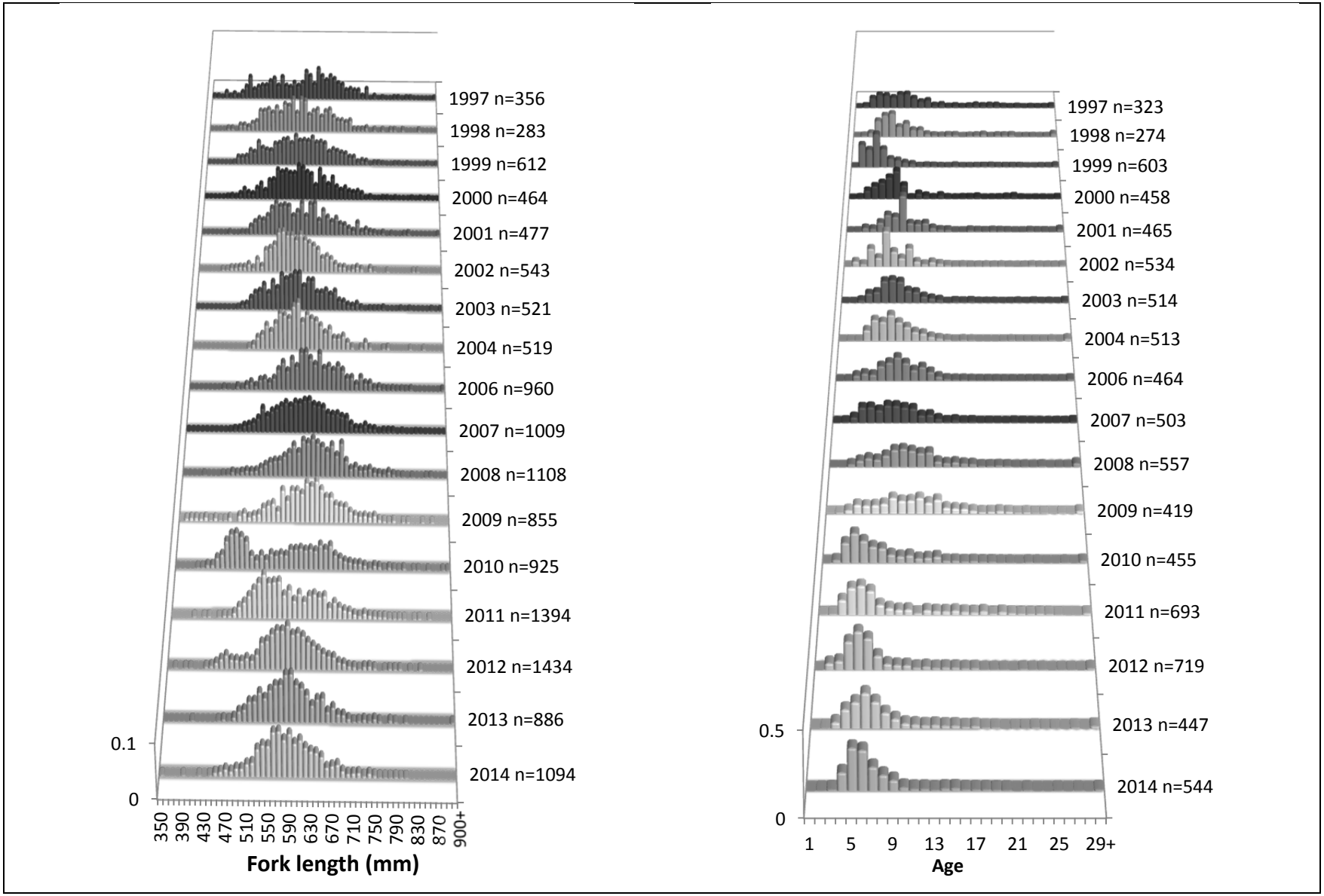

Figure 10.–Southern Southeast Inside longline survey sablefish length and age frequency histograms from 1997 to 2014.

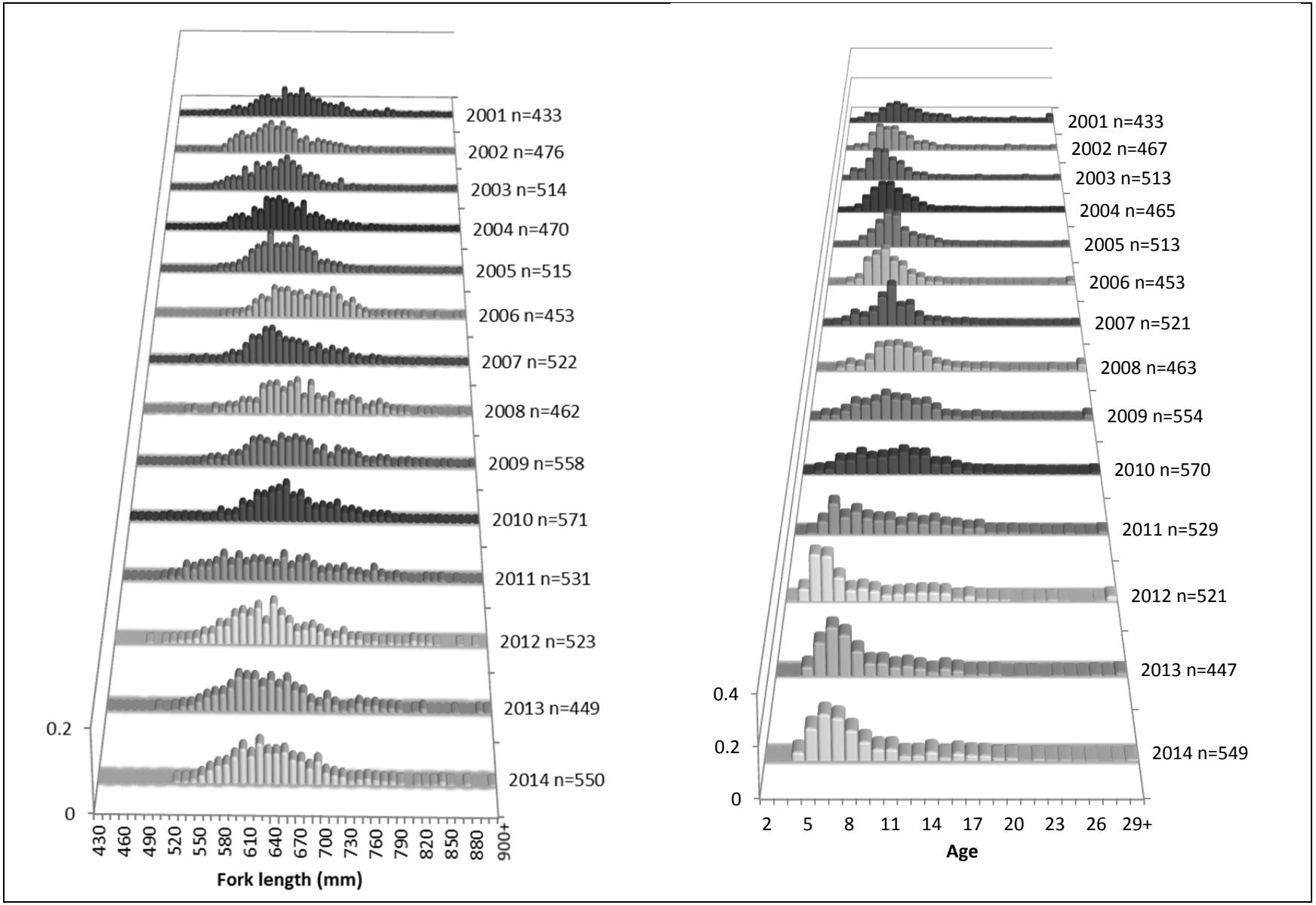

Figure 11.–Sablefish length and age distributions for the commercial Southern Southeast Inside longline fishery from 2001 to 2014.

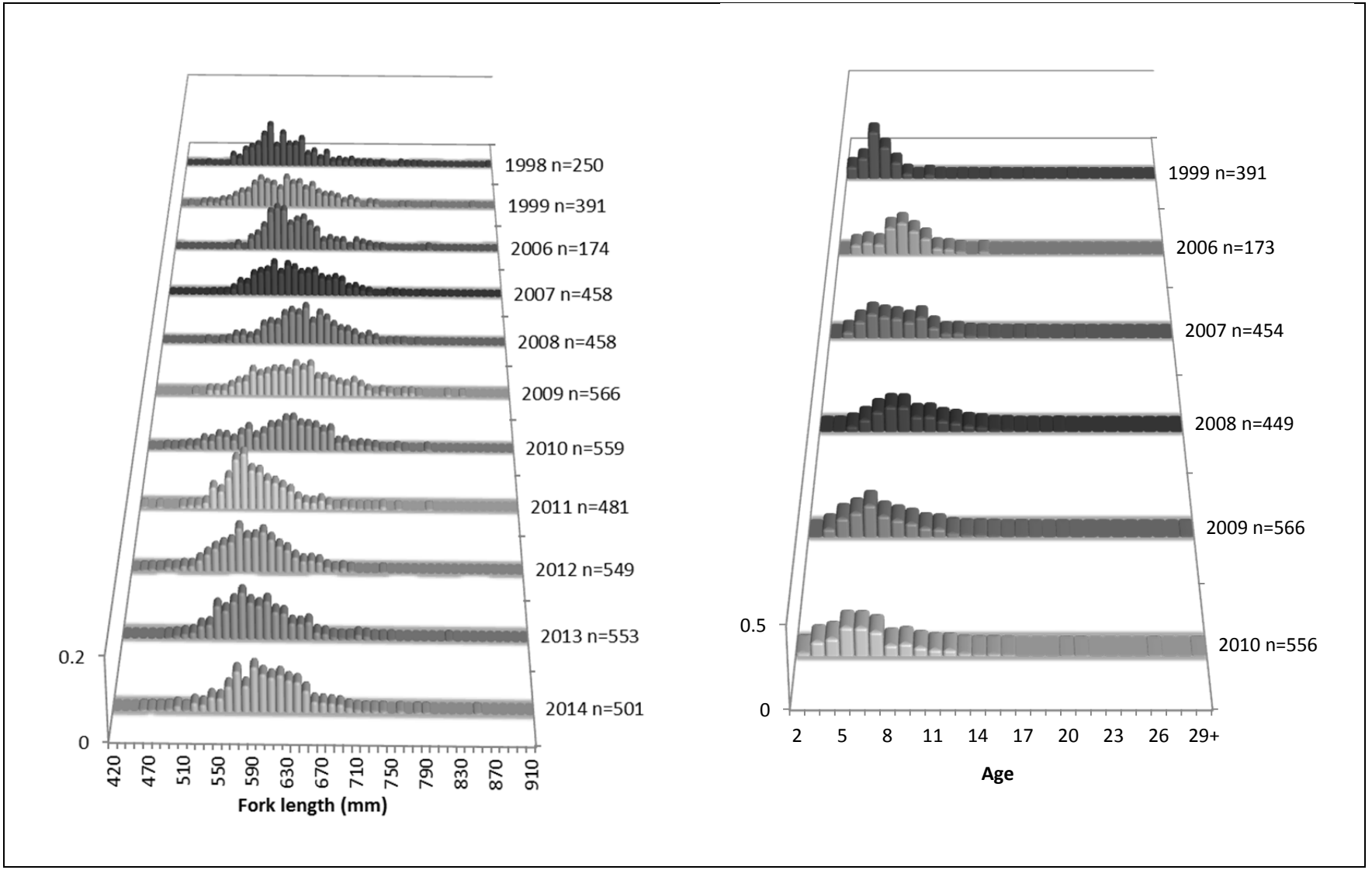

Figure 12.–Sablefish length and age distributions for the commercial Southern Southeast Inside pot fishery from 1998 to 2014. No length data were collected from 2000 to 2005 and no age data from 2000 to 2005 and since 2011.

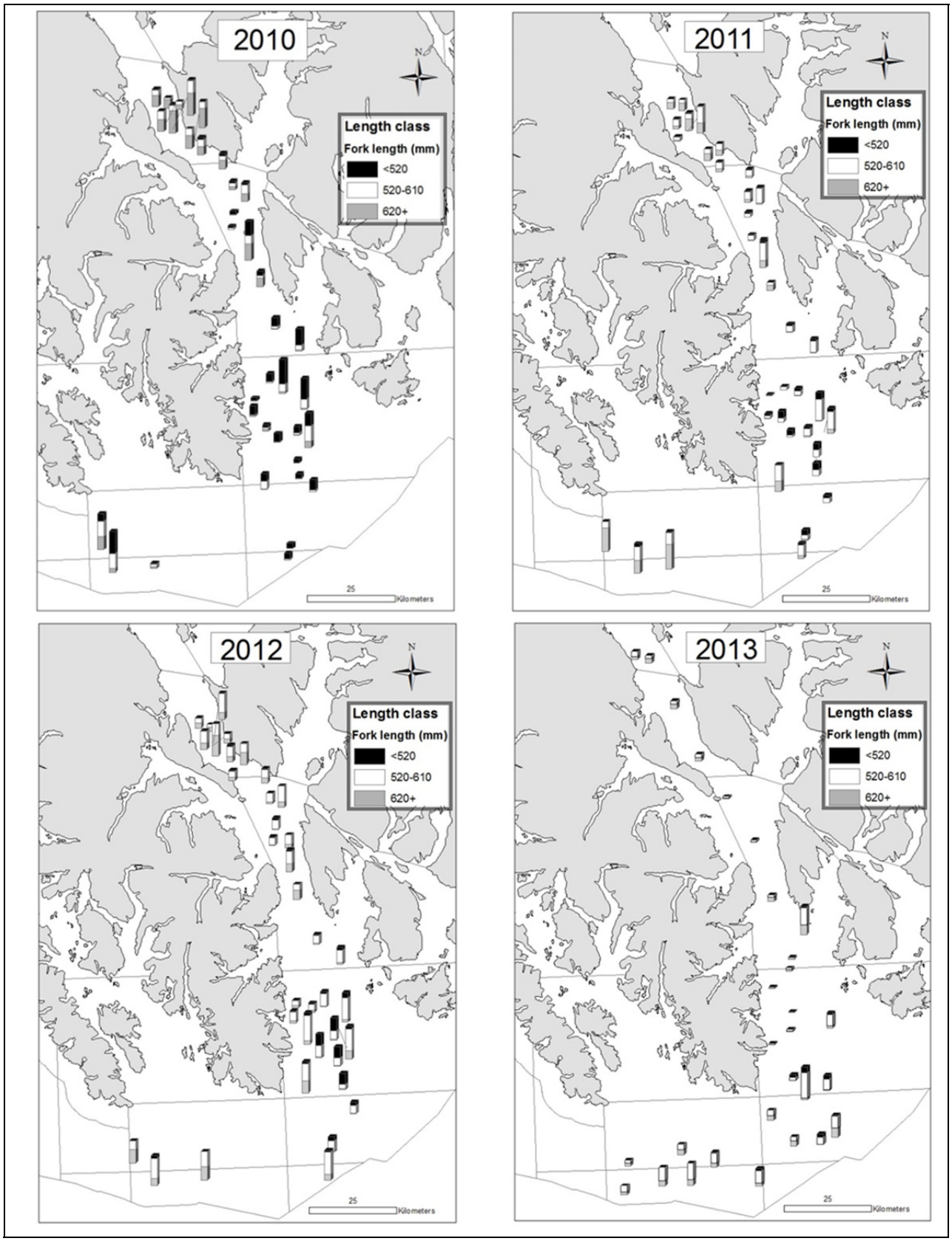

Figure 13.–Southern Southeast Inside longline survey catch by set and length class from 2010 to 2014.

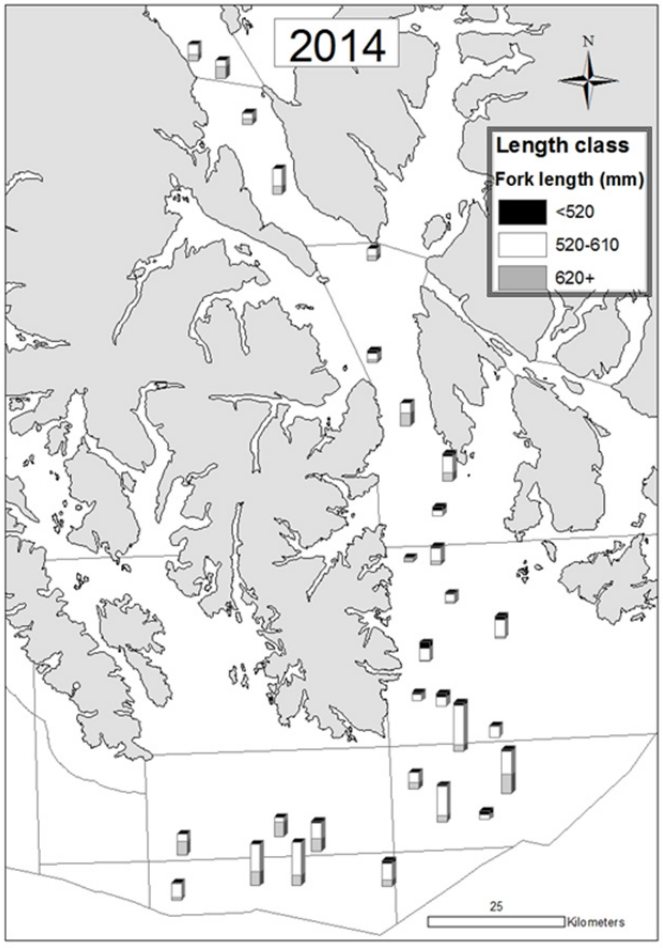

Figure 13.–Page 2 of 2.

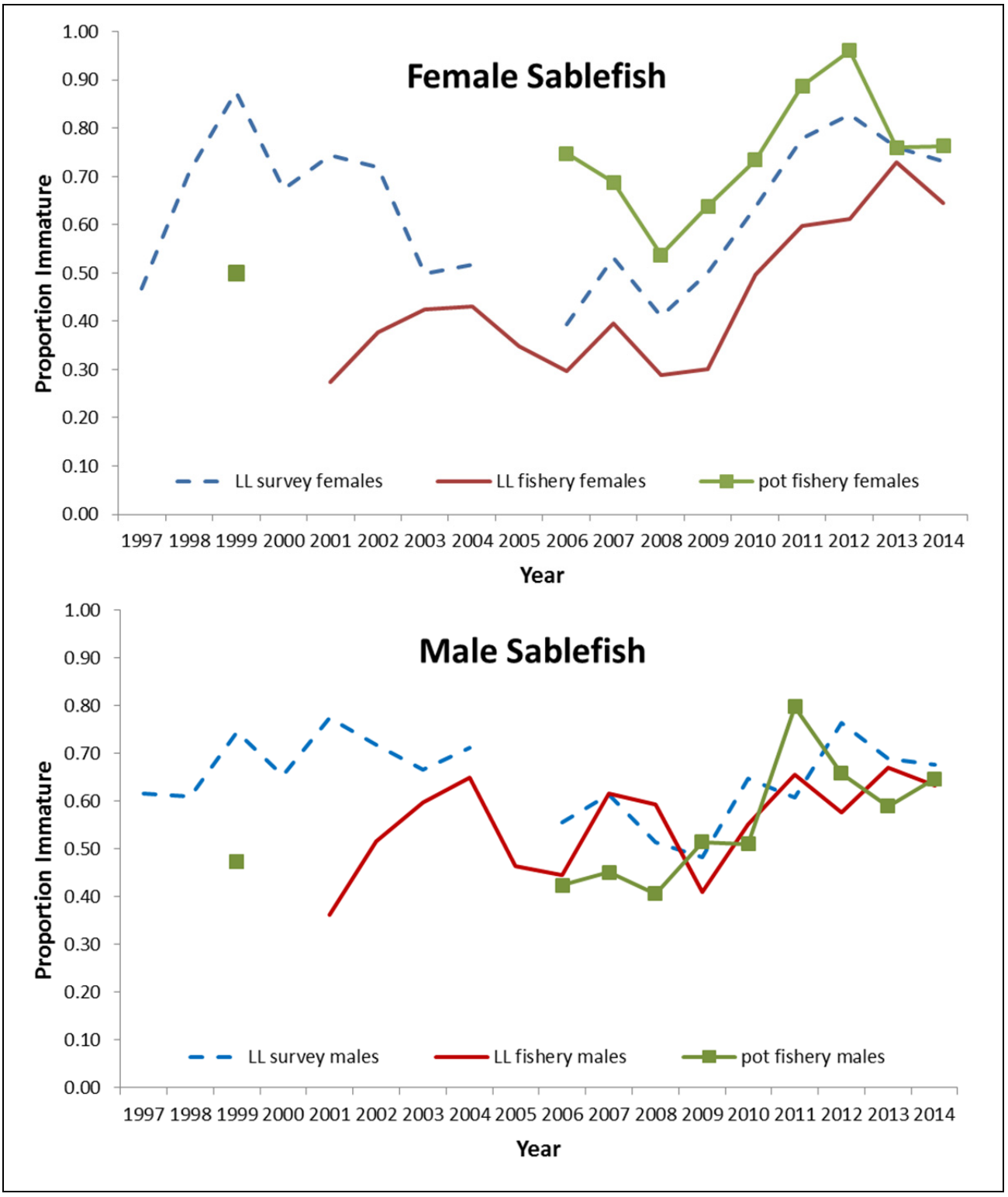

Figure 14.–Proportion of immature female and male sablefish sampled from the SSEI longline survey and the SSEI longline and pot fisheries from 1997 to 2014. Sablefish maturity data for the pot fishery is only available for 1999 and 2006–2014.

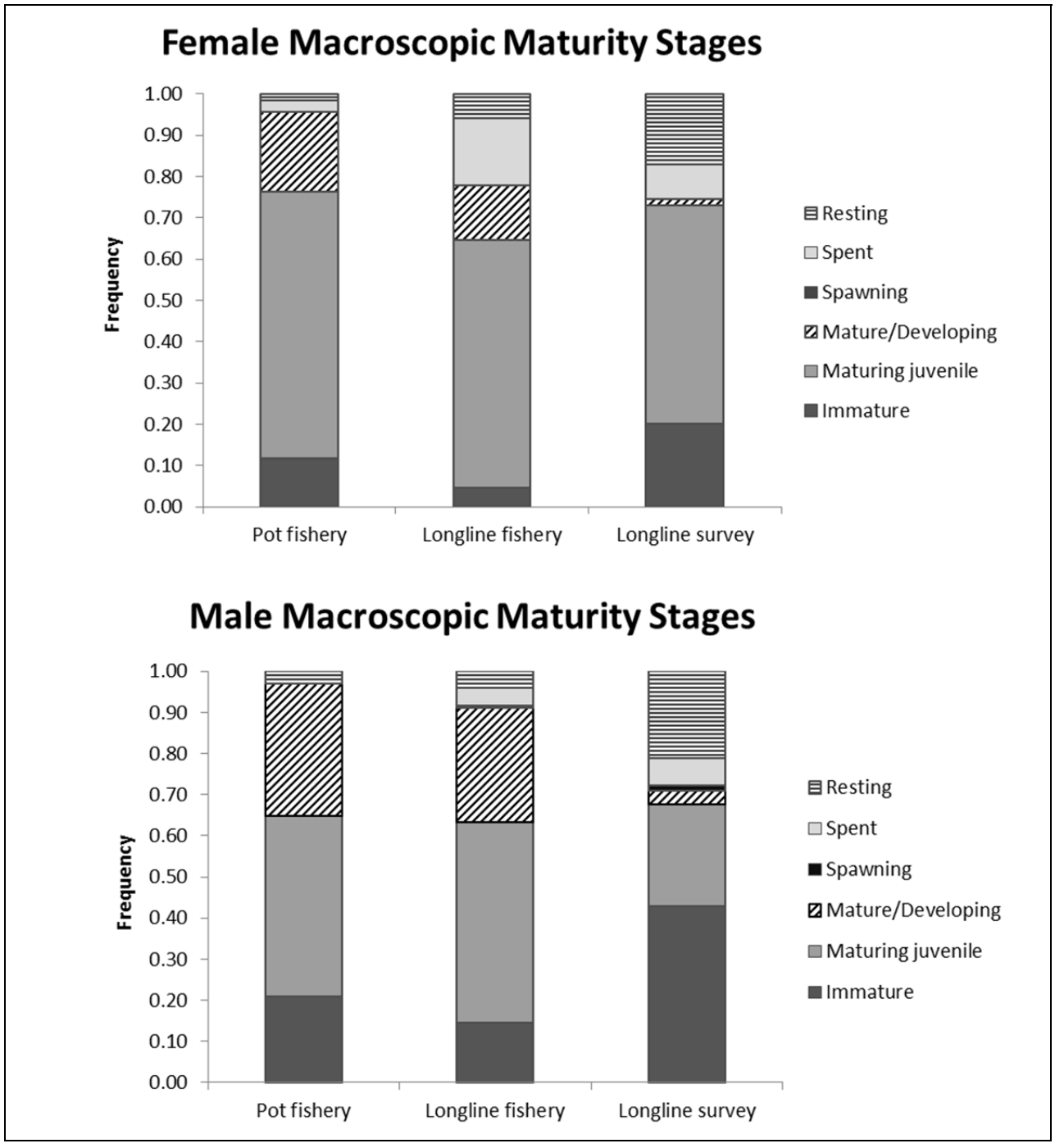

Figure 15.–Macroscopic maturity stages sampled in 2014 from the Southern Southeast Inside survey and pot and longline fisheries by sex.

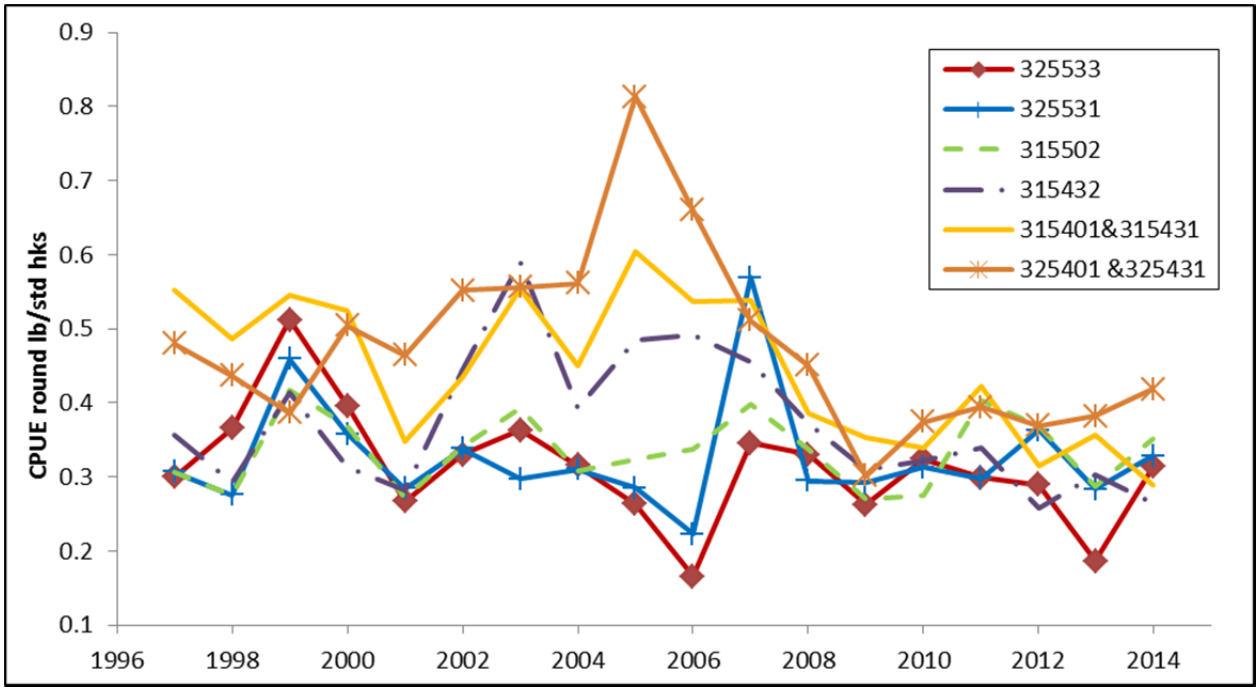

Figure 16.–Southern Southeast Inside longline fishery catch per unit effort (CPUE) in round lb/hook from 1997 to 2014. Fishery CPUEs are shown by area within SSEI management area: northern (325533 and 325531), middle (315502), and southern (315432) Clarence Strait, eastern Dixon Entrance (315401 and 315431), and western Dixon Entrance (325401 and 325431). Fishery CPUE data are not weighted by area.

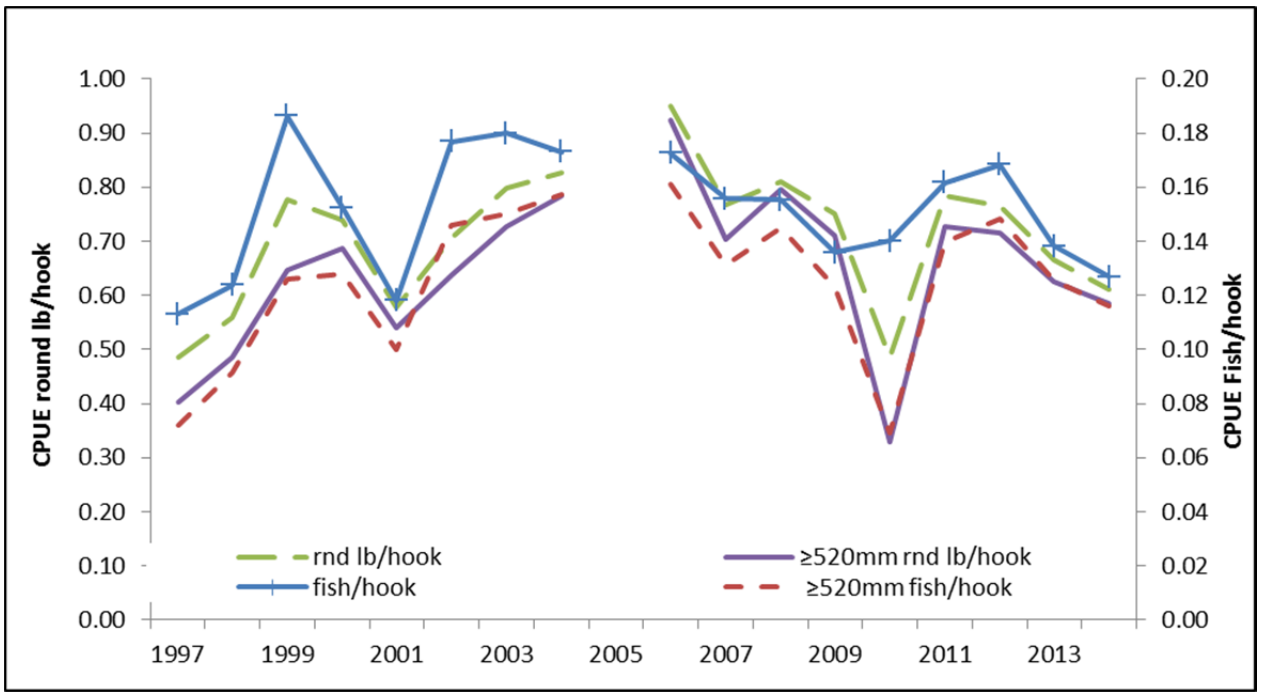

Figure 17.–Southern Southeast Inside Survey CPUE (round lb per hook and fish per hook) weighted by the area of sablefish habitat in each strata for all fish and fish ≥520 mm from 1997 to 2014.

Figure 18.–Southern Southeast Inside survey CPUE (round lb/hook) by area for fish ≥ 520 mm from 1997 to 2014. Survey CPUEs are estimated by stratum: northern 1 (325533), northern 2 (325531), middle (315502), and southern Clarence Strait (315432) and eastern (315401 and 315431) and western Dixon Entrance (325401 and 325431). In 2013 statisitical area 325533 was added as a stratum and statistical area 315401 was removed from the eastern Dixon Entrance stratum. CPUE have been weighted by the area of sablefish habitat in each strata.

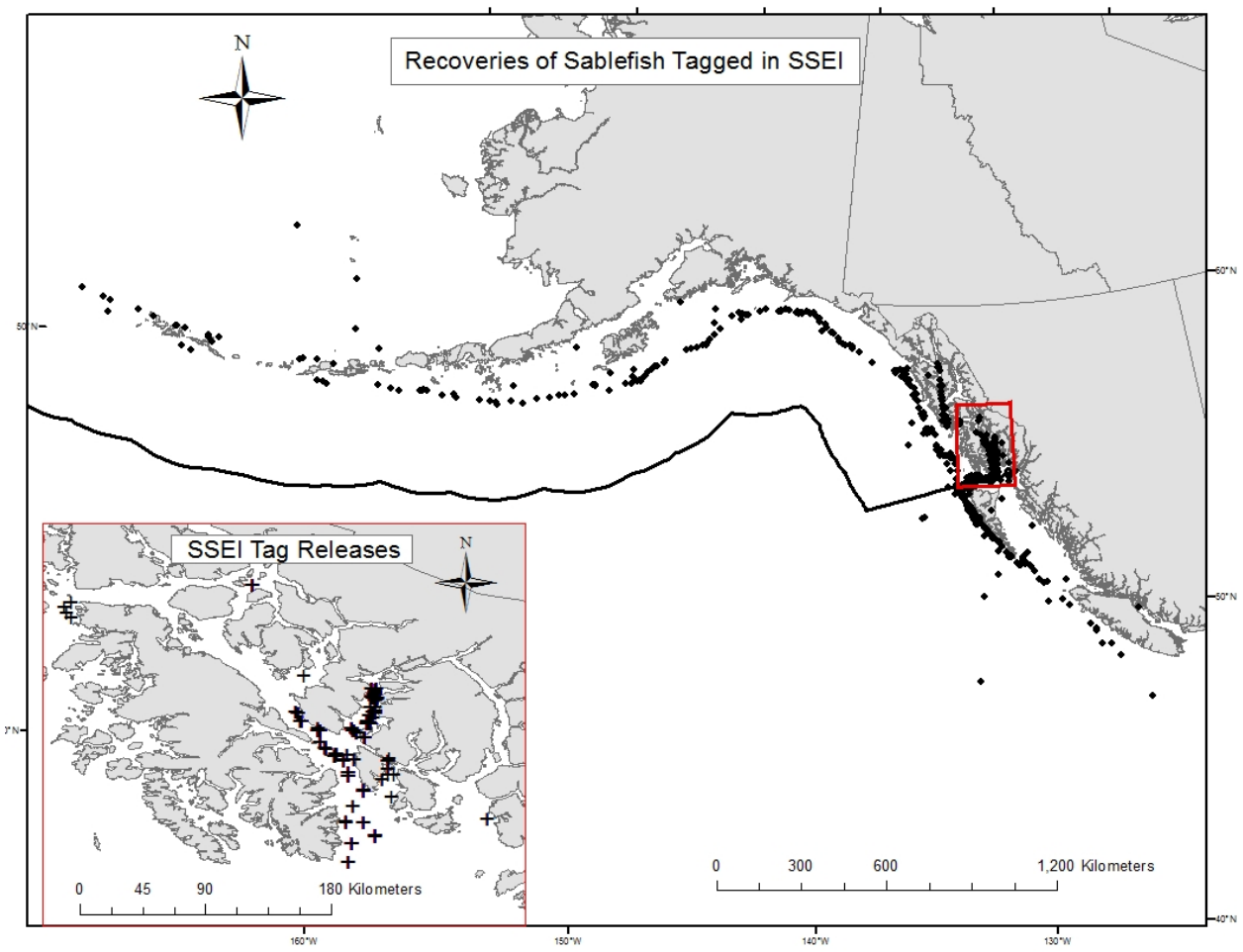

Figure 19.–Tagging (plus symbols) and recovery locations (black diamonds) for sablefish released in SSEI management area. Tag releases occurred from 1979 to 1981, 1983, 1985–1986, and 1988–1989.

APPENDICES

Appendix A.–Set location information for the 2014 Southern Southeast Inside Subdistrict sablefish longline survey; locations are presented in degrees and decimal minutes.

Station	Statistical area	General location	Area description	Start latitude	Start longitude	End latitude	End longitude
101	325533	Upper Clarence Strait	Little Ratz Harbor	55 48.77	132 28.77	55 50.20	132 29.91
102	325533	Upper Clarence Strait	Narrow Point	55 46.96	132 24.01	55 48.39	132 25.25
103	325531	Upper Clarence Strait	Tolstoi Point	55 42.33	132 19.64	55 40.88	132 18.49
44	325531	Upper Clarence Strait	Ship Island	55 35.34	132 14.96	55 34.03	132 13.43
37	315502	Middle Clarence Strait	Caamano Point	55 28.43	131 59.02	55 29.15	132 01.37
31	315502	Middle Clarence Strait	Skin Island	55 18.44	131 59.66	55 19.92	132 00.09
107	315502	Middle Clarence Strait	Wedge Island	55 12.05	131 54.46	55 10.48	131 54.22
108	315502	Middle Clarence Strait	Dall Head	55 03.06	131 49.64	55 01.51	131 49.51
109	315502	Middle Clarence Strait	Canoe Cove	55 06.43	131 47.66	55 05.23	131 45.90
110	315432	Lower Clarence Strait	Percy Island	54 58.24	131 50.36	54 59.88	131 50.32
111	315432	Lower Clarence Strait	Ingraham Bay	54 58.62	131 54.99	54 57.01	131 55.11
18	315432	Lower Clarence Strait	Hidden Bay	54 54.43	131 48.20	54 55.90	131 48.13
113	315432	Lower Clarence Strait	West Rock	54 50.76	131 39.99	54 49.46	131 40.92
12	315432	Lower Clarence Strait	Island Point	54 48.77	131 53.00	54 50.36	131 52.81
115	315432	Lower Clarence Strait	McLean Arm	54 44.91	131 54.62	54 46.45	131 54.64
116	315432	Lower Clarence Strait	Cape Chacon	54 44.28	131 50.46	54 42.60	131 50.50
117	315432	Lower Clarence Strait	West Devil Rock	54 41.03	131 41.73	54 42.54	131 41.67
118	315431	Dixon Entrance	West Devil Rock	54 39.76	131 47.85	54 38.11	131 47.71
119	315431	Dixon Entrance	Cape Chacon	54 36.30	131 55.80	54 34.59	131 56.06
120	315431	Dixon Entrance	Celestial Reef	54 32.90	131 51.26	54 34.48	131 51.87
121	315431	Dixon Entrance	Celestial Reef	54 32.95	131 44.02	54 31.33	131 44.07
122	315431	Dixon Entrance	West Devil Rock	54 35.44	131 40.07	54 33.90	131 40.11
123	325401	Dixon Entrance	Celestial Reef	54 26.81	132 01.02	54 26.83	132 03.69
124	325431	Dixon Entrance	Point Nunez	54 30.53	132 12.70	54 30.53	132 15.74
125	325431	Dixon Entrance	Point Marsh	54 32.16	132 18.93	54 32.13	132 21.43
126	325401	Dixon Entrance	Surf Point	54 27.29	132 16.30	54 27.32	132 19.07
127	325401	Dixon Entrance	Point Marsh	54 27.40	132 23.29	54 27.43	132 28.41
128	325431	Dixon Entrance	Cape Muzon	54 30.66	132 35.49	54 30.67	132 38.01
129	325401	Dixon Entrance	Cape Muzon	54 26.28	132 36.68	54 26.30	132 39.44

Appendix B.–Set and haul information for the 2014 Southern Southeast Inside Subdistrict sablefish longline survey.

							Depth (fathoms)		
Trip	Station	Date set	Time set	Soak time (h)	Haul time (h)	Haul direction	Start	End	Avg.
1	123	4-May	5:25	3.4	1.8	Same	164	185	176
1	119	4-May	7:40	5.6	1.7	Opposite	193	186	194
1	120	4-May	12:57	3.1	1.5	Same	185	185	185
1	118	5-May	5:06	3.0	1.4	Same	196	191	192
1	121	5-May	6:07	5.3	1.5	Same	194	192	193
1	122	5-May	10:51	3.5	1.7	Opposite	208	181	190
1	107	6-May	4:47	3.1	1.7	Same	234	230	233
1	108	6-May	6:20	4.9	1.4	Same	226	223	224
1	109	6-May	10:44	3.1	1.6	Opposite	275	280	278
1	31	7-May	2:29	3.1	1.4	Same	243	236	241
1	101	8-May	4:54	3.1	1.5	Opposite	291	277	285
1	102	8-May	6:34	3.7	1.4	Same	325	330	329
1	103	8-May	12:58	3.0	1.5	Opposite	316	326	316
1	44	9-May	4:57	3.0	1.5	Opposite	304	265	283
1	37	9-May	6:45	4.3	1.5	Opposite	232	243	239
2	127	7-May	5:44	3.4	2.1	Same	197	198	197
2	129	7-May	6:49	6.4	2.4	Same	188	196	191
2	128	7-May	12:00	4.3	1.9	Opposite	206	205	205
2	125	8-May	5:28	3.2	1.9	Same	186	196	192
2	126	8-May	6:52	5.8	1.9	Same	198	196	197
2	124	8-May	11:52	3.9	1.9	Opposite	185	196	190
2	115	9-May	5:05	3.1	1.4	Same	226	228	228
2	117	9-May	7:05	4.3	1.4	Opposite	229	238	233
2	116	9-May	10:33	3.1	1.6	Opposite	209	205	207
2	113	11-May	4:25	3.1	1.8	Opposite	193	220	200
2	18	11-May	6:10	5.5	1.5	Opposite	225	228	224
2	12	11-May	10:45	3.4	1.7	Opposite	218	224	220
2	111	12-May	6:02	3.0	1.5	Opposite	239	240	241
2	110	12-May	8:12	2.8	1.5	Same	237	221	230