Special Publication No. 05-12

An Assessment of Age Determination Needs and Samples Sizes for Groundfish Fisheries Managed by the State of Alaska

by

Dave Carlile

June 2005

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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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

SPECIAL PUBLICATION NO. 05-12

AN ASSESSMENT OF AGE DETERMINATION NEEDS AND SAMPLES SIZES FOR GROUNDFISH FISHERIES MANAGED BY THE STATE OF ALASKA

by

Dave Carlile,
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau

June 2005

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

The Division of Sport Fish Special Publications series was established in 1991 for the publication of techniques and procedures manuals, informational pamphlets, special subject reports to decision-making bodies, symposia and workshop proceedings, application software documentation, in-house lectures, and other documents that do not fit in another publication series of the Division of Sport Fish. Since 2004, the Division of Commercial Fisheries has also used the same Special Publication series. Special Publications are intended for fishery and other technical professionals. Special Publications are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm. This publication has undergone editorial and peer review.

Dave Carlile,
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th Street, P.O. Box 25526, Juneau, AK, USA

This document should be cited as:
Carlile, D. 2005. An Assessment of Age Determination Needs and Samples Sizes for Groundfish Fisheries Managed by the State of Alaska. Alaska Department of Fish and Game, Special Publication No. 05-12, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

The State of Alaska has management and stock assessment responsibility for a variety of groundfish species both within and beyond the boundaries of Alaska State waters. Age data are often used in the assessment of groundfish abundance and population condition. This report evaluates the need for age data for various groundfish species and species groups assessed and managed by the State of Alaska. The report provides recommendations for samples sizes for those groundfish species, or species groups, for which age sampling and analysis are deemed desirable.

Key Words: age-determination, groundfish, sample size, stock assessment, otolith, sablefish, rockfish, Pacific cod, lingcod, pollock, flatfish

INTRODUCTION

The State of Alaska has some level of management responsibility for more than 30 individual, commercial groundfish fisheries, with a combined exvessel value greater than $18.5 M in 2002.

Management of some of these fisheries is the exclusive purview of the State because they occur wholly within state waters. In this category are fisheries such as sablefish of the Aleutian Islands, Prince William Sound (PWS) and Chatham and Clarence Straits. Other fisheries, which may have catch and effort both within and outside state waters, (i.e. in the Exclusive Economic Zone), are managed exclusively by the State due primarily to the relatively small nature of the fisheries and/or the majority of the catch occurring in state waters. Fisheries in this category include those such as black rockfish in the Gulf of Alaska (GOA) and lingcod throughout the state. The demersal shelf rockfish fishery in Southeast Alaska falls under a somewhat unique management category. This fishery is managed, and the associated stock assessment conducted, largely by the State, but in cooperation with the North Pacific Fisheries Management Council (NPFMC) and the National Marine Fisheries Service (NMFS) under the GOA Federal Fisheries Management Plan (FMP). Finally, catch of some groundfish species occurs in state waters from groundfish stocks that are assessed and managed primarily by NMFS. The portions of the catch that occur in state waters are managed as parallel fisheries, as the name implies paralleling the counterpart federally managed fishery for a particular species.

Part of the state's management responsibility entails assessing the status of commercially exploited groundfish stocks and promoting the sustainability of the groundfish populations and, thus, the fisheries. Age data, collected primarily from examination of hard structures such as otoliths or fin rays, are often a key element used to assess status of groundfish stocks and for determining appropriate harvest rates.

Quinn and Deriso (1999) note the increasing importance of age composition estimates for understanding fish population dynamics. With time series of length, weight, and age data, fish year-classes may be followed through time to understand growth, track population changes over time and derive age- and sex-specific estimates of population parameters.

Estimates of age compositions and age-related growth patterns may be used to infer stock structure of various species of groundfish (Spencer and Ianelli 2003), in turn providing important information about the relevant geographic scale at which to assess and manage different groundfish stocks. Spencer and Ianelli (2003) indicate that "Spatial differences in age or length compositions can be used to infer differences in recruitment patterns that may correspond to population structure."

For many groundfish species in the North Pacific, age structured analysis, dependent largely on long time series of age composition data, is the main analytical method used to estimate abundance and other important population parameters (e.g. Dorn et al, 2003, Sigler et al. 2003, Hanselman, et al. 2003).

The extent of stock assessment activities associated with the State's management of groundfish fisheries varies considerably, from basic catch accounting, through the collection of biological and catch-per-unit effort data, to the application of specific abundance estimators to determine biomass and the use of state-collected data in population models.

With respect to age data specifically, at this point only pollock age data from otoliths collected by ADF&G during the Central Region and the Westward Region trawl surveys, have been used expressly in an age structured model (Dorn et al. 2003). This model is the principal analytical tool used to determine the status of pollock in the Gulf of Alaska. Historically, ADF&G staff at the ADU has also aged Central Region pollock otoliths. Pollock otoliths are currently being archived pending resolution of issues about pollock age determination criteria.

The groundfish project in the Southeast Region explored the use of an age-structured model for NSEI (Chatham Strait) sablefish, but currently is emphasizing the use of mark-recapture methods as the principle approach for estimating abundance of sablefish (Carlile et al 2002) in that area. Researchers in the Westward and Central Regions anticipate eventual application of an age-structured model, incorporating age composition and abundance index data, for black rockfish. Application of an age-structured model is being considered for the sablefish fishery in PWS (B. Bechtol, ADF&G Homer, pers. com.).

However, currently none of the state's groundfish stock assessment programs use age data directly to estimate abundance of groundfish species, for example in an age-structured model. Rather, graphs of age frequency distributions are examined visually for such purposes as identifying standout recruitment events, tracking cohorts through time, comparing age distributions among areas and/or over time, etc. Age composition estimates are used to corroborate other information, such as trends in fishery-independent survey and/or fishery CPUE, to indicate possible trends or levels in overall abundance. For some populations and fisheries (e.g. yelloweye rockfish and sablefish in Southeast Alaska) age data are also used to estimate growth parameters which are then used in spawning stock biomass per recruit analyses and determination of harvest rates.

This report assesses the needs for groundfish age data in support of the department's groundfish stock assessment and management responsibilities. First, criteria are presented with which to evaluate whether, or to what extent, it may be appropriate for the state to collect age data for particular groundfish stocks, or other population units. For those populations for which it is deemed advisable to collect age data, I discuss criteria for determining the sample sizes of age structures and make recommendations about samples sizes.

CONSIDERATIONS AND RECOMMENDED CRITERIA FOR COLLECTION OF GROUNDFISH AGE DATA

Ideally, the use of age data or sampling of groundfish populations for age determination should be undertaken only after it has been confirmed that the age structures and methods for determining age from the structures, provide sufficiently accurate and precise indications of age—that is, after validation of the age determination method (Beamish and McFarlane 1983). For those species and area combinations for which age validation has not yet been conducted, plans and efforts to conduct age validation should proceed at least in parallel—if not precede—

ongoing production age structure sampling and age determination activities. Although age validation may have been conducted for some species in certain geographic areas there may be a need for age validation of some species from other areas because of obvious differences in otoliths external morphology and annuli patterns that are associated with the geographic area of origin (K. Munk, J. Brodie personal communication, ADF& G, Juneau and Kodiak).

Although groundfish age data are used for a variety of purposes, the focus of this assessment is the use of age data to estimate the age composition of groundfish stocks. The objective is to estimate the age composition with a specified degree of precision. As part of contemporary groundfish stock assessments, time series of age compositions are often employed in a refined quantitative manner as input data into age-structured models to estimate abundance and other population parameters, or used more qualitatively to corroborate other data that may reflect changes in groundfish abundance.

Several factors should be considered in assessing the need for sampling for groundfish ages when the primary objective is to estimate age composition. With respect to advisability of the state collecting groundfish age data, the highest priority should be given to those species for which the State of Alaska has primary management jurisdiction and attendant assessment responsibility. This would include stocks such as sablefish in the Southeast Inside Management Districts and in PWS, and black rockfish and lingcod, in both in state and federal waters. For those species for which the state has only parallel fisheries in state waters, and/or for which we rely on federal stock assessments to determine guideline harvest levels (GHL), serious consideration should be given to forgoing sampling of age structures from those populations or fisheries, except under special circumstances. An example of such circumstance would be where the state collects otoliths from pollock from fisheries and trawl surveys in the Central and Westward regions and provides the otoliths to NMFS, where the otoliths are read and the resulting age data incorporated into the population modeling for the pollock in the Gulf of Alaska (GOA; Dorn et al. 2003).

Stock—or other population unit—distinctness should be addressed in evaluating the need for ageing, as well as other stock assessment sampling. For stock assessment and management considerations groundfish populations may be distinguished by one or more biological, spatial or temporal bounds. If there is a high degree of interchange of a groundfish species between state and federal waters or if there is effectively one stock with high rates of exchange between state and federal waters, separate stock assessment activities may not be necessary or desirable. For those stocks, populations or fisheries for which it is known, or for which there is a high probability, that the fished population is already included in NMFS surveys and stock assessments, collection of age and other stock assessment data may be redundant and unnecessary. For example, because sablefish in the Cook Inlet Area are believed to be part of the Gulf of Alaska sablefish stock (Trowbridge et al. 2001), additional age sampling, either during fishery independent surveys or from the commercial fishery, beyond that conducted by NMFS, may be redundant. As a contrasting example, although there is some exchange of pollock between the internal waters of PWS and the EEZ, studies suggest that pollock in PWS and off Middleton Island may have sufficient genetic distinction from pollock spawning in Shelikof Strait to warrant separate management (Olsen et al. 2002). In this case, because of geographic bounds—owing to PWS being a largely enclosed body of water—and the biological bound suggested by genetic studies, it seems appropriate to conduct assessment activities, including collection of age data, at least somewhat independently of assessment activities conducted for pollock in the EEZ by NMFS, as is currently done.

For some groundfish populations, there may sufficient—but as yet unconfirmed—distinction among portions of the population to warrant separate assessment and management. In addition to genetic studies as one method of determining biological bounds among population units or subunits, standard age, weight and length (AWL) data may be useful. For example, similarities or differences in age compositions among groundfish from particular areas, or times, may provide additional useful information about whether there is sufficient distinction among groundfish to merit separate assessment and management. Some uncertainties regarding the need for separate state-federal assessment and management efforts, may be at least partially addressed by comparing length and/or age compositions from samples from state vs. federal waters (e.g., age composition of Pacific cod from Lower Cook Inlet vs. from NMFS longline or trawl surveys in the GOA), tag returns, etc. Such comparisons must consider potential dissimilarities in age compositions due to the different selectivity of (e.g. state vs. federal) sampling gear. As a more specific example, age composition samples may be useful in differentiating segments of populations of pollock in PWS vs. the GOA, information in turn useful for determining the degree to which stock assessment of PWS pollock independent of federal assessments may be desirable.

As another criterion for assessing age sampling needs, highest priority should be given to those species with the greatest economic or ecological value. For example, species such as sharks and rays may be of greater interest or concern in the future, than currently. Because of the current relatively low interest and/or harvest rates for these species, it may be inappropriate to invest significant resources in stock assessment activities for these species, at this time. Age structures perhaps should not be collected yet for these species, or if collected, archived only and not read, to provide the basis for future age time series, should fisheries for such species develop to greater extent. However, in some instances it may be appropriate to accumulate good stock assessment (including age) data for a species, prior to significant interest/activity in a commercial fishery, to avoid the all-too-common syndrome of the stock assessment lagging far behind the development of the fishery.

Age data alone are insufficient to allow effective application of age structured modeling for a population. Any intended use of age data in an age-structured analysis should have sampling of auxiliary data, such as relative (e.g. CPUE) or absolute abundance information, as a parallel and equally high priority objective. For species (e.g., black rockfish) for which appropriate auxiliary data, or methods for collecting such data, have not been developed, it may still be appropriate to collect age data with a view toward eventual application of age-structured modeling. Age sampling in the absence of auxiliary data may be recommended for at least two reasons. First, in the absence of relative or absolute abundance data, age composition data may provide the most informative data on which to base management decisions for a species, such as rockfish, for which little other information is available but for which the state has primary management responsibility. The age data, then, may have immediate use for stock assessment. Second, age-structured models rely on long time series of data, including age composition, to adequately characterize the dynamics of groundfish populations and estimate various useful population parameters; in general, the longer the time series, the better. So, even if other requisite information—such as abundance data—are not yet available for a particular species, it still may eventually be useful to have accumulated age structures or data which can be incorporated to good effect into an age-structured model once relative or absolute abundance data become available. The age data, if collected, may have future, longer-term use for stock assessment.

An example of the latter case is Pacific cod in the EEZ. Up to the current time, the analytical models used to assess the status of Pacific cod in the GOA and Eastern Bering Sea (EBS) have been length- rather than age-based (Thompson and Dorn 2003, Thompson et al. 2003). An age-structured model has not been used because Pacific cod otoliths have been difficult to read for age determination (Kimura and Lyons 1990). However, recent research combining new age reading criteria, along with a thin-sectioning preparation method apparently holds some promise for producing more accurate age determination for Pacific cod (Roberson 2001). With the advent of the new methods, the NMFS Alaska Fisheries Science Center (AFSC) has recently renewed production aging of Pacific cod, with the intent of eventually implementing an age-structured model as the primary analytical tool for assessing Pacific cod in the GOA and EBS (Thompson and Dorn 2003). In this case application of the refined age determination methods to the archived age structures will provide an accumulated time series of age data to be used in an age-structured model. Absent a backlog of archived structures, any application of an age-structured model would await accumulation of a sufficiently long time series of age data. Therefore while few fisheries managed entirely or partially by ADF&G currently use age composition data directly in age structured models, collection, or continued collection, of age structures should be considered because parameter estimates from age-structured models are generally improved with longer time series of age data.

SAMPLE SIZE RECOMMENDATIONS

Fish age data are used to estimate a variety of population parameters. Frequent uses include estimating age compositions and defining growth (e.g. length-at-age) relationships. Age related parameters, such as age composition, might be used in a variety of additional analyses, including age-structured analyses to estimate abundance and other population parameters. Many applications of age-structured analysis do not rely solely on age composition data, but use age and length data, in combination, to develop age-length keys which are used with length frequency data to estimate age composition (Quinn and Deriso 1999, M. Dorn, NMFS, Seattle, personal communication).

Once it has been determined that sampling for age is desirable for a particular groundfish population or population segment, the sampling design and sample size goals need to be established. For example, two common sampling approaches to estimate age composition are simple random sampling from the population or using an age-length relationship (Kimura 1977). When sampling to define an age-length relationship, either random or fixed sampling is used most often. Southward (1976) and Kimura (1977) determined that random sampling is the more efficient approach. In estimating age compositions based on the use of an age length relationship, Kimura (1977) also concluded that small increases in samples of ages are generally more effective in improving the accuracy of age composition estimates than are increases in sample sizes for lengths.

For most current or intended uses of age data for groundfish fisheries managed by the State, the primary objective for collection of age data is to estimate age composition. Therefore, the focus of this section is the determination of appropriate sample sizes for age structures to use in estimating age composition of various species of groundfish. Regardless of whether estimates of age composition are used in more analytically formal approaches – such as population models or abundance estimators – or more qualitatively, to visually corroborate other indicators of fish stock condition, sample sizes of age structures must be large enough to yield estimates of age composition that are sufficiently accurate and precise.

For application of length-frequency analysis Erzini (1990) concluded that sample sizes in excess of 1000 are necessary to identify more than half the modes in length frequency distributions (after Quinn and Deriso 1999).

Quinn and Deriso (1999) present a method for determining sample sizes to estimate age compositions in the context of sampling for length-at-age estimation. This approach is appropriate when sampling using proportional or fixed allocation (e.g., sampling to achieve a specific sample size for each sex and length interval category combination).

Using this method, Hanselman (NMFS, Juneau, pers. com.) determined that a minimum of 400–600 ages would be needed to obtain estimates of age compositions of important age groups (i.e., comprising 5% or more of the catch) of rockfishes (Pacific ocean perch, northern rockfish and light dusky rockfish) with coefficients of variation (CV) less than 25%. To be able to precisely estimate the proportion of a single age group, using a CV of 10%, Hanselman concluded that age sample sizes in the range of 900–1500 would be needed. Hanselman pointed out that gains in precision decline after about 1,000 fish are aged and suggested 1,000 may be a good target sample size for rockfish. He maintained that samples of this size would generally provide acceptably precise estimates of age composition for important age groups, while simultaneously providing the ability to estimate, more precisely, the proportion of a single age group. Greater precision in estimating a single age group is often desirable, for example, to increase the probability of detecting standout recruitment events early in the history of a cohort.

Sigler (NMFS, Juneau, pers. com.), generally using Kimura's (1977) approach, determined that a sample size of 300 otolith pairs is optimal for estimating sablefish age compositions within depth and area strata. Because sablefish exhibit age/size-associated depth stratification, Sigler prescribes target sample sizes of 300 ages for each of two depth strata, providing a total ageing sample size of 600 sablefish within a geographic area. Sigler increased the target size for collecting ageing structures to 600 per strata to account for special studies and unreadable otoliths. This target is then applied to each area in which the longline survey is conducted.

In a situation where age-length keys are used to estimate pollock age distribution , M. Dorn (NMFS, Seattle, pers. com.) prescribes a minimum of 350 age structures per stratum. Depending on the objectives of a study or survey, strata might include specific fisheries, geographic areas, depth categories, time, sex, etc.

Assuming that age compositions of groundfish follow a multinomial distribution, the method of Thompson (1987) is an alternative approach to determine sample size appropriate for estimating age composition. In 1997 I used this approach to recommend sample sizes appropriate for sampling various species of groundfish in the Southeast Region (Carlile 1997). These sample sizes (Table 1) were prescribed to estimate age compositions such that estimated proportions in each age class are simultaneously within 0.05 of the population proportions, 90% of the time. The sample size needed to achieve this minimal level of precision, regardless of the number of age categories, was 403 readable age structures. These estimates were increased to 433 for NSEI and SSEI sablefish and 415 for yelloweye rockfish in each of the Southeast Outside districts to account for known levels of unsatisfactory age structure readability for those species. Gove

(2002) also used Thompson's approach to make recommendations for groundfish sampling in the Central Region for estimating age proportions.

In prescribing sample sizes for sablefish, Sigler similarly increased the base recommended sample collection sizes, per stratum, from 300 to 600 (pers. com.). This increase in sample sizes was recommended partly to account for unreadable or damaged otoliths.

For more mobile species, such as sablefish, sample sizes may be applied to wider geographic areas to provide a representative sample. For less mobile species, such as yelloweye rockfish, the same sample sizes may need to be applied to multiple, more geographically limited strata (e.g. region or depth) to yield desirable estimates with a specified precision within those more limited strata.

In planning sampling, it is important to sample adequately to achieve the stated objective(s). In general for the goal of estimating age composition with sufficient precision, sampling less than 300 fish, or opportunistically—"… as many as we can get"—will generally not be a worthwhile use of resources. Such opportunistic under-sampling will likely be wasting collection, storage, archiving, and age reading time for minimally useful, perhaps effectively useless or even potentially misleading data. Recent records from the ADU indicate receipt of otoliths from species such as thornyheads, shortraker and dusky rockfishes as well as several other species, from certain areas, with samples sizes less than 150. Such small samples sizes most probably will not yield reliable estimates of age composition.

While small sample sizes will probably not yield reliable annual estimates of age composition—the principle focus of this evaluation—small samples, collected periodically, may be useful for estimating other fish population parameters of interest. An example would be determining the relationship between fish weight and age, information that may be used to estimate other relationships such as spawning biomass per recruit and for determining appropriate harvest rates. Assuming that the underlying relationship between weight and age did not change over the period that weight and age data were collected, small sample sizes of weight and age data, perhaps collected opportunistically, say over a number of years, could, cumulatively, provide a sufficiently large sample size covering an adequate range of ages to provide acceptable parameter estimates defining the age-weight relationship. Although collection of small samples of age structures and data may be defensible in some instances, even this type of data collection should be undertaken only with clear objectives and procedures for such collections should be well defined. Wholly opportunistic collection of structures is inadvisable. Some design would be needed to detail, among other aspects of the sampling, the range of ages needed. As the planned sampling for particular age (or size) ranges is completed, focus for further collections should shift to those ages (or sizes) for which the planned sample sizes have not been achieved. No further collections or ageing should be undertaken for those fish sizes for which planned sample sizes have already been attained.

The potentially misleading results of insufficient sampling are evident in Figure 1, using length, a correlate of age, to show how apparent length composition can change depending upon sample size. The varying sample sizes and attendant length compositions were obtained by randomly selecting length samples of varying sizes from the n = 9,890 total sample size from the 2002 commercial sablefish fishery in the NSEI (Chatham Strait) district of the Southeast Region. In this figure, sample sizes in the n = 100–200 range suggest that the proportion of fish from a cohort, or cohorts, in the 620 mm length category is greater than that in the 660 mm category.

However, increasing sample sizes, in the n ≥ 500 range, indicate what is more likely the case—that cohorts represented by the 660 mm category predominated in the 2002 catch. In this case, the apparent standout size class suggested by the smaller (n=100–200) sample sizes is probably a misleading artifact of insufficient sample sizes. The distribution seems to stabilize at a sample size between 1000 and 2000. Smaller sample sizes may suggest standout year classes (presumably due partly to variation related to small sample sizes), whereas larger sample sizes (probably more representative of the population) are more likely to alleviate what may be false indications of standout year classes. While this example reflects the affect of sample size on estimates of length composition, similar outcomes might be expected for age compositions. The main point is that insufficient sample sizes may yield apparent age distributions that are biased and may substantially degrade the performance of an age structured model, lead to inappropriate conclusions about stock condition and trends, and poor management decisions.

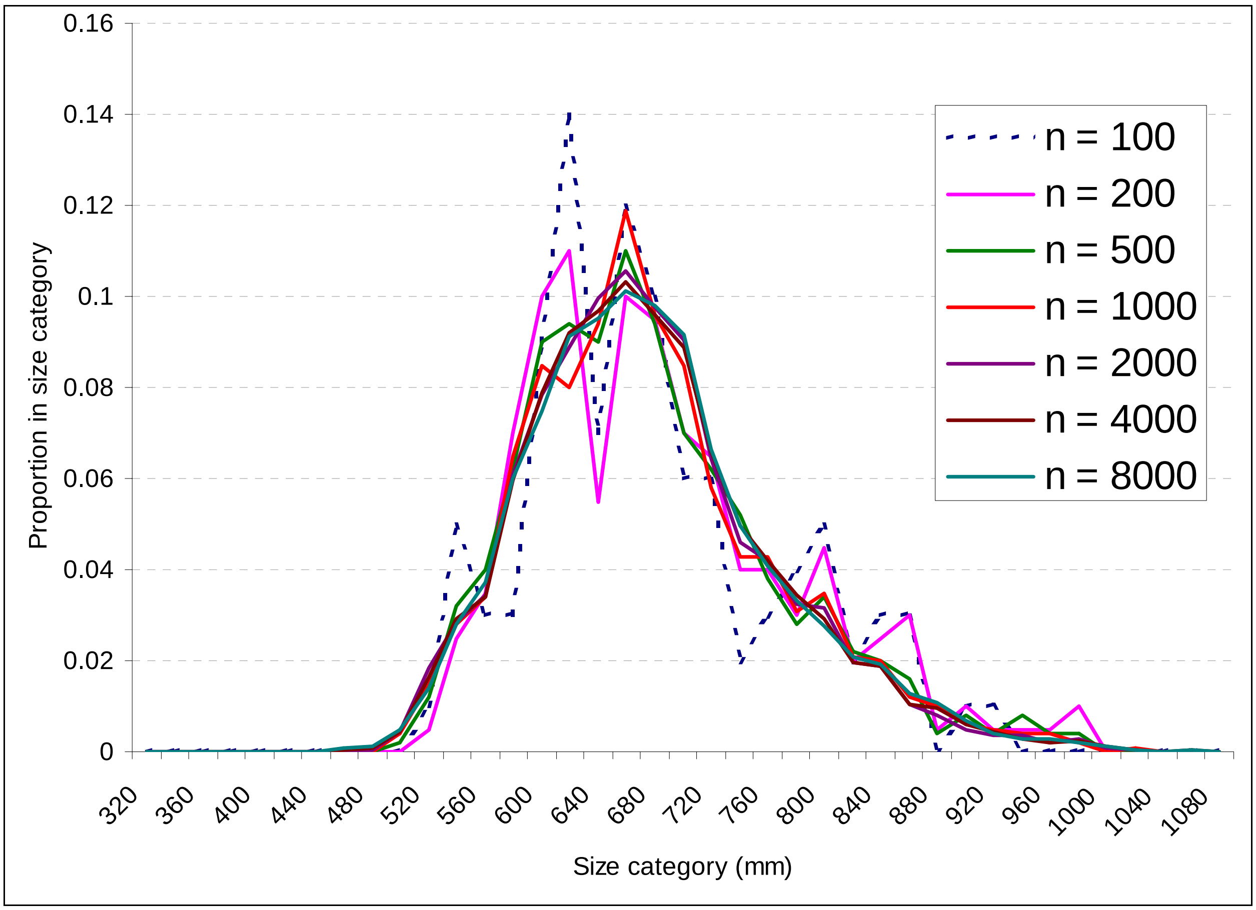

Figure 1.–Comparison of length distributions of sablefish from the 2002 NSEI (Chatham Strait) commercial sablefish fishery, based on sample sizes in the range n = 100–8000.

Table 1.– Recommended annual sample size for S.E. Alaska groundfish age structures.

Species	Area	Recommended sample size	Number of structures submitted for ageing in 1995
Anoplopoma fimbria	NSEI	433	
Subtotal	SSEI	433	
Ophiodon elongatus	All areas combined	403	478
Subtotal		403	
Sebastes ruberrimus	E. Yakutat	415	
	NSEO	415	
	CSEO	415	
	SSEO	415	
Subtotal		1660	1828
Other species	All areas combined	0	359
Total Annual Age Structure		2929	

Source: AGELAB95.XLS

For those species associated with a particular fishery for which there is no established abundance estimator that relies on age composition data, and for which age compositions are used primarily to identify potential standout recruitment, larger sample sizes, in the 800–1,000 range, should be considered, (e.g. per Hanselman, NMFS Juneau, pers. com.), in order to identify those standout recruitments. Current applications of age compositions for state GF stock assessments use the estimates to identify marked or standout recruit classes. However, consideration should also be given to achieving sample sizes sufficiently large to identify more modest recruit classes with sufficient precision also, since several years of back-to-back modest recruitment can have a cumulatively profound effect on abundance levels and trends.

In the following section, sample size recommendations specific to groundfish population units for which the state has at least some assessment and management responsibilities are included for each species or species group within a region.

REVIEW OF STATE OF ALASKA GROUNDFISH FISHERIES, MANAGEMENT AND STOCK ASSESSMENT, AND AGE COMPOSITION SAMPLE SIZE RECOMMENDATIONS.

The State of Alaska manages major commercial groundfish fisheries in the internal and coastal waters (0–3 miles from shore) of the Southeast, Central and Westward Regions. Determining the need for age sampling and age structure sample sizes is dictated by considerations such as stock assessment goals, management responsibilities and behavior of various groundfish species. With that in mind, in this section I provide a brief synopsis of groundfish fishery management and stock assessment activities, to place the discussion of age sampling and sample sizes in the context of the stock assessment and fishery management activities to which sampling for age estimation may contribute. I then make recommendations about the level of age structure sampling needed, if any, to fulfill the state's assessment and management responsibilities associated with each of the fisheries. For those fisheries and/or populations for which I recommend sampling for age structures, I again use Thompson's (1987) method of sample size determination. However, I have increased the target precision, relative to a previous recommendation (i.e. Table 1.) and the sample sizes are chosen to promote simultaneous estimates of age proportions that are within +/– 0.05 (absolute) of the true age proportions, 95% of the time, rather than 90% of the time. This increase in the target precision is intended, in part, to increase the chance of detecting potential standout recruitment age classes.

Southeast Region

Sablefish

The State of Alaska manages two sablefish fisheries in the internal waters of Southeast Alaska, in the Southern Southeast (Clarence Strait) and Northern Southeast (Chatham Strait) Inside (NSEI and SSEI) Districts. Both fisheries are managed under equal share quota systems, wherein the annual guideline harvest levels (GHL) are divided equally among a limited (under license limitation programs) number of permit holders. The NSEI district fishery is a longline fishery, which runs from August 15 through November 15. In the SSEI district longline gear may be used from June 1 to August 15, and pots from September 1 to November 15.

The GHL for the NSEI District currently is based on an $F_{40\%}$ harvest rate applied to a biomass estimate determined from an annually updated mark–recapture-based abundance estimate. The GHL for the SSEI is based on historical catches and trends in relative abundance, presumably reflected in catch-per-unit-effort (CPUE) data from the fishery and an annual fishery independent longline survey, along with evaluation of age composition trends. In addition to mark–recapture data from the NSEI District, additional stock assessment activities, in both districts, include port sampling to collect data on age, sex, weight, length and sexual maturity. These, as well as catch-per-unit-effort (CPUE) data, are also collected during annual, fishery independent longline surveys. Data on commercial fishery CPUE and effort location are collected from mandatory logbooks. Otoliths are collected during the longline surveys and port sampling and sent to the ADF&G Age Determination Unit (ADU) in Juneau for age determination.

Use of an age-structured model for assessing status of the NSEI sablefish has been explored, but has been problematic because of widely varying biomass estimates from the model, and questionable assumptions about applying such models to sablefish in the NSEI District. As yet, use of an age-structured, or other population, model has not been explored for sablefish in the SSEI District.

Exchange of sablefish between the internal waters of Southeast Alaska and the Gulf of Alaska (GOA) and the West Coast of British Columbia, and to lesser extents the Bering Sea/Aleutian Islands and West Coast of the U.S., has long been documented in tag returns from a variety of tagging programs (e.g. Kimura et al. 1998, Maloney and Heifetz 1997, Heifetz and Fujioka 1991, Bracken 1982). Sablefish in the NSEI and SSEI districts are generally considered to be part of a North Pacific sablefish stock (Kimura et al. 1998). However, the status of sablefish inhabiting the internal waters of Southeast Alaska is currently assessed separately from those of external waters because of the apparent low movement rates of sablefish between inside and outside waters over the short (i.e. 1–4 years) term, particularly for the NSEI district (e.g. Maloney and Heifetz 1997, Bracken 1982).

Sampling recommendation: Sample 550 sablefish each from the longline surveys and commercial fisheries for each of the NSEI and SSEI districts, for a total of 2,200 sablefish annually. Randomize the order of reading 550 structures collected per stratum, Age otoliths until 510 structures with age readability codes less than 3 have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: The state has sole management and stock assessment responsibility for these fisheries. Age data are needed to corroborate abundance data to determine levels and trends of abundance. Age data may also be incorporated into a region-wide [i.e. state internal waters, GOA and Bering Seas/Aleutian Islands (BS/AI)] age structured analysis in the future, which also may account directly for movement among internal waters of the state, the GOA and BS/AI. Age data are also needed to estimate size-at-age parameters for use in conducting spawning stock biomass per recruit (SSB/R) analyses to determine appropriate harvest levels for sablefish. The sample size of 510 fish aged is adequate to characterize age composition of sablefish at the specified acceptable level of precision.

Demersal Shelf Rockfish

The fishery for demersal shelf rockfish (DSR) in the Southeast Outside (SEO) Management Areas is managed jointly by the State of Alaska and NMFS, although the state has primary management authority and assessment responsibility. The fishery in the outside management areas (SEO) is included under the NPFMC's GOA Fishery Management Plan (FMP). The fishery for DSR in the two internal state water subdistricts, NSEI and SSEI, are managed by ADF&G. These are open access fisheries. There is a directed longline fishery and significant bycatch mortality in the halibut fishery (O'Connell et al. 2002). Seven species of rockfish comprise the DSR management assemblage, although most (90%) of the catch is yelloweye and to a lesser extent (8%), quillback rockfish. In part because of the limited movement of DSR species, and to reduce the chance of localized depletion, separate harvest ranges are applied to each of six management areas (O'Connell et al. 2002). The directed quota is apportioned between two seasons: 2/3 during January 1 to March 15 and the remaining 1/3 during November 16 to December 31 (O'Connell et al. 2002).

Although managed jointly by the state and NMFS, the state conducts stock assessments for DSR. A habitat-based stock assessment approach is used, wherein abundance of yelloweye rockfish is determined using line transect methods (Buckland et al. 2001) from a research submersible. Only rocky habitats, comprising the vast majority of the habitat types occupied by DSR, are surveyed and resultant biomass estimates are applied only to estimated rocky habitat areas. Abundance is estimated separately for each of the SEO areas.

Age structures are obtained from catch in the commercial fishery and from fish sampled during fishery-independent longline surveys, and sent to the ADU for age determination. The age data are not used in any type of age structured, or other population model. Graphical displays of age compositions are examined and evaluated to determine recruitment patterns and trends. There are currently no plans to incorporate AWL data into a formal population model for DSR. In addition to AWL data, CPUE data are collected during fishery-independent longline surveys and mandatory logbooks from the commercial fishery. Catch data are collected from fish tickets.

The quota for DSR in the outside management areas is determined by applying an F=M harvest applied to biomass estimates from the line-transect-derived abundance estimates (O'Connell et al. 2003).

In 2003, 1,337 yelloweye otoliths were sent to the Age Determination Unit in Juneau.

Sampling recommendation: Sample 550 yelloweye rockfish each from longline surveys, or the fishery for each of the SSEO, CSEO and E. Yakutat districts, for a total of 1,650 yelloweye rockfish annually. Randomize the order of reading 550 structures collected per stratum. Age otoliths until 510 structures with age readability codes less than 3 have been read. Cease ageing after the target 510 readable structures per stratum has been attained.

Rationale for sampling recommendation: The state has sole management and stock assessment responsibility for the demersal shelf rockfish fishery. Yelloweye rockfish constitute over 90% of the annual catch from the management assemblage. Age data are needed to corroborate abundance data to determine levels and trends of abundance and may be incorporated into region-wide age-structured analysis at some point in the future. The prospect for developing and implementing such a model is good, since a time series of abundance data, in the form of periodically updated line-transect-based density and biomass estimates, is available as auxiliary data for an age-structured model. Age data are also needed to estimate size-at-age parameters for use in conducting spawning stock biomass per recruit analyses in order to determine appropriate harvest levels for yelloweye rockfish. The recommended 510 age structures read, per stratum, should be adequate to characterize the age composition of yelloweye rockfish at the specified, acceptable precision.

Black Rockfish

Prior to 1998, black rockfish and blue rockfish were included in the pelagic shelf rockfish management assemblage, the fishery for which was managed by NMFS under the GOA FMP. In April 1998, management responsibility for these two species was transferred to the State of Alaska (Clausen et al 2003). There is a directed fishery for black rockfish, with legal gear restricted to dinglebar troll or hand troll gear or mechanical jigging machines. All internal waters of Southeast Alaska, as well as four areas in the SEO, are closed to directed fishing for black rockfish.

Variably sized GHLs are specified for each of the subdistricts in the SEO Area, and the East Yakutat and the Icy Bay Subdistrict.

Logbooks are required and yield CPUE and fishing time and location data. Age, weight and length data are collected during port sampling of the commercial catch. Otoliths are collected during port sampling and sent to the ADU for age determination. In 2001, 101 black rockfish were sampled for age, weight, length, sex, and maturity (O'Connell et al. 2002).

Research to evaluate a mark–recapture method for abundance estimation was conducted in 1999, 2000 and 2002. Sampling to examine spatial structure in genetic variation of black rockfish was completed in 2001.

In 2003, 244 black rockfish otoliths were sent to the ADU for age determination.

Sampling recommendation: Sample 550 black rockfish from the fishery for the SEO area, for a total of 550 black rockfish annually. Randomize the order of reading 550 structures collected. Age otoliths in the order randomized, until 510 structures with age readability codes less than three have been read. Cease ageing after the target 510 readable structures has been attained. (Table 2).

Rationale for sampling recommendation: The state has sole management and stock assessment responsibility for the black rockfish population(s) and fisheries throughout the state. Age data collected from port sampling may be the most readily available data for use in assessing possible trends in abundance since, as yet, there is no method developed for directly estimating abundance of black rockfish in the SEO. The sample size of 510 fish read, per stratum, should be adequate to characterize the age composition of black rockfish with the specified acceptable precision.

Lingcod

There is a directed fishery for lingcod in Southeast Alaska using dinglegar troll gear. In addition, there is significant bycatch in directed longline fisheries for rockfish and halibut, and in the troll fisheries for salmon (Gordon 1994).

Key elements of lingcod management include: area-specific quotas, seasons, allocation of GHLs among commercial and sport fisheries and directed and bycatch commercial fisheries, possession and landing requirements and size limits.

Stock assessment data related to the fisheries have been collected from port sampling, skipper interviews and onboard observers (Gordon 1994). Data collected has included CPUE, fishing locations, and length, sex and maturity of fish in the commercial catch. Data such as CPUE and fishing location are also collected from mandatory logbooks. Fisheries independent estimates of length, sex, maturity and age have been obtained from data collected primarily during research surveys to tag fish for movement and migration studies. Both otoliths and fin rays have been collected and sent to the ADU for age determination. In 2003, 2,319 structures were submitted to the ADU for processing. Both otoliths and fin rays have been collected since it has not been determined definitively which structure, if either, provide more accurate indication of age.

As with Southeast sablefish and rockfishes, age data are not currently used directly in any type of population modeling to estimate abundance.

Most lingcod appear to undergo minimal movement. Multi-year tagging studies in Southeast Alaska indicate a median distance between mark and relocating points of less than 5 km. (http://www.cf.adfg.state.ak.us/region1/finfish/grndfish/lingcod/lcprofile.php)

Sampling recommendation: All age reading should halt and structures be archived only, until age validation and determination of the preferred age structure – otoliths or fin rays – has been completed. Once age validation and selection of a preferred structure for ageing has been completed, sample 550 lingcod from each of the E. Yakutat, CSEO and SSEO districts in the SEO area, for a total of 1,650 lingcod annually. Randomize the order of reading 550 structures collected from each district. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 (?) have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: The state has sole management and stock assessment responsibility for the lingcod population and fishery in Southeast Alaska. Age data collected from port sampling, in concert with fishery CPUE data from logbooks, may be the most readily available data for use in assessing possible trends in abundance since, as yet, there is no method developed for directly estimating abundance of lingcod in Southeast Alaska. The three sub districts recommended for accrual of a time series of age composition data contributed over 70% of the catch from the longline (i.e. sablefish and halibut) and 85% of the directed lingcod fisheries in the SEO between 2000 and 2003. Age data may provide future basis for application of an age-structured model if an abundance estimator is developed and implemented to provide the necessary abundance estimates as auxiliary data for the ASA. The recommended 550 fish, per stratum, is sufficient to characterize the age composition of lingcod with the specified acceptable precision.

Pacific Cod

The State of Alaska manages Pacific cod fisheries in the internal waters of Southeast Alaska. In addition, the state also manages a fishery in the outer coastal waters of Southeast (0–3 mi; Coonradt 2002), which parallels the NMFS management in the federal waters of the Gulf of Alaska (3–200 mi). The majority of Pacific cod harvested in Southeast waters is caught on longline gear (O'Connell et al 2002). In 1993, the Alaska Board of Fisheries (BOF) established a guideline harvest range (GHL) of 340 to 570 mt for Pacific cod. This GHR was based on average historic harvest levels (O'Connell et al. 2002).

Although there are no fishery-independent surveys conducted expressly for Pacific cod in Southeast, some Pacific cod are caught during periodic longline surveys for sablefish and DSR. Pacific cod are also tagged during longline surveys. Biological data collected from these surveys and port sampling include: length, weight maturity stage and age. Pacific cod are also tagged during longline surveys. As with all other groundfish species in Southeast a mandatory logbook provides data on fishery CPUE. Commercial harvest data are collected from fish tickets.

Tagging (e.g., Shimada and Kimura 1994) and genetic studies (e.g., Grant et al. 1987) suggest significant exchange of Pacific cod within and among the EBS, AI, and Gulf of Alaska (GOA) areas (Thompson and Dorn 2003). These findings would tend to suggest little, if any, distinction between Pacific cod assessed in federal vs. state waters.

In 2003 the Southeast groundfish project submitted 132 Pacific cod otoliths to the ADU for age determination.

Sampling recommendation: No collection of age structures (Table 2).

Rationale for sampling recommendation: Currently, harvest of Pacific cod in state waters of Southeast Alaska is insufficient to warrant a stock assessment effort that includes collection of age structures and age reading. Stock assessment and management responsibilities for other species such as sablefish, demersal shelf rockfish, lingcod and black rockfish eclipse needs for Pacific cod stock assessment, and require more assessment resources than are currently available.

Flatfish

A beam trawl fishery for flatfish is confined to three small areas in the internal waters of Southeast Alaska. As with all other Southeast fisheries, logbooks are mandatory and some areas cannot be fished without an ADF&G observer on board. A history of very high prohibited species bycatch rates, coupled with reduced flatfish stocks, necessitated these restrictive management measures. In addition, there is a 20,000-pound maximum weekly trip limit (O'Connell et al. 2002). Starry flounder comprised the majority of the flatfish catch in the Southeast and is used for bait in other groundfish fisheries (O'Connell et al. 2002).

Beyond catch records and the potential for collection of biological data by on board observers, there are no stock assessment data collected regularly for flatfish in the internal waters of Southeast Alaska.

Sampling recommendation: No collection of age structures (Table 2).

Rationale for sampling recommendation: Current harvest of flatfish in state waters of Southeast Alaska is insufficient to warrant a stock assessment effort that includes collection of age structures and age reading. Stock assessment and management responsibilities for other species such as sablefish, demersal shelf rockfish, lingcod and black rockfish require more assessment resources than are currently available and supercede any need or capability for flatfish stock assessment.

Central Region

Sablefish

The PWS District has separate seasons and guideline harvest ranges. Sablefish fisheries in outer coastal state waters (0–3 miles) of North Gulf District of Cook Inlet have been managed in conjunction with the federal-managed fishery in the EEZ. Unlike the fishery in the EEZ, this fishery is an open access fishery in state waters. The GHL for the North Gulf District is set based on a historic 5-year harvest level that is adjusted annually by the same relative change in the Central Gulf Area TAC set by the NPFMC (Trowbridge et al. 2001). This proportional adjustment is deemed appropriate because sablefish in the Cook Inlet Area are believed to be part of the stock assessed in the Gulf of Alaska (Trowbridge et al. 2001). The sablefish fishery in internal waters of PWS has occurred under limited entry since 1996. There are gear and vessel size restrictions in this fishery. Logbooks and catch reporting are mandatory in the PWS sablefish fishery. The GHL is set as the midpoint of a harvest range based on a yield-per-habitat-estimate using the 1969–1979 sablefish catch in SSEI (Clarence Strait) district in Southeast Alaska as a basis (B. Bechtol pers. com.).

Biological and fishery data from the PWS and Cook Inlet Areas sablefish fisheries are collected annually during post fishery skipper interviews and port sampling (O'Connell et al. 2002). This sampling provides data on date and location of harvest, length, weight, sex, and maturity. Otoliths are also collected and sent to the ADU for determination of ages. In 2003 1,375 sablefish otoliths were sent to the ADU for age determination (K. Munk pers. com.) A limited mark–recapture study of PWS sablefish was implemented in 1999 and resumed in 2001, marking fish captured during biennial bottom trawl surveys.

Fishery independent longline surveys have been conducted annually since 1996 in PWS, and in the North Gulf District in 1999, 2000 (O'Connell et al. 2002) and 2002 (B. Bechtol pers. com.). There are currently no plans for further surveys without supplementary funding (B. Bechtol pers. com.).

Sampling recommendation: Sample 550 sablefish each from the longline survey and commercial fishery in PWS, for a total of 1,100 sablefish annually. Randomize the order of reading 550 structures collected. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: The State of Alaska has sole management and stock assessment responsibility for the sablefish fishery and population in PWS. Like Chatham Strait in Southeast, PWS is a large, partially enclosed, body of water that may have at least a semi-resident population of sablefish with slow (i.e. multiple years) rates of exchange with the outside waters of the GOA and beyond. These attributes suggest the probability of a degree of distinction, or separation, between sablefish in PWS and in the GOA that may merit management and assessment activities distinct from those in federal waters. Age data are needed to corroborate abundance data to determine levels and trends of abundance. In the future, age data may be incorporated into region-wide age structured analysis, as suggested as a possibility for sablefish in the Southeast. The recommended sample size of 510 fish aged should be adequate to characterize age composition of PWS sablefish at the specified acceptable precision.

Rockfishes (including Black rockfish)

Rockfishes in the Central Region are managed as three groups: demersal shelf (DSR), pelagic shelf (PSR), and slope rockfish. The DSR group includes yelloweye, quillback, china, copper, rosethorn, canary, and tiger rockfish. Pelagic shelf rockfish (PSR) includes black, blue, dusky, yellowtail, and widow. For management purposes, black and blue rockfish were removed from the PSR group of the GOA FMP and transferred to state management in 1998. Slope rockfish contain all other *Sebastes* species.

Rockfish fisheries in the Cook Inlet and PWS Areas are managed under Rockfish Management Plans. Plan elements include a directed fishery in Cook Inlet with a GHL followed by a bycatch-only fishery and 5-day trip limits varying in size among districts, and a 5% rockfish bycatch limit for jig gear during the state waters Pacific cod season. The directed rockfish fishery in the Cook Inlet Area is restricted to jigs only, primarily because this fishery typically targets pelagic rockfish species. At The PWS area has a bycatch-only fishery with mandatory retention of all incidentally harvested rockfish (O'Connell et al. 2002). Guideline harvest levels are currently based on long term catches of all rockfish species in aggregate and do not necessarily reflect changes in abundance of individual species or in fishing patterns (O'Connell et al. 2002).

Data collected from skipper interviews and port sampling used to sample commercial rockfish deliveries includes date and location of harvest, species, length, weight, sex, and gonad condition. Additional sampling for species length, weight, sex and maturity occurs during the Cook Inlet and PWS trawl and sablefish longline surveys. Otoliths are collected from most sampled fish. Central Region staff determines ages of pelagic and demersal shelf rockfish from otoliths, while otoliths from all other rockfish species are sent to the ADU (O'Connell et al. 2002). In 2003, 804 rockfish otoliths were sent to the ADU, the majority of these being rougheye and shortraker.

Beginning in 2000, Central Region groundfish staff conducted a 3-year project designed to develop and implement a sampling approach for estimating black rockfish abundance in specific nearshore habitats of Southcentral Alaska along the Northern Gulf of Alaska. The project focused on the use of mark–recapture methods and scuba as elements of a habitat-based assessment of black rockfish (O'Connell et al. 2002).

Sampling recommendation: Sample 550 black rockfish each from the fisheries in the Cook Inlet (North Gulf and Cook Inlet Districts combined) Management Areas, for a total of 550 black rockfish annually. Randomize the order of reading 550 structures collected. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 (?) have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: Management and stock assessment for the black rockfish population and fisheries is the responsibility of the State of Alaska. Age data collected from port sampling is the most readily available data for use in assessing possible trends in abundance since, as yet, there is no method developed for directly estimating abundance of black rockfish in the Central Region. Sample size of 510 fish read, per stratum, should be adequate to characterize the age composition of black rockfish at the specified acceptable level of precision. Other rockfish, which may be caught in sufficiently significant numbers in state waters of the

Central Region, are assessed by NMFS. Harvest of black rockfish in PWS is insufficient to yield minimum sample sizes necessary to estimate age compositions with adequate accuracy and precision (W. Dunne, ADF&G Homer, pers. com.).

Lingcod

Regulations for the Central Region commercial lingcod fishery include seasons, spawning/nest guarding season closures, bag and possession limits, closed areas (Resurrection Bay), minimum size and gear limits (jig only in the Cook Inlet Area) and GHLs (O'Connell et al. 2002). In 1997, commercial lingcod fishery GHLs for the Central Region were set at 50% of the mean 1987–1996 catch. In 2001 the GHL for the PWS Area was increased to 75% of the mean. The GHL was increased to be consistent with the most conservative NPFMC-prescribed harvest approach for fisheries with little data on abundance or stock structure (Berceli et al. 2002). These regulations are intended to be quite conservative, given the minimal quantitative stock assessment data (O'Connell et al. 2002).

Assessment data that are available are collected from skipper interviews and port sampling. The data include date and location of harvest, length, weight, and sex. Maturity usually cannot be determined because most fish are delivered already gutted. Both otoliths and fin ray sections are collected for age determination. Fin rays are prepared and ages determined by Central Region staff. Otoliths are sent to the Age Determination Unit. Both fin rays and otoliths are collected with the intent of comparing age estimates between the two structures and determining which method is preferable. In 2003, 350 otoliths were sent to the ADU for age determination.

Sampling recommendation: Any current production age reading should halt, and future collected structures be archived only, until age validation and determination of the preferred age structure – otoliths or fin rays – has been completed. Once age validation and selection of a preferred structure for ageing has been completed, sample 550 lingcod from each of the PWS Outside District and the Cook Inlet Management Area, for a total of 1,100 lingcod annually. Randomize the order of reading 550 structures collected. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 (?) have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: As in the Southeast Region, the state has sole management and stock assessment responsibility for the lingcod population and fishery in the Central Region. Age data collected from port sampling are currently among the most readily available data for use in assessing possible trends in abundance. Currently, no method has been developed for directly estimating abundance of lingcod in the Central Region. The two areas recommended for accrual of a time series of age composition data have contributed over 80% of the commercial lingcod catch in the Central Region thus far in 2004. The GHL for lingcod in the PWS Inside District for 2004 was only 5,500 pounds compared to 19,000 and 52,500 for the PWS Outside District and Cook Inlet Management Area. The recommended samples may provide future basis for application of an age-structured model when an abundance estimator is developed and implemented to provide the necessary abundance estimates as auxiliary data for the ASA. The recommended sample size of 510 structures read, per stratum, should be sufficient to estimate the age composition of lingcod with the specified acceptable precision.

Pacific cod

Fisheries for Pacific cod in the PWS Area are managed under the PWS Pacific Cod Management Plan. There are two seasons, a parallel season and a state waters season. On the outer coast of the Central Region cod are managed in conjunction with TAC levels set by the federal government for the adjacent EEZ. There are gear restrictions in place in state waters of PWS and lower Cook Inlet to reduce crab bycatch. Under Pacific cod Management Plans adopted by the BOF in 1996, the fisheries are managed through season, gear, and harvest specifications. State fishing seasons follow the federal season, only pot or jig gear are allowed and GHLs are gear specific. Annual GHLs are determined as percentages of the allowable biological catches (ABC) established by the NPFMC.

Earlier tagging (e.g., Shimada and Kimura 1994) and genetic studies (e.g., Grant et al. 1987) suggest significant exchange of Pacific cod within and among the EBS, AI, and Gulf of Alaska (GOA) areas (Thompson and Dorn 2003). These findings would tend to suggest little, if any, distinction between Pacific cod assessed in federal vs. state waters. However, more recent tagging programs being conducted by ADF&G and NMFS, in the GOA and the BS/AI, suggest there may be less movement of Pacific cod, at least from certain areas, and greater site fidelity than previous studies suggested (D. Urban, ADF&G Kodiak, pers. com.). Also, new genetic work has been proposed by NMFS to evaluate possible stock distinctness at scales smaller than currently assumed.

Commercial catches are sampled for age, weight, length, sex, and stage of maturity. On board observers are used on day trips to collect catch and at-sea discard data in the nearshore pot fisheries.

Pacific cod otoliths have been particularly difficult to read for age determination (Kimura and Lyons 1990). However, recent research combining new age reading criteria along with new preparation methods holds some promise for producing more accurate age determination for Pacific cod (Roberson 2001). However, to this point, abundance estimates and other population parameters for GOA Pacific cod are obtained from length- rather than age-structured population modeling (Thompson et al. 2002).

In 2003, 1,078 otoliths from Central Region Pacific cod were sent to the ADU for age determination.

Sampling recommendation: The current otolith collection and age reading regime for Pacific cod should be maintained for the remainder of the fishing year. Prior to next year's Pacific cod fisheries, the sampling design for collection of Pacific cod otoliths should be evaluated to determine if the current geographic distribution of otolith samples (fisheries and areas) is appropriate to evaluate the possible stock distinctness at scales finer than currently assumed. This possibility of stock distinctness has been suggested by recent tagging. Therefore, currently available tagging data should be analyzed to further address the question of stock distinctness. A future recommendation on appropriate sample size and distribution among fisheries and geographic areas will be based on these recommended evaluations and analyses (Table 2).

Rationale for sampling recommendation: The GHLs for Pacific cod in Central Region are based on percentages of the allowable biological catches (ABC) established by the NPFMC. The NMFS has a well-established stock assessment program for Pacific cod, which has included collection of age structures. However to this point in time, the primary analytical tool used to assess the status of Pacific cod in the GOA and BS/AI has been a length-, rather than age-, structured model. The use of a length-, as opposed to age-based model has been due to insufficient confidence in the ability to accurately age Pacific cod from otoliths. Recently, improved methods of age reading have been developed and the AFSC is resuming production ageing of Pacific cod. Tagging (e.g., Shimada and Kimura 1994) and genetic studies (e.g., Grant et al. 1987) suggest significant exchange of Pacific cod within and among the EBS, AI, and Gulf of Alaska (GOA) areas (Thompson and Dorn 2003). Based on the fact that the State's current approach for setting GHLs is based on NMFS stock assessment, the acknowledged difficulty in accurately ageing Pacific cod, and the apparent lack of population differences among Pacific cod throughout the GOA and BS/AI, collection of Pacific cod age data by the state seems somewhat difficult to justify at this time. However, recent indications of possible greater-than-assumed site fidelity of Pacific cod, in some areas, do suggest the need for further evaluation of stock distinctness and perhaps more focused assessment and management of Pacific cod in state waters. Existing length and age composition data from Pacific cod commercial fisheries from state and federal waters should be analyzed to further explore for possible population differences in Pacific cod. In addition, existing state, and if possible federal, tagging data should be analyzed to further address questions about distinctness of Pacific cod stocks or other population sub-units.

Pollock

Most of the commercial pollock catch in PWS is taken with mid-water trawls (Bechtol 2001). Regulations for management of the PWS commercial pollock fishery include a permit requirement, a registration deadline, mandatory logbooks, catch reporting, and accommodation of a department observer upon request. Vessels are required to check in and out of the area and fishery and provide a daily catch, effort, and fishing location report to the department. Harvest from any one of three sections within the PWS Inside District is limited to no more than 40% of the GHL from any section (O'Connell et al. 2002).

Fishery-independent pollock stock assessment activities in PWS include summer and winter hydroacoustic surveys, with sample collection by mid-water trawl, a longline survey and biennial bottom trawl surveys of post-spawning pollock during the summer. Age, weight, length, sex and maturity data are collected from each of these surveys. Biomass estimates derived from the latter survey are used to set the harvest guideline for the winter commercial fishery. This approach is used because a substantial part of the spawning population targeted in the winter fishery is thought to have immigrated from federal waters, whereas the summer population is not assessed by the NMFS summer survey in federal waters (Bechtol 2001, O'Connell et al. 2002).

Catch sampling from the commercial fishery yielded age, weight, length and maturity data (O'Connell et al. 2002)

Genetic studies of pollock indicate significant variation between North American and Asian pollock and evidence that spawning aggregations in the Gulf of Alaska, including PWS, may be sufficiently distinct to warrant management as distinct stocks. (O'Connell et al. 2002)

Results of genetic studies of pollock stock structure in the Gulf of Alaska are somewhat ambiguous. There is evidence that spawning populations in the northern Gulf of Alaska (PWS and Middleton Island) may be genetically distinct from the spawning population in Shelikof Strait (Olsen et al. 2002). However there was also significant genetic variation in pollock samples within PWS between 1997 and 1998, suggesting some instability in genetic structure for this spawning population. Possible reasons suggested for the interannual variation included variable reproductive success, adult philopatry, source-sink population structure, or the use of common spawning areas by genetically distinct stocks with different spawning timing (Olsen et al. 2002, Dorn et al. 2003).

Ages from samples of pollock otoliths collected during the 2000 and 2002 ADF&G surveys were determined by age readers in the AFSC age and growth unit and used in the NMFS pollock assessment (Dorn et al. 2003).

To account for pollock catch in the State-managed fishery, the federal TAC was set below the ABC in each of the years 1997 through 2003 (15% in 1997 and 1998; 20% in 1999; and 23% in 2000–2003; Thompson et al. 2003).

In 2003, 1,501 pollock otoliths were submitted to the ADU for purposes of age determination.

Sampling recommendation: Sample 550 pollock from the fishery and trawl survey in Inside District of PWS combined, for a total of 1100 pollock annually. Randomize the order of reading 550 structures collected from each of the fishery and survey. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 (?) have been read. Cease ageing after the target 510 readable structures has been attained. If deemed feasible (see "*Rationale for Sampling Recommendation*", below), age determination from pollock otoliths collected by ADF&G from state-managed pollock fisheries should be conducted by age readers associated with ADF&G's Age Determination Unit (ADU). This could include age readers in Juneau, Homer and Kodiak (Table 2).

Rationale for sampling recommendation: Management and stock assessment for the pollock population(s) and fishery in PWS State is the state's responsibility. Genetic information suggests that spawning aggregations in the GOA, such as PWS, are genetically distinct and may warrant management as distinct stocks. The age data collected from port sampling of the commercial catch, and the fishery-independent trawl survey, along with CPUE collected from longline and trawl surveys, are the among most readily-available data for use in assessing possible trends in abundance since. Catch of pollock in the longline survey is insufficient to meet the 550-fish sampling goal, so no age sampling from the longline survey is recommended. Age data are desirable to support information on population trends and size structure that may be suggested by survey CPUE data. The recommended sample size of 510 fish read, per stratum, would probably be sufficient to characterize the age composition of pollock at the specified acceptable precision. The recommendation that age determination from pollock otoliths collected by ADF&G from state-managed pollock fisheries be conducted in the future by age readers from the state's ADU is predicated on the condition that ageing criteria used by ADU agers would be consistent with the NMFS ageing criteria and wouldn't compromise the ability to produce reliable, defensible estimates of pollock abundance from that model. Alternatively, if differences in ageing criteria between the NMFS and ADF&G persist, it may be desirable and necessary to have the same pollock otoliths aged by both ADF&G and NMFS age readers.

Flatfish

In PWS a mixture of shallow-water flatfish species is harvested as bycatch in directed fisheries, such as the pollock trawl fishery (Berceli et al. 2002, O'Connell et al. 2002).

Fishery independent longline and trawl surveys, primarily focusing on Pacific cod, pollock, sablefish, halibut and rockfish also catch flatfish species such as arrowtooth flounder, flathead sole and Dover sole. Length and CPUE data are collected for flatfish (Bechtol 2001).

In 2003, only 11 otoliths from flatfish (i.e. yellowfin and rock sole) were submitted to the ADU for age determinations.

Sampling recommendation: No collection of age structures.

Rationale for sampling recommendation: The current bycatch harvest of flatfish in state waters of the Central Region is insufficient to warrant a stock assessment effort that includes collection of age structures and age reading. Stock assessment and management responsibilities for other species such as sablefish, pollock, black rockfish and lingcod in the Central Region require more assessment resources than are currently available and supercede needs for flatfish stock assessment.

Sharks and Skates

Since 1998 the only permitted commercial harvest of sharks and skates has been as bycatch (Coonradt et al. 2004). Trowbridge et al. (2001) indicate that relatively little retention of bycaught sharks and skates occurs in the Cook Inlet Area. Commercial sale of bycaught spiny dogfish is permitted, although there were no reported landings in 2003 from the Central Region (Feb. 3, 2003 Memo: Dunne et al. to Woodby). Some interest has been expressed for a sport fishery for salmon sharks in the Central Region (B. Bechtol pers. com.)

Relative abundance (CPUE) and biological data on spiny dogfish are collected during the regular PWS longline and PWS and Cook Inlet trawl surveys (Feb. 3, 2003 Memo: Dunne et al. to Woodby).

Sampling recommendation: During any port sampling or fishery independent surveys in PWS, collect age structures (otoliths, fin rays and/or other candidate ageing structures) opportunistically only from Pacific sleeper sharks previously injected with oxytetracycline (OTC) and tagged as part of a study to evaluate methods for ageing this species. As part of the directed spiny dogfish fishery for Cook Inlet state waters, collect ageing structures from up to 550 spiny dogfish, both from the commercial catch (directed and bycatch) and from surveys (longline and trawl) (Table 2).

Rationale for sampling recommendation: Although fisheries for sharks and skates are currently very limited, the level of interest expressed and the potential for further development is sufficient to justify sampling for age structures and other biological data. Sampling for age structures now, even in the absence of significant effort and catch, can help establish the database needed to evaluate the impact of the limited fisheries and serve as part of the foundation for stock assessment and management programs for potential future shark fisheries. The recommendation to opportunistically collect age structures from Pacific sleeper sharks, tagged previously as part of the study to evaluate methods for ageing this species, is in support of efforts to establish methods for ageing this species in the event that a fishery might develop for sleeper sharks in the future.

Westward Region

Sablefish

In the Westward Region, only the Aleutian Islands area has enough habitat to support sablefish populations of sufficient size to allow commercial fishing (O'Connell et al. 2002). A state waters season has been in place for sablefish in this area since 1995 (Ruccio et al. 2003). All other sections within the region are closed annually to reduce the chance of localized depletion. Bycatch from areas closed to directed fishing is limited to 1% (O'Connell et al. 2002). This bycatch allowance is managed by NMFS in both state and federal waters (Ruccio et al. 2003).

Requirements for the fishery include registration and mandatory logbooks. Legal gear for sablefish includes longline, pot, jig, and hand troll (Failor-Rounds 2003).

The department does not conduct stock assessment of sablefish in the Aleutian Islands. Guideline harvest limits are based on NMFS longline surveys, recent fishery performance, and historic fishery harvest (Failor-Round 2003).

The Westward Region does not send any sablefish otoliths to the ADU.

Sampling recommendation: No collection of age structures (Table 2).

Rationale for sampling recommendation: Currently there is insufficient harvest of sablefish in state waters of the Westward Region is to justify a stock assessment effort that includes collection of age structures and age reading. Beyond catch accounting, the department does not conduct stock assessment activities for sablefish in the Westward Region. Guideline harvest limits for sablefish in the Aleutian Islands are based on NMFS longline surveys and stock assessments, recent fishery performance, and historic fishery harvest.

Rockfish

The state manages black rockfish fisheries in the state waters of the BS/AI Area. All other groundfish fisheries occurring in state waters are parallel fisheries. For these parallel fisheries the state generally adheres to openings and legal gear types of the federal seasons (Failor-Rounds 2003).

In 1998 ADF&G assumed management responsibility for black and blue rockfish in the waters of the EEZ in the Gulf of Alaska when the NPFMC amended the GOA FMP, granting management authority to the state of Alaska. Management and assessment responsibilities were transferred to the state because black and blue rockfish are shallow water, nearshore pelagic shelf species that were not assessed well by federal surveys nor well addressed by federal management practices (Failor-Rounds 2003). In addition much of the fishery occurs in state waters.

Regulations for black rockfish management in state waters include gear and vessel length restrictions for vessels fishing rockfish in state waters (Failor-Rounds 2003).

Parallel fisheries for rockfish in the Aleutians include Pacific Ocean perch, red rockfish (shortraker, rougheye, sharpchin and northern rockfish), and an aggregated rockfish species complex (Failor-Rounds 2003). These fisheries occur primarily in federal waters of the EEZ, although some of the harvest occurs in waters under state jurisdiction (Failor-Rounds 2003).

Thirteen of the 34 species of rockfish that occur in Alaskan waters are found in the BSAI Area (Kramer and O'Connell, 1988). For management rockfish are included in five groups. Pacific ocean perch is one group; in the Aleutian Islands, shortraker and rougheye rockfish are considered as a group, and sharpchin and northern rockfish another group. In the Bering Sea shortraker, rougheye, sharpchin and northern rockfish are combined in an "other red rockfish" group. The remaining rockfish comprise the "other rockfish" group (Failor-Rounds 2003).

With federal funding under the Nearshore Marine Research program, efforts are continuing to develop methods to assess abundance of black rockfish in the Westward Region. These efforts have focused thus far on the use of dockside sampling and fishery independent jig surveys—to gather data on size- and age-at-maturity data—as well as habitat mapping, and a comparison of jigging, hydroacoustic and SCUBA equipment as candidate methods to obtain estimates of relative abundance. A regular dockside sampling program since 1993 provides basic biological data including length and age compositions, sex, maturity and fishing location and effort (Failor-Rounds 2003, Ruccio et al. 2003).

Otoliths collected from these fishery independent surveys and port sampling efforts are processed by age readers in Westward Region, rather than being sent to the ADU (Failor-Rounds 2003, Ruccio et al. 2003).

Sampling recommendation: Sample 550 black rockfish each from the fisheries Kodiak, Chignik, and South Alaska Peninsula and Aleutian Islands Areas for a total of 1,800 black rockfish annually . Randomize the order of reading 550 structures collected. Age otoliths in the order randomized, until 510 structures with age readability codes less than 3 (?) have been read. Cease ageing after the target 510 readable structures has been attained (Table 2).

Rationale for sampling recommendation: As in all other areas of Alaska, the state has manages and assesses black rockfish in the Westward region. Age data collected from port sampling are one of the few types of data available for use in assessing possible trends in abundance. An age-structured model for black rockfish is being developed for the Westward Region, which would use the time series of age compositions generated from the recommended age collections. The recommended sample size of 510 fish read, per stratum, should be enough to characterize the age composition of black rockfish at the specified acceptable precision. Other rockfish, caught in sufficiently significant numbers in state waters, are assessed by NMFS.

Lingcod

There has been relatively little directed fishing for lingcod in the Westward Region. Most harvest occurs as bycatch in other fisheries, although there is some occasional directed harvest with jig gear. Lingcod are caught with longline, jig, pot, and trawl gear (Ruccio et al. 2003).

Although not generally targeted in commercial fisheries, lingcod in the in the Kodiak and Chignik Areas of the Westward Region are managed through seasons and size limits. The restrictions are intended to reduce fishing impacts on nest guarding lingcod and promote harvest of lingcod that have spawned at least one time. There are no season or size limits for the South Alaska Peninsula Area as the abundance of lingcod appears significantly lower in that area and is along the western boundary of the species range (Mecklenburg. et al 2002 after Ruccio et al. 2003). In the Westward Region all commercial gear types are legal to use for harvesting lingcod (Ruccio et al. 2003).

Data are lacking on the distribution of lingcod and CPUE for the commercial fishery. The department has implemented a conservative management approach until further information of the sustainability of lingcod harvest can be determined. A long-term goal is to determine an acceptable biological catch level (Ruccio et al. 2003). The relatively few lingcod structures collected recently (n ≈ 100) have been submitted to age readers within the Westward Region, rather than being sent to the ADU.

Sampling recommendation: No collection of age structures (Table 2).

Rationale for sampling recommendation: Although management and stock assessment responsibilities for lingcod fall to the state, current commercial harvest of lingcod in state waters of the Westward Region seem insufficient, at this time, to justify a stock assessment effort that includes collection of age structures and age reading. Beyond catch accounting, and lingcod CPUE data collected from regular trawl surveys, the department does not conduct stock assessment activities for lingcod in the Westward Region. No population modeling that would be reliant on lingcod age data is planned for the foreseeable future (Woodby 2004).

Pacific cod

There are both state-water and parallel fisheries for Pacific cod in the Westward Region. There are specific Pacific cod Management Plans for fisheries in Kodiak, Chignik, and South Alaska Peninsula. State-waters fisheries generally occur after the parallel season, which typically close in late winter/early spring (Ruccio et al. 2003). The majority of Pacific cod catch in the BS/AI area was harvested with trawls (Failor-Rounds 2003).

Fishery management regulations include seasons, vessel size limits, exclusive area registrations, harvest allocations and gear limits (O'Connell et al. 2002, Failor-Rounds 2003). As in Central Region, GHLs are set as a percentage of the ABC of Pacific cod as determined by the NPFMC (Ruccio et al. 2003).

Dockside sampling provides information on catch location, CPUE, bycatch, fish length, reproductive status, weight, and age. Otoliths are collected and sent to the Westward Region's aging laboratory for age determination. Some additional biological and bycatch data have been obtained through the use of onboard observers (Ruccio et al. 2003). Pacific cod are also captured during the regular crab/groundfish bottom trawls conducted in the Kodiak Island, Chignik, the South Alaska Peninsula, and the Eastern Aleutian Areas. The objectives of these surveys, with respect to groundfish are to estimate species and length compositions, and to tag Pacific cod (Worton 2001).

Recently, annual aging volume for Pacific cod has been about 2,500 otoliths, processed by age readers in the Westward Region (Woodby 2004).

A cod tagging study is being conducted in the Cape Sarichef area of the Aleutian Peninsula, to learn more about short-term and seasonal movements of Pacific cod. More than 1,000 tags from this program have been returned to the Alaska Fisheries Science Center.] http://www.afsc.noaa.gov/Quarterly/amj2004/divrptsREFM2.htm#update

Sampling recommendation: The current otolith collection and age reading regime for Pacific cod should be maintained for the remainder of the year. Prior to next year's Pacific cod fisheries, the sampling design for collection of Pacific cod otoliths should be re-evaluated to determine if the current geographic distribution of otolith samples (fisheries and areas) is appropriate to evaluate the possible stock distinctness at scales finer than currently assumed. This possibility of stock distinctness, greater than formerly assumed, has been suggested by recent tagging. Therefore, currently available tagging data should be analyzed to further address the question of stock distinctness. A future recommendation on appropriate sample size and distribution among fisheries and geographic areas will be based, partly on these recommended evaluations and analyses (Table 2).

Rationale for sampling recommendation: Although the state manages both state-water and parallel fisheries for Pacific cod in the Westward region, and commercial catch from these fisheries is substantial, the GHLs for these fisheries are based on the ABCs determined as part of the NPFMC process and the stock assessments conducted by NMFS. Up until very recently, the primary analytical tool used for assessment of Pacific cod in federal waters has been a length- rather than age-structured model, due largely to the lack of confidence in the ability to age Pacific cod from otoliths. There have been questions about the ability to accurately age Pacific cod otoliths. Length data from commercial harvests in state managed Pacific cod fisheries are used directly in the NMFS stock assessment (N. Sagalkin pers. com.). Analysis of existing data is needed before finalizing a sample size recommendation for Pacific cod.

Pollock

Parallel fisheries for pollock occur in the Westward Region. Although the fisheries occur primarily in federal waters of the EEZ, some harvest occurs in waters under state jurisdiction (Failor-Rounds 2003). Pollock harvest is primarily in directed fisheries with over 99% of the catch by trawl vessels (Failor-Rounds 2003).

Pollock are captured during the regular crab/groundfish bottom trawls conducted in the Kodiak Island, Chignik, the South Alaska Peninsula and the Eastern Aleutian Areas. The objectives of these surveys, with respect to groundfish are to estimate species and length compositions, and to tag Pacific cod (Worton 2001).

Biomass, length and age composition data from recent ADF&G crab/groundfish trawl surveys have been used in the NMFS GOA pollock stock assessment (Dorn et al. 2003).

Sampling recommendation: Collect otoliths from 550 pollock from the ADF&G crab/groundfish trawl survey in each of the Kodiak, Chignik and South Peninsula Areas for age determination. This would yield a total of 1,350 otoliths. If deemed feasible (see "*Rationale for Sampling Recommendation*", below), age determination from pollock otoliths collected by ADF&G from state-managed pollock fisheries should be conducted by age readers associated with ADF&G's Age Determination Unit, and the data provided to NMFS, AFSC for inclusion in the pollock assessment analysis for the GOA.

Rationale for sampling recommendation: Although the state manages parallel fisheries for pollock in the Westward region, and the commercial catch in these fisheries is large, the GHLs for these fisheries are based on the ABCs determined as part of the NPFMC process and the stock assessments conducted by NMFS. Beyond catch accounting and periodic bottom trawl surveys from which CPUE might be estimated, the department does not conduct direct stock assessment activities for pollock in the Westward Region. However, in recent years, pollock otoliths have been collected and provided to NMFS for age determination in order to determine what portion of the pollock population was available to the ADF&G trawl survey (e.g. Worton 2001) and for incorporation into the NMFS age structured model as part of the GOA pollock stock assessment (Dorn et al. 2003). The recommendation that age determination from pollock otoliths collected by ADF&G from state-managed pollock fisheries be conducted in the future by age readers from the state's ADU is predicated on the assumption that ageing criteria used by ADU agers would be consistent with the NMFS ageing criteria and wouldn't compromise the ability to produce reliable, defensible estimates of pollock abundance from that model. Alternatively, if differences in ageing criteria between the NMFS and ADF&G persist, it may be desirable and necessary to have the same pollock otoliths aged by both ADF&G and NMFS age readers. Should this be necessary, this dual approach might be accomplished by having pollock otoliths aged by ADF&G age readers who would develop age data based upon their guidelines. The structure could then be logged-out to NMFS-AFSC for development of age data consistent with NMFS criteria and used in the NMFS age-structured assessment model. The structures would then be logged back in to the State's age structure repository for archiving.

Flatfish

Parallel fisheries occur in state waters for a variety of flatfish including Greenland turbot, arrowtooth flounder, flathead sole, yellowfin sole, rock sole, and an aggregated "other flatfish" species complex (Failor-Rounds 2003). Flatfish harvest in state waters is relatively limited, because non-pelagic trawls are prohibited in most state waters (Failor-Rounds 2003).

Stock assessment activities consist only of regular bottom trawl surveys in which a variety of flatfish species are caught. With respect to groundfish, the objectives of these surveys are to estimate species and length compositions, and to tag Pacific cod (Worton 2001).

Sampling recommendation: No collection of flatfish age structures (Table 2.).

Rationale for sampling recommendation: Although the state manages parallel fisheries for flatfish in the Westward region, flatfish catch is limited because of prohibitions on bottom trawling in most state waters. Beyond catch accounting and bottom trawl surveys that provide data that might be used to estimate flatfish CPUE, the department conducts no other stock assessment activities for flatfish in the Westward Region.

REFERENCES CITED

Beamish, R. J. and G. A. McFarlane. 1983. The forgotten requirements for age validation in fisheries biology. Trans. Amer. Fish. Soc. 112:735–743.

Bechtol, W. R. 2001. Prince William Sound walleye pollock: Current assessment and 2002 management recommendations. Alaska Department of Fish and Game. RIR No. 2A01-23.

Bechtol, W. R. 2001. Relative abundance of sablefish and other groundfish caught on longline gear in Prince William Sound, Alaska, 1998. Alaska Department of Fish and Game. RIR No. 2A01-15.

Berceli, R., C. Trowbridge, M. A. Lambdin, W. Dunne, and W. R. Bechtol. 2002. Review of groundfish fisheries in the Prince William Sound Management Area: 2002 report to the Alaska Board of Fisheries. Alaska Department of Fish and Game. RIR No. 2A02-33.

Bracken, B. E. 1982. Sablefish (Anoplopoma fimbria) migration in the Gulf of Alaska based on Gulf-wide tag recoveries, 1973–1981. ADF&G Informational Leaflet No. 199.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford Univ. Press. Oxford, U.K.

Carlile, D. W. 1997. More on sample sizes for groundfish port/survey sampling. ADF&G Div. of Comm. Fisheries. Memo to Meg Cartwright and Tory O'Connell, May 14, 1997. Available from: Dave Carlile.

Carlile, D.W., B. Richardson, M. Cartwright and V.M. O'Connell. 2002. Southeast Alaska sablefish stock assessment activities 1988–2001. Alaska Department of Fish and Game. RIR 1J02-02.

Clausen, D. M., C. R. Lunsford, D. H. Hanselman and J. T. Fujioka. 2003. Pelagic shelf rockfish. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Coonradt, E. E. 2002. The Southeast Alaska Pacific cod fishery. Alaska Department of Fish and Game. RIR No. 1J02-10

Coonradt, E. E., et al. 2004. State of Alaska groundfish fisheries associated investigations in 2003. Prepared for the Forty Fifth Annual Meeting of the Technical Sub-committee of the Canada-United States Groundfish Committee. May 4–5, 2004.

Dorn, M.W., S. Barbeaux, M. Guttormsen, B. Megrey, A.B. Hollowed, M. Wilkins, and K. Spalinger. 2003. Assessment of the walleye pollock stock in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Erzini, K. 1990. Sample size and grouping of data for length-frequency analysis. Fisheries Res. 9:355–366.

Failor-Rounds, B. J. 2003. Bering Sea–Aleutian Islands area state-waters groundfish fisheries and groundfish harvest from parallel seasons in 2002. Alaska Department of Fish and Game. RIR No. 4K03-59

Gordon, D.A. 1994. Lingcod fishery and fishery monitoring in Southeast Alaska. Alaska Fishery Research Bulletin. 1:140–152.

Gove, N. 2002. Groundfish sample sizes. ADF&G Div. of Comm. Fisheries. Memorandum to Distribution (Brian Bue, Willy Dunne). Available from: N. Gove, B. Bue, W. Dunne or Dave Carlile.

Grant, W. S., C. I. Zhang, and T. Kobayashi. 1987. Lack of genetic stock discretion in Pacific cod (*Gadus macrocephalus*). Can. J. Fish. Aquat. Sci. 44:490–498.

Hanselman, D., J. Heifetz, J.T. Fujioka, and J.N. Ianelli. 2003. Gulf of Alaska Pacific ocean perch. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Heifetz, J. and J.T. Fujioka. 1991. Movement dynamics of tagged sablefish in the northeastern Pacific. Fisheries Research 11:355–375.

Kimura, D. 1977. Statistical assessment of the age-length key. J. Fish. Res. Board Can. 34:317–324.

Kimura, D. K. and J. J. Lyons. 1990. Choosing a structure for the production aging of Pacific cod (*Gadus macrocephalus*). Int. North Pac. Fish. Comm. Bull. 50:9–23.

Kimura, D.K., A.M. Shimada and F.R. Shaw. 1998. Stock structure and movement of tagged sablefish, Anoplopoma fimbria, in offshore northeast Pacific waters and the effects of El Nino-Southern Oscillation on migration and growth. Fish. Bull. 96:462–481.

Maloney, N.E. and J. Heifetz. 1997. Movements of tagged sablefish released in the Eastern Gulf of Alaska. pp. 115–121. *In* Wilkins, M.E. and M.W. Saunders (eds.) 1997. Biology and management of sablefish, Anoplopoma fimbria. Papers from the International Symposium on the Biology and Management of Sablefish. Seattle, WA. 13–15 April 1993. NOAA Technical Report NMFS 130

Mecklenburg, Catherine W., T. Anthony Mecklenburg, and Lyman K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society. Bethesda, Maryland.

O'Connell, V., C. Brylinsky and D. Carlile. 2003. Demersal Shelf Rockfish Assessment for 2004. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

O'Connell, V., D. Urban, C. Trowbridge, W. Dunne, T. Brookover, E. Coonradt, C. Brylinsky, S. Meyer, K. Munk, M. Jaenicke, B. Piorkowski, L. Seeb, T. Haverland, B. Bechtol, and M. Ruccio. 2002. State of Alaska groundfish fisheries associated investigations in 2001. Alaska Department of Fish and Game. RIR No. 1J02-32.

Olsen, J. B., Merkouris, S. E., and Seeb, J. E. 2002. An examination of spatial and temporal genetic variation in walleye pollock (Theragra chalcogramma) using allozyme, mitochondrial DNA, and microsatellite data. Fishery Bulletin 100: 752–764.

Quinn, T.J. and R. B. Deriso. 1999. Quantitative fish dynamics. Oxford University Press.

Roberson, N. 2001, Pacific cod: The Aging of a difficult species. Alaska Fish, Sci. Center, Quarterly Rep., April–May–June 2001, 1–5p.

Ruccio, M. P., Michael E. Cavin, Jr., and Kally A. Spalinger. 2003. Annual management report for the groundfish fisheries in the Kodiak, Chignik, and South Alaska peninsula Management Areas, 2002. Alaska Department of Fish and Game. RIR No. 4K03-46

Shimada, A. M., and D. K. Kimura. 1994. Seasonal movements of Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea and adjacent waters based on tag-recapture data. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 92:800–816.

Sigler, M.F., C.R. Lunsford, J.T. Fujioka, and S.A. Lowe. 2003. Alaska Sablefish Assessment for 2004. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Southward, G.M. 1976. Sampling landings of halibut for age composition. Int. Pac. Halibut Comm. Sci. Rep. 58.

Spencer, P. D. and J. N. Ianelli. 2003. Pacific ocean perch. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. Prepared by the BS/AI Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Thompson, S. K. 1987. Sample size for estimating multinomial proportions. The American Statistician 41:42–46.

Thompson, G. and M. Dorn. 2003. Assessment of the pacific cod stock in the eastern bering sea and Aleutian islands area. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. Prepared by the BS/AI Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Thompson, G. G., H. H. Zenger, and M. W. Dorn. 2003. **A**ssessment of the Pacific cod stock in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Trowbridge, C., W.R. Bechtol, M.A. Lambdin and W. Dunne. 2001. Cook Inlet Area groundfish report to the Alaska Board of Fisheries. 2001. Alaska Department of Fish and Game. RIR No. 2A01-18.

Woodby, D. 2004. Age lab issues, teleconference, and recommendations. ADF&G Div. of Comm. Fisheries. Memorandum to Doug Mecum. Available from: D. Woodby or Dave Carlile.

Worton, C. 2001. Bottom trawl survey of crab and groundfish: Kodiak Island, Chignik, South Peninsula, and Eastern Aleutian Areas. Alaska Department of Fish and Game. RIR No. 4K01-53.