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Using Groundfish Data-Limited Methods to Assess Coastal Pelagic Species

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Introduction

The Pacific Fishery Management Council's (PFMC) fishery management plan (FMP) for Coastal Pelagic Species (CPS) includes two 'actively managed' stocks (Pacific sardine and Pacific mackerel), four 'monitored' stocks (market squid, northern anchovy central (California) and northern (Oregon-Washington) subpopulations, and jack mackerel), and one prohibited species category (krill) (PFMC 1998, 2011). Market squid is actively managed by the State of California; moreover, this species' life history characteristics preclude assessing stock status with traditional population dynamics models and given its biology, the population remains exempt from federal Magnuson-Stevens Fishery Conservation and Management Act Reauthorization legislation. Pacific sardine and Pacific mackerel have been assessed and managed on a regular basis using modern statistical catch-at-age models (e.g., Hill et al. 2015, Crone and Hill 2015). The quality and availability of data for the Pacific mackerel assessment are limited and uncertainty in recent estimates of biomass is high. In this context, the SSC downgraded the 2015 Pacific mackerel assessment to Category '2' ('Data Moderate', Table 1), making this species a logical candidate for data-limited approaches. Stock status information is currently lacking for three monitored finfish stocks in the CPS-FMP: the central and northern subpopulations of northern anchovy, and jack mackerel. The northern anchovy central subpopulation off California and northern Baja California was last assessed in 1995 (Jacobson et al. 1995). The jack mackerel stock was evaluated using a simple dynamic pool model several decades ago (MacCall and Stauffer 1983), however this stock has never been formally assessed. The northern anchovy northern subpopulation off Oregon and Washington has never been assessed, and potential time series of abundance to assess this stock have never been evaluated. Despite the relatively minor fisheries for these monitored stocks, NOAA/NMFS is nonetheless obligated to determine stock status on some intermittent basis.

Data-limited assessment methods present the most practical approach to determining current stock status for monitored species in the CPS-FMP. In 2011, the Pacific Fishery Management Council adopted data-limited assessment methods for groundfish (see Appendix 1 Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2015-2016; 'TOR'; PFMC 2014). Assessment methods for data-limited CPS stocks were not addressed in the TOR, but methods reviewed and adopted for groundfish may prove practical toward this end. The purpose of this document is to: 1) summarize data-limited methods approved for groundfish species; 2) review/prioritize available data for developing CPS stock assessments; and 3) identify potential methods for data-limited CPS assessments.

Data-Limited Methods Currently Endorsed for Groundfish (excerpted from PFMC 2014)

<u>Data-Poor Methods for Groundfish Species (DCAC, DB-SRA, and SSS)</u>

"Data-poor assessment methods to assess groundfish species were adopted by the Council in 2011 to inform harvest specifications for category 3 stocks (Appendix E). These adopted methods include: 1) Depletion Corrected Average Catch (DCAC), 2) Depletion Based Stock Reduction Analysis (DB-SRA), and 3) Simple Stock Synthesis (SSS).

DCAC provides estimates of sustainable yield on long lived species based on catches and associated number of years, as well as the relative reduction in biomass during that period, the natural mortality rate (M), and the assumed ratio of MSY fishing rate (FMSY) to M (MacCall 2009). DB-SRA combines DCAC and stock reduction analysis to produce probability distributions of management reference points concerning yield and biomass (Dick and MacCall 2011). DB-SRA *is based on estimates of historical annual catches, natural mortality rate (M) and age at maturity. A production function is specified based on the relative location of maximum productivity and the ratio of FMSY to M. Unfished biomass, the only unknown parameter, is then calculated based on a designated relative depletion level near the end of the time series. Uncertainties in natural mortality, stock dynamics, optimal harvest rates, and recent stock status are incorporated using Monte Carlo exploration. SSS utilizes a similar approach as DB-SRA using the Stock Synthesis modeling platform (Cope 2013)."*

Data-Moderate Methods for Groundfish Species (XDB-SRA and XSSS)

"Data-moderate assessments for groundfish species are a refinement over the adopted data-poor methods. Data-moderate assessments are used for category 2 stocks; the defining distinction between category 2 and category 3 stocks is that abundance trend information is incorporated in a category 2 assessment enabling an estimate of stock status.

Two data-moderate assessment methods have been endorsed since the 2013-14 assessment cycle: 1) extended DB-SRA (XDB-SRA) and 2) extended Simple Stock Synthesis (XSSS). In both cases, abundance trend information (e.g., survey or fishery CPUE indices) is included in the assessment.

XSSS assumes that recruitment is related deterministically to the stock-recruitment relationship and allows index data to be used within a Bayesian framework. The Markov chain Monte Carlo (MCMC) or Sample Importance Resample (SIR) algorithm (perhaps implemented using Adaptive Importance Sampling) is used to quantify uncertainty for XSSS-based assessments. XDB-SRA is implemented within a Bayesian framework, with the priors for the parameters updated based on index data. The additional parameters in XDB-SRA compared with DB-SRA include the catchability coefficient (q), and the extent of observation variance additional to that inferred from sampling error (a). The priors for these parameters are a weakly informative log-normal and a uniform distribution, respectively.

Comparison of alternative methods (XDB-SRA and XSSS) is encouraged, but it is acceptable to present an assessment using a single modeling approach. The STAR panel can make requests of the STATs for additional runs, but should not impose an alternative method if STATs consider this is not appropriate for the stock concerned. In the event that more than one model is presented, the panel should recommend adoption of a preferred model, if one can be identified, for use in management."

Available Data and Potential Approaches for Assessing CPS Stocks

Information for evaluating CPS stocks varies in quantity and quality. Landing data exist for all species, however, given the generally low volumes of catch, fishery samples have been scant to non-existent for many years. California, Oregon, and Washington have recently initiated sampling programs for commercially landed northern anchovy. Several fishery-independent surveys have collected data potentially useful as time series of relative abundance, but the data have not been fully vetted for this purpose. For each species, potential sources of data and relevant modeling approaches follow.

Northern Anchovy Central Subpopulation (California)

Northern anchovy central subpopulation fishery samples (including ages) were collected by CDFW from 1966 to 1982, as well as INAPESCA (Ensenada) from 1978 to 1989 (Table 2), after which landings diminished to low volumes (e.g., 1,000 to 5,000 mt per year). California's fishery increased to 10,511 mt in 2014, at which time, CDFW resumed port sampling. Recent fishery samples have not been processed for age determination.

Survey indices of relative abundance (spawning stock biomass, SSB) could be derived from ichthyoplankton samples collected during the CalCOFI winter and spring surveys and the SWFSC's spring CPS survey (1951-present; MacCall and Prager 1988, Fissel et al. 2011). Adult reproductive data from Spring CPS Survey trawls are likely inadequate to produce traditional DEPM estimates, so the most practical approach will be either estimates of total egg production (TEP, i.e. P_0 x Area) or simple egg or larval densities. The SWFSC is presently processing a considerable backlog of ichthyoplankton samples, so the CalCOFI/Spring CPS ichthyoplankton data set is currently complete through 2012. An additional time series of relative abundance could be derived from the SWFSC-Santa Cruz juvenile rockfish trawl survey (1990-present; Ralston and Howard 1995; Sakuma et al. 2006; Field et al. 2010). Data would include trawl samples of abundance and size of adult and juvenile anchovy.

Several more years of fishery samples must be collected and aged before data-rich methods (i.e., statistical catch-at-age analysis) can be applied to this stock. A complete time series of catch is available, as are previously established estimates of natural mortality and age-at-maturity (Methot 1989, Jacobson et al. 1995). Time series of relative SSB can be developed from CalCOFI/SWFSC surveys and thus, data-moderate methods (e.g., XDB-SRA and XSSS) are likely the best approach for assessing this stock (Table 3). At this time, processing of anchovy ichthyoplankton samples from the winter and spring surveys is behind schedule, so any time series developed from these samples to date would end in 2012. Given the short life span and early maturation of northern anchovy, the most meaningful survey time series for informing current stock abundance would need to be based on terminal-year estimates within 1-2 years of the current timeframe. At present, the SWFSC's juvenile rockfish survey (mid-water trawl samples) is the only potential time series of abundance that is up-to-date (through 2015) for assessing the central subpopulation, although, this data source has not been examined to date for this specific purpose.

Northern Anchovy Northern Subpopulation (Oregon-Washington)

The northern subpopulation of northern anchovy has been lightly fished (typically, 100 to 250 mt per year) off Oregon-Washington for many years. Fishery samples have been collected since 2013, but these samples have not yet been processed for age determination (Table 2). Historic fishery samples do not exist.

Potential abundance time series could be developed from three surveys conducted by the NWFSC Fish Ecology Group at the Newport Laboratory: 1) BPA/FE pelagic surface trawl survey (1998-present); 2) Predator-forage fish survey (1998-2012); and 3) Columbia River estuary purse seine survey (2001-2013) (Table 2). The BPA/FE pelagic trawl survey has the broadest range (nine transects, six stations per transect; Cape Flattery, WA to Newport, OR) and is an ongoing project, so would be the best potential candidate of the three NWFSC surveys. The Predator/Forage Fish Survey consists of two transects (6 stations per transect) near the Columbia River plume, and the

Columbia River Estuary purse seine survey is limited to two locations in that estuary. All three surveys include collection of fish ID, number, and length.

The utility of data-limited approaches for assessing the northern anchovy northern subpopulation remains undetermined (Table 3). Natural mortality (*M*) rate and age-at-maturity are unknown for this species, but could be estimated from fishery/survey samples once age estimates become available. This species likely exhibits an *M* much higher than 0.2, which potentially introduces additional uncertainty if using data-poor methods (e.g., DCAC, DB-SRA, and SSS) on higher productivity stocks. Data-moderate methods (XDB-SRA/XSSS) might be feasible if: 1) abundance time series can be developed from one of the NWFSC surveys; and 2) objective estimates of *M* and age-at-maturity can be obtained.

<u>Jack Mackerel</u>

Jack mackerel landings were sampled by CDFW during the historically active fishery (1967-1988, including ages; Table 2), but no samples have been taken since that time, as the fishery has remained at a low volumes (~1,000 mt per year). MacCall and Stauffer (1983) provided estimates of *M* and maturity for jack mackerel. Jack mackerel can live up to 30 years (Fitch 1956), however, *M* has been estimated to range from 0.5 to 0.25 for ages 0 to 6, respectively (MacCall & Stauffer 1983).

Potential indices of abundance include: 1) CalCOFI egg/larval densities (1951-present; MacCall & Prager 1988); 2) SWFSC acoustic-trawl biomass estimates (2006-present); and 3) California CPFV logbooks (1936-present) (Table 2). Each of these data sources has shortcomings, given the life history and distribution of jack mackerel in the North Pacific Ocean. Jack mackerel are broadly distributed from Baja California Sur to the Aleutian Islands, Alaska and can inhabit oceanic waters far-offshore (Blunt 1969) and thus, any index of abundance derived from these sources will likely represent local trends in abundance/availability, rather than population-level changes. Data-moderate methods (e.g., XDB-SRA and XSSS) might be suitable if abundance time series can be developed from the above information (Table 3), however, caveats regarding sampling synopticity and representativeness should temper expectations concerning the quality of existing data for informing any type of assessment of this stock.

<u>Pacific Mackerel</u>

Pacific mackerel have been managed using age-structured population models since the mid-1990s. The most recent stock assessment (Crone and Hill 2015) included fishery age and size-at-age compositions, and one time series of relative abundance (CPUE from CPFV logbooks). The SWFSC's acoustic-trawl time series was initially included, but was not deemed acceptable for formal assessment purposes at this time, and was excluded from the final base model. Given the overall quality of data and a strong retrospective pattern in terminal biomass estimates, the SSC downgraded this assessment from Category 3 (data rich) to Category 2 (data moderate) in June 2015 (Table 1). The SWFSC will explore application of data-moderate methods to this stock and will revisit abundance time series to apply in this context, including 1) SWFSC acoustic-trawl biomass estimates (2006-present); 2) CalCOFI egg and larval densities (1951-2012); and 3) CPFV logbooks (1936-present) (Table 2).

Concluding Remarks

At this time, stock status determinations are out-of-date or unknown for three of the five finfish species in the CPS-FMP. Data are currently insufficient to support statistical catch-at-age (Category 1) assessments of the unassessed CPS stocks. All CPS stocks have natural mortality rates higher than 0.2, which essentially limits assessment efforts to the data-moderate approaches (Category 3) discussed above, including XDB-SRA or XSSS. Conducting data-limited assessments will be possible once defensible time series of abundance have been developed for each stock. Further, new biological information (ages for age-at-maturity and *M*) will be needed before the northern anchovy northern subpopulation can be assessed. It is important to note that the quantity and quality of information available for data-limited approaches varies by stock and in many cases, reflects sparse sampling and variable estimates for basing stock status conclusions, i.e., management guidance from such assessments should be considered accordingly. However, if in the future these methods are applied, reviewed, and adopted for CPS, they can be updated on an intermittent basis. Nationally, NOAA Fisheries is continually looking to update the stock status of these species as part of the Fish Stock Sustainability Index (FSSI). The FSSI is a performance measure for the sustainability of 199 U.S. fish stocks selected for their importance to commercial and recreational fisheries.

This report is intended to inform the PFMC of the current data available and a proposed course of action for assessing these data-limited CPS stocks under the current groundfish data-limited methods. Additional guidance from the SSC on any other or new data-limited methods that would be more appropriate for these short-lived species is requested. If new methods are suggested, a new methodology review might be necessary. After that discussion has taken place, the prioritization (see Agenda Item I.7.a, November 2015) and timing of these assessments can be provided.

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Table 1. Matrix of assessment tiers for groundfish and CPS (PFMC 2014).

			Northern Anchovy - Central Subpopulation	Northern Anchovy - Northern Subpopulation	Jack Mackerel	Pacific Mackerel	Pacific Sardine
		CPS Management Status (Active-A, Monitored-M):	**M**	**M**	**M**	**A**	**A**
Category 3: Data poor. OFL is derived from historical catch.	**a**	No reliable catch history. No basis for establishing OFL.					
	b	Reliable catch estimates only for recent years. OFL is average catch during a period when stock is considered to be stable and close to BMSY equilibrium on the basis of expert judgment.					
	c	Reliable aggregate catches during period of fishery development and approximate values for natural mortality. Default analytical approach DCAC.					
	d	Reliable annual historical catches and approximate values for natural mortality and age at 50% maturity. Default analytical approach DB-SRA.					
Category 2: Data moderate. OFL is derived from model output (or natural mortality).	**a**	M*survey biomass assessment (as in Rogers 1996).					
	b	Historical catches, fishery-dependent trend information only. An aggregate population model is fit to the available information.					
	c	Historical catches, survey trend information, or at least one absolute abundance estimate. An aggregate population model is fit to the available information.	**X**	**?**	**X**	**X**	
	d	Full age-structured assessment, but results are substantially more uncertain than assessments used in the calculation of the P* buffer. The SSC will provide a rationale for each stock placed in this category. Reasons could include that assessment results are very sensitive to model and data assumptions, or that the assessment has not been updated for many years.				**X**	
	e	Assessments of a complex of species cannot be designated as a category 1 assessment unless there is good evidence that the component species have very similar life-history characteristics and similar rates of biological productivity.					
Category 1: Data rich. OFL is based on FMSY or FMSY proxy from model output. ABC based on P* buffer.	**a**	Reliable compositional (age and/or size) data sufficient to resolve year-class strength and growth characteristics. Only fishery-dependent trend information available. Age/size structured assessment model.					
	b	As in 1a, but trend information also available from surveys. Age/size structured assessment model.					**X**
	c	Age/size structured assessment model with reliable estimation of the stock-recruit relationship.					

Table 2. Data available for data-limited assessments of CPS. Northern anchovy CSP = central subpopulation (CA); Northern anchovy NSP = northern subpopulation (OR-WA); 'n/a' = not applicable due to distribution, season, biology, or method.

FISHERY DATA

Source	Data Type	Northern Anchovy CSP	Northern Anchovy NSP	Jack Mackerel	Pacific Mackerel
Washington	Landings	n/a	1981-2015	1981-2015	1981-2015
	Length	n/a	2013-2015	unknown	unknown
	Age	n/a	2013-2015 (not aged)	unknown	unknown
	Maturity	n/a	2013-2015	unknown	unknown
Oregon	Landings	n/a	1981-2015	1981-2015	1981-2015
	Length	n/a	2013-2015	1995-2015 (whiting)	1995-2015 (whiting)
	Age	n/a	2013-2015 (not aged)	not aged	not aged
	Maturity	n/a	2013-2015	some data	some data
California	Landings	1916-present	n/a	1916-2015	1916-2015
	Length	1966-1982; 2014-1015	n/a	1967-1988	1962-2015
	Age	1966-1982 (2014-2015 not aged)	n/a	1967-1988	1962-2015
	Maturity	1966-1982; 2014-2015	n/a	1967-1988	1962-2015
Mexico (Ensenada)	Landings	1971-2014	n/a	1988-2014	1962-2014
	Length	1978-1989	n/a	no data	not available
	Age	1978-1989	n/a	no data	not available
	Maturity	1978-1989	n/a	no data	not available

POTENTIAL INDICES OF ABUNDANCE

Source	Data Type	Northern Anchovy CSP	Northern Anchovy NSP	Jack Mackerel	Pacific Mackerel
SWFSC Spring CPS Survey (SD-SF, CA)	Ichthyoplankton	1994-2012	n/a	1994-2012	n/a
	Acoustic Biomass	n/a	n/a	2006-2015	2006-2015
	Adult Comp/Biology	1994-2015 (not aged)	n/a	1994-2015 (not aged)	1994-2015 (not aged)
SWFSC Sardine-Hake Summer (CA-BC)	Ichthyoplankton	2012	n/a	2012	2012
	Acoustic Biomass	n/a	n/a	2012-2015	2012-2015
	Adult Comp/Biology	2012-2015 (not aged)	2012-2015 (not aged)	2012-2015 (not aged)	2012-2015 (not aged)
CalCOFI Winter (SD-SF, CA)	Ichthyoplankton	1951-2012	n/a	n/a	n/a
CalCOFI Spring (SD-SF, CA)	Ichthyoplankton	1951-2012	n/a	1951-2012	n/a
CalCOFI Summer (SCA)	Ichthyoplankton	n/a	n/a	1951-2012	1951-2012
SWFSC Juvenile Rockfish Survey (Midwater Trawl, CA)	Abundance & Length	1990-2015	n/a	probably n/a	probably n/a
RecFIN (MRFSS; CRFS) (CA)	Catch, Effort, Length	n/a	n/a	1980-2003; 2004-2015	1980-2003; 2004-2015
CPFV Logbook (summary data; raw data) (CA)	Catch, Effort	n/a	n/a	1936-2015; 1980-2015	1936-2015; 1980-2015
NWFSC BPA Pelagic Surface Trawl (OR-WA)	Adult Comp/Biology	n/a	1998-2015	n/a	n/a
NWFSC Predator Forage Fish Trawl (Columbia River)	Adult Comp/Biology	n/a	1998-2012	n/a	n/a
NWFSC Estuary Seine (Columbia River)	Adult Comp/Biology	n/a	2001-2013	n/a	n/a

Table 3. Proposed methods for CPS assessments based on data-limited methods. Northern anchovy CSP = central subpopulation (CA); Northern anchovy NSP = northern subpopulation (OR-WA).

Assessment Category	Model	Data/Parameter	Northern Anchovy CSP	Northern Anchovy NSP	Jack Mackerel	Pacific Mackerel
Data Poor	DCAC	Catch	yes	yes	yes	yes
		Natural mortality	too high (>0.2)	presume >0.2	too high (>0.2)	too high (>0.2)
	DB-SRA / SSS	Age-at-maturity	yes	pending age data	yes	yes
Data Moderate	XDB-SRA / XSSS	Catch	**yes**	yes	**yes**	**yes**
		Natural mortality	**yes**	pending age data	**yes**	**yes**
		Age-at-maturity	**yes**	pending age data	**yes**	**yes**
		Abundance series	**yes**	maybe	**yes**	**yes**