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Current methods for setting catch limits for data-limited fish stocks in the United States

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ABSTRACT

This paper examines how the requirement for annual catch limits (ACLs) has been implemented for data-limited stocks in all federally-managed fisheries in the United States. The legal mandate to establish ACLs in the U.S. has spurred substantial scientific advances, including the development and adoption of at least 16 methods for establishing catch limits for data-limited fisheries. This study analyzed the assessment methods that form the basis of ACLs, those which determine the overfishing limits (OFLs) and the acceptable biological catches (ABCs). Nationally, 30% (150) of OFLs/ABCs are currently calculated using conventional data-rich assessment methods, 11% (59) using data-moderate methods, and 59% (295) using data-poor approaches. There is substantial variation in the proportion of stocks that are currently managed with data-rich versus data-limited methods across regions, and there are clear geographical patterns in the types and diversity of methods being utilized to calculate OFLs/ABCs. Data-poor methods are the most commonly used OFL/ABC-setting methods in the U.S., particularly in the Southeast, Atlantic highly migratory species (HMS), Pacific, and Western Pacific regions. The Southeast and Atlantic HMS regions use some form of catch scalar or an ABC of zero landings for each data-limited stock. The Pacific and North Pacific regions currently employ a higher diversity of data-limited methods than any other region; these include both data-moderate methods and data-poor methods. Regional disparities in data-limited method development and implementation are attributed to regional differences in the number of stocks being managed, the data types and lengths of the time series available, and the resources dedicated to data processing and stock assessment. Recommendations for improving management of data-limited stocks include establishing a complete inventory of all available data for each managed stock, dedicating resources and expertise to data-limited method development and evaluation, and developing a more streamlined assessment process to handle the expanded volume of stocks requiring ACLs.

1. Introduction

One of the most significant changes to the Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA) due to the 2006 amendments was the requirement for scientifically-derived annual catch limits (ACLs) for all federally-managed stocks in the United States, with some limited exceptions. By making this change, the U.S. Congress introduced a standard mechanism to limit catch and trigger measures to ensure accountability. While the adoption of ACLs for well-assessed stocks did not require significant new scientific methods, it had the power to transform the science for, and management of, previously unassessed stocks with limited data and/or assessment resources to analyze unprocessed data. These stocks, and the methods used to set ACLs for them, are referred to as “data-limited.”

It is well acknowledged that ACLs have been effective at preventing overfishing and rebuilding assessed and relatively data-rich stocks, which has resulted in significant economic and social benefits (NMFS, 2013c). Since ACLs began to be implemented in 2010, the number of assessed stocks subject to overfishing has been reduced from 16% to 10% (NMFS, 2010a, 2013a), while the average U.S. commercial landings and revenues for 2011 and 2012 were at or near the highest levels seen in the previous 15 years (NMFS, 2012, 2013b). The application of ACLs to data-limited stocks and the methodologies for doing so are relatively new and thus less well developed and understood.

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Glossary of Acronyms.

ABC	Acceptable biological catch
ACL	Annual catch limit
CFMC	Caribbean Fishery Management Council
DB-SRA	Depletion-based stock reduction analysis
DCAC	Depletion-corrected average catch
exSSS	Extended simple stock synthesis
FMP	Fishery Management Plan
GMFMC	Gulf of Mexico Fishery Management Council
HMS	Highly migratory species
MAFMC	Mid-Atlantic Fishery Management Council
MSFMCA	Magnuson-Stevens fishery conservation and management act
NEFMC	New England Fishery Management Council
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
OFL	Overfishing limit
ORCS	Only reliable catch stocks
PFMC	Pacific Fishery Management Council
SAFMC	South Atlantic Fishery Management Council
SSC	Scientific and Statistical Committee
WPFMC	Western Pacific Fishery Management Council
XDB-SRA	Extended Depletion-Based Stock Reduction Analysis

Historically, many of these unassessed stocks were overlooked by fisheries managers due to their relatively low commercial landings compared to the more commercially-valuable fisheries. This lack of prioritization has meant fewer resources expended for data-collection and assessment of these stocks. This changed when the U.S. Congress mandated the adoption of ACLs for most federally-managed stocks, including hundreds of previously unassessed, data-limited ones. Congress intentionally designed the ACL mandate broadly to include previously unassessed stocks to drive improvements in data collection and research into more precise assessment methods, and to improve the reliability of management measures to restrain mortality within sustainable levels (US Senate, 2006). The ACL mandate was widely supported, including by the U.S. Oceans Commission (US Commission on Ocean Policy, 2004), and the National Marine Fisheries Service (Witherell, 2005), and the mandate has the unanimous consent of all U.S. fishery management councils (US Senate, 2006).

This policy shift toward fully-managing data-limited stocks by requiring ACLs signaled Congress' desire to extend a well-tested management approach to all U.S. fisheries, including those that have traditionally been referred to as minor stocks due to low landings or revenues. The traditional measure of value for a fishery – resource extraction as quantified by landings and ex-vessel revenues – does not fully capture the economic and ecological importance of many data-limited stocks. Many data-limited stocks are significant components of recreational fisheries, which generated $56 billion in total economic output in 2011, yet released 63% of the 380 million fish caught (Lovell et al., 2013; NMFS, 2013b). Non-extractive uses of fisheries resources, such as catch-and-release fishing, diving, and wildlife viewing from boats, have been shown to be economically comparable to the value of commercial fisheries in the same region (Ihde et al., 2011; Ruiz-Frau, 2013). Lightly-targeted stocks also provide forage for more highly-valued, target stocks (e.g., Atlantic butterfish) or play other important ecological roles, such as the trophic energy transfer provided by parrotfishes in coral reef ecosystems (Bellwood, 1996; Choat, 1991).

Implementation of the 2006 ACL requirement has been a significant undertaking by the fishery management councils and NMFS. Regional differences in fish species, data availability, preferred modeling approaches, and fishery management council procedures provide an opportunity to examine the range of challenges and solutions to effectively managing data-limited stocks. This paper presents a summary and assessment of how the ACL mandate has been implemented for data-limited stocks in the U.S. Berkson and Thorson (2014) previously presented the number of ACLs in use by region, but limited their analysis to the overall number and percentage involving catch-only methods by region. This paper describes regional variations, analyzes progress and continuing challenges, and provides recommendations for improving the consistent use of best practices.

2. Methods

We reviewed all 47 federal fishery management plans to examine how the ACL provision has been implemented for data-limited stocks in the U.S. Additionally, we communicated with NMFS stock assessment scientists and fishery management council staff to verify our findings and to identify changes being proposed for 2015. The MSFCMA requires that ACLs must be set at or below the acceptable biological catch (ABC) level as defined by a fishery management council's scientific and statistical committee (MSFCMA, 2007). According to NMFS's Guidelines, the ABC must be set at or below the overfishing limit (OFL) that is prescribed by the most recent stock assessment, with the difference between the OFL and ABC based on a pre-defined control rule that is intended to account for scientific uncertainty in the OFL estimate (NMFS, 2009). In cases where a conventional stock assessment has not been conducted, as is typical of most data-limited stocks, other measures of reproductive potential and biomass may be used as reasonable proxies for OFL (NMFS, 2009).

In practice, fishery management councils have not applied this approach consistently in setting ACLs for data-limited stocks. Only in some cases are ABCs for data-limited stocks calculated using the two-step process described above where a data-limited method is used to calculate an OFL for a particular stock and the OFL is modified by a pre-defined control rule to calculate the ABC (e.g., $ABC = 0.75 \times OFL$). In other cases, the same data-limited method is used to calculate both the OFL and ABC in relation to each other (e.g., $OFL = 2 \times$ catch scalar; $ABC = 1 \times$ catch scalar). In yet other cases, a data-limited method is used to calculate the ABC directly, while the OFL is listed as "unknown." Given this diversity of approaches, we refer to each data-limited method calculation as an "OFL/ABC calculation."

There are many ways to classify assessment and OFL/ABC-setting methods in terms of data availability (Berkson and Thorson, 2014; Vasconcellos and Cochrane, 2005). For purposes of this paper, "data-rich" OFL/ABC-setting methods are defined as those derived from conventional methods for fisheries stock assessments (e.g., surplus production models, virtual population analysis, or statistical catch-at-age models). These methods are based on population models that synthesize data that may include catch, relative abundance, and biological information to determine current stock size and fishing rate relative to maximum sustainable yield. "Data-limited" OFL/ABC-setting methods include those that lack sufficient information to conduct a conventional stock assessment. Data-limited methods are further defined along a continuum between "data-moderate" and "data-poor." A method is defined "data-moderate" if it provides some dynamic feedback on stock status based on information such as an index of abundance or biological sampling data. A method is considered "data-poor" if it is based on static assumptions that lack any feedback about current or historical stock status. Data-poor methods are generally based on catch history, as informed by expert judgment.

In many cases, OFLs/ABCs are calculated for an aggregate of two or more component stocks, called a stock complex. There are important regional differences in how OFLs/ABCs for complexes are calculated. The South Atlantic, Gulf of Mexico, and Pacific regions generally calculate individual OFLs/ABCs for each component stock and then sum the totals within an applicable stock complex to calculate a complex-wide OFL/ABC. For example, the Pacific Minor Nearshore Rockfish North complex is comprised of 12 stocks, each with its own individually-calculated OFL and ABC (using a variety of data-limited methods) that are added together to form the complex-wide OFL and ABC. In these cases, we reference each of the component stock's OFL/ABC-setting methods. In contrast, the Caribbean, North Pacific, and Western Pacific regions generally derive OFLs/ABCs for complexes by computing one single aggregated OFL/ABC, combining all stocks together. For example, the Gulf of Alaska Sculpin complex uses combined survey data for 47 sculpin species to calculate the aggregated complex-wide OFL, which is then reduced to calculate a single ABC. We refer to this as a single OFL/ABC data-limited calculation.

We also count complexes that include unspecified species, such as the Guam Coral Reef Ecosystem Multi-Species complex that includes 117 currently harvested coral reef taxa and innumerable potentially harvested coral reef taxa, as a single OFL/ABC calculation since the catch limit is set based on aggregated landings data of all component species. We reference the number of stocks when known. When the number of stocks is not known, such as for coral reef taxa, we reference it as a single stock. When a stock complex contains one or more stocks with individually-calculated ABCs, plus a number of other stocks with an aggregate OFL/ABC calculated for multiple species at the same time, we count the former as one OFL/ABC calculation for each of the stocks, and the latter as a single OFL/ABC calculation. For example, the Gulf of Alaska Other Rockfish complex contains one stock, sharpchin rockfish, that has an OFL and ABC derived from a conventional stock assessment and ABC control rule, and 17 other rockfish species that use aggregated survey data in a data-moderate assessment method to calculate an aggregate OFL and ABC. We count this as two OFL/ABC calculations, one that uses a data-rich method and another that uses a data-moderate approach.

3. Results

3.1. OFL/ABC-setting classifications

A total of 504 OFLs/ABCs were calculated in 2014 for individual stocks and stock complexes in the U.S. (Table 1). These OFLs/ABCs form the scientific basis used to derive ACLs for 189 individual stocks and 99 stock complexes, the latter of which contain 1,366 component stocks. The median number of stocks contained within each ACL stock complex is 5 and the interquartile range is 9, while four ACL stock complexes in the Western Pacific region contain more than 35% of all stocks managed as part of ACL complexes. Overall, nearly 88% of all federally-managed stocks requiring ACLs are currently being managed within stock complexes. OFLs/ABCs are not required for an additional 165 federally-managed stocks because they are currently exempt from the ACL requirement because they are: internationally-managed stocks, ecosystem component species, stocks managed under the Endangered Species Act, those with a lifecycle of less than one year, and hatchery born stocks (MSFCMA, 2007; NMFS, 2009).

Nationally, 30% (150) of OFLs/ABCs are currently calculated using conventional data-rich assessments, 11% (59) using data-moderate methods, and 59% (295) using data-poor approaches (Table 1). There is substantial variation in the proportion of stocks that are currently managed with data-rich versus data-limited methods across regions. Regions that manage relatively fewer stocks, such as New England and the Mid-Atlantic, have a much lower proportion of stocks for which data-limited OFL/ABC-setting methods are used (10% and 20%, respectively). Nearly the inverse is observed in the Caribbean (100%), Atlantic Highly Migratory Species Region (92%), and Western Pacific (91%), with most stocks being managed with data-poor OFLs/ABCs. The South Atlantic, Gulf of Mexico, Pacific, and North Pacific regions set OFLs/ABCs using data-limited methods 77%, 74%, 71%, and 62% of stocks, respectively (Table 1). The Pacific region is responsible for calculating nearly one-third of OFLs/ABCs for all federally-managed stocks, including the largest number of data-rich and data-poor stocks. The North Pacific region is responsible for the vast majority (81%) of all data-moderate OFLs/ABCs.

There are significant regional differences in how data-limited methods and control rules are used to set OFLs and ABCs across the country. In the Pacific and North Pacific regions, data-limited methods like F_{MSY}/M, DB-SRA and DCAC are used to set the OFL, which is then reduced by a fixed percentage to calculate the ABC (e.g., the Gulf of Alaska Sculpin complex uses OFL = ($F_{\mathrm{MSY}}/M = 1.0$) × Abundance, and ABC = 0.75 × OFL). By contrast, in the Gulf of Mexico, the dominant data-limited approach is used to set both OFL and ABC, where OFL = 2 standard deviations > mean historical landings and ABC = 1 standard deviation > mean historical landings. In these cases, there is no distinct control rule to reduce ABC from OFL, although the approach could be conveyed as a more conventional control rule (e.g., ABC = 0.5 × OFL), the Gulf of Mexico Fishery Management Council (GMFMC) and NMFS have chosen not to characterize it this way. In the South Atlantic, the OFL is considered "unknown," and data-limited approaches are used directly to calculate ABC (e.g., ABC = 3rd highest landings over a fixed 10 year period).

3.2. OFL/ABC-setting methodologies

At least 16 methods are currently being used to calculate OFLs/ABCs for federally-managed data-limited stocks, with an additional three methods proposed for use in 2015 (Table 2). These methods can be grouped into several broad categories. Data-moderate methods include those that are based on current estimates of abundance (e.g., F_{MSY}/M (Gulland, 1971; Walters and Martell, 2002)), those that are based on updated estimates of depletion (e.g., Extended Depletion Based Stock Reduction Analysis (XDB-SRA) (Cope et al., 2013) and Extended Simple Stock Synthesis (exSSS) (Cope, 2013; Cope et al., 2013)), and those that "Piggyback" on recent assessments of closely related stocks of the same species (WPFMC, 2011a, 2013). Data-poor methods include those that set OFL/ABC at some multiple or fraction of recent landings or catch, known as catch scalars, methods that adjust catch history with knowledge about life history and expert-informed estimates of depletion (e.g., Depletion-Based Stock Reduction Analysis (DB-SRA) (Dick and MacCall, 2011) and Depletion-Corrected Average Catch (DCAC) (MacCall, 2009)), and a miscellaneous group of other approaches (e.g., prohibited landings, SAFMC, 2011) and zero-contribution to a complex-wide ABC (PFMC, 2012)).

There are clear geographical patterns in the types and diversity of methods being utilized to calculate OFLs/ABCs for data-limited stocks (Fig. 1). The Pacific and North Pacific regions currently employ a higher diversity of data-limited methods than any other region; these include data-moderate methods (e.g., F_{MSY}/M, Piggyback) in addition to data-poor methods (e.g., DB-SRA, DCAC, zero contribution, catch scalars). The current use of data-moderate methods is nearly restricted to use in the Pacific and North Pacific regions, with the exception of one stock in the Northeast and one stock in the Mid-Atlantic regions. No data-moderate methods are currently in use or proposed for use in the Southeastern U.S. (i.e., Gulf of Mexico, South Atlantic, and U.S. Caribbean) or

Table 1
2014 OFL/ABC-setting methods by region.

	NEFMC	MAFMC	SAFMC	GMFMC	CFMC	HMS	PFMC	NPFMC	WPFMC	National
Data-rich	28	8	14	9	0	3	46	38	4	150
Data-moderate	1	1	–	–	–	–	8	48	1	59
F_{MSY}/M	–	–	–	–	–	–	5	22	–	27
Piggyback related assessed stock	–	–	–	–	–	–	5	1	1	7
Median catch/current biomass	1	–	–	–	–	–	–	–	–	1
Predation model	–	–	–	–	–	–	–	1	–	1
Envelope catch + recent survey	–	1	–	–	–	–	–	–	–	1
Data-poor	2	1	47	25	23	37	106	13	41	295
Catch scalar > mean/median	–	–	39	20	3	–	2	–	10	74
DB-SRA	–	–	–	–	–	–	57	–	–	57
Catch scalar = mean/median	1	1	5	3	13	17	2	3	–	45
Prohibited landings	–	–	3	2	5	18	4	1	8	41
Zero contribution to complex ABC	–	–	–	–	–	2	28	–	–	30
% Habitat of indicator stock habitat	–	–	–	–	–	–	–	–	18	18
DCAC	–	–	–	–	–	–	12	–	–	12
Catch scalar < mean/median	–	–	–	–	2	–	–	9	–	11
MSY estimate from old assessment	–	–	–	–	–	–	–	–	5	5
% of Assessed co-occurring stock ABC	1	–	–	–	–	–	–	–	–	1
Estimate from scientific literature	–	–	–	–	–	–	1	–	–	1
Exempt stocks	1	2	15	7	–	11	86	25	18	165
International management	–	–	–	–	–	11	37	1	18	67
Ecosystem component species	–	–	6	–	–	–	11	24	–	41
Endangered species act listed	1	–	–	–	–	–	24	–	–	25
Life history < 1 year	–	2	9	7	–	–	1	–	–	19
Hatchery stock	–	–	–	–	–	–	13	–	–	13

Atlantic HMS regions. Among data-moderate methodologies, the Pacific Council most often uses depletion-based methods and the North Pacific Council predominantly uses the abundance method of F_{MSY}/M (Table 1).

Data-poor methods are the most commonly used OFL/ABC-setting method in the U.S., particularly in the Southeast, Atlantic HMS, Pacific and Western Pacific regions (Table 1). With the exception of the widespread use of DB-SRA and DCAC by the Pacific region, catch scalars are the most common data-poor method currently in use (Fig. 1). The Southeast and Atlantic HMS region use some form of catch scalar (e.g., the 3rd highest historic landings or 75% of mean historic landings) or an ABC of zero landings for each data-limited stock. The Western Pacific region also uses catch scalars for many of its data-poor finfish, but, for its numerous coral and crustacean stocks, it uses a method that sets OFLs/ABCs as a fraction of the habitat areas of other indicator stocks of the same species from different island management areas.

For 2015, an additional 27 data-moderate and five data-rich OFLs/ABCs have been proposed as of April 2014, according to communications with NMFS stock assessment scientists and fishery management council staff (Table 3). Most of the changes are occurring in the Pacific region, where data-moderate assessments have been completed for an additional 21 stocks, including nine using F_{MSY}/M, six using XDB-SRA, and four using exSSS. Four of the five new data-rich OFLs/ABCs are in the South Atlantic region.

4. Discussion

4.1. Impacts of the ACL mandate

The task of setting ACLs for hundreds of stocks nationwide was ambitious, particularly given the number of stocks with limited data. The undertaking required investigating data availability, developing new methods, and applying them on a large-scale with limited additional resources in a short time-frame. Despite these challenges, the mandate was fulfilled on time. In the process, the ACL mandate has spurred substantial

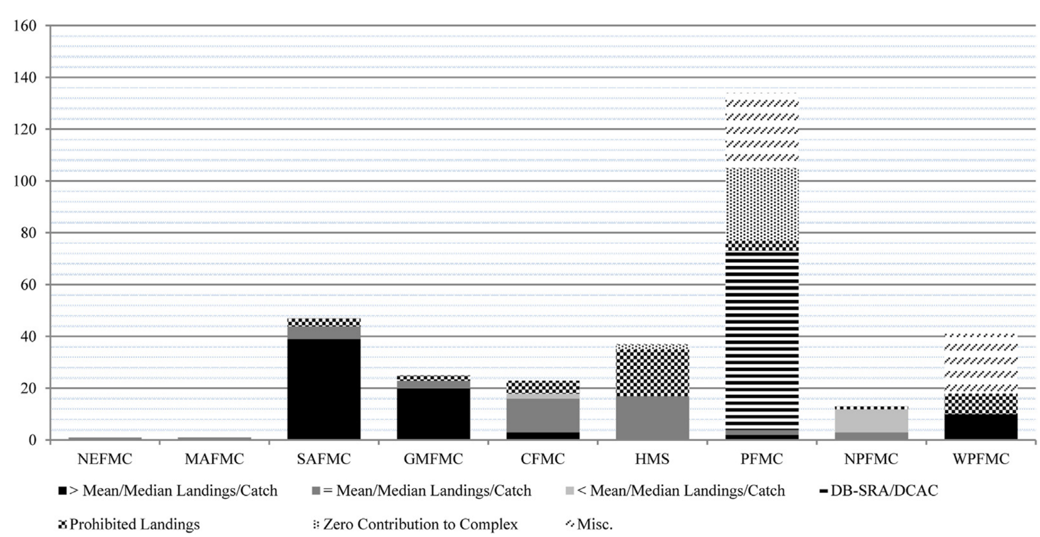

Fig. 1. Data-poor OFL/ABC methods by region.

Table 2
Current data-limited OFL/ABC methods in the U.S.

Data-moderate methods	Examples	FMPs	Sources
F_{MSY}/M	Sculpin complex	Bering sea/Aleutian island groundfish	Gulland (1971), Walters and Martell (2002), NPFMC (2013a)
	California skate	Pacific groundfish	Gulland (1971), Walters and Martell (2002), Cope et al. (2012), Taylor et al. (2013)
Piggyback	Yellowtail kalekale	Hawaii ecosystem	WPFMC (2011a, 2013)
Median catch/current biomass	Skate complex	Northeast skate	NEFMC (2009)
Predation model	Octopus complex	Gulf of Alaska groundfish	NPFMC (2013a)
Envelope catch + recent survey	Atlantic butterfish	Atlantic mackerel, squids, and butterfish	Miller and Rago (2012)
XDB-SRA*	China rockfish*	Pacific groundfish	Cope et al. (2013)
exSSS*	English sole*	Pacific groundfish	Cope (2013), Cope et al. (2013)
Biomass-augmented catch*	White Ulua*	Hawaii ecosystem	Sabater and Kleiber (2014), Martell and Froese (2013)
Data-poor methods	**Examples**	**FMPs**	**Sources**
Catch scalar < mean/median	Parrotfishes	Caribbean reef fish	CFMC (2010)
	Greenland halibut	Gulf of Alaska groundfish	NPFMC (2013a)
Catch scalar = mean/median landings/catch	Aquarium trade reef fish	Caribbean reef fish	CFMC (2011)
	Snowy grouper	Gulf of Mexico reef fish	GMFMC (2011)
	Atlantic mackerel	Mackerel, squids, and butterfish	MAFMC (2011)
	Red crab	Northeast red crab	NEFMC (2011)
	Bull shark	Atlantic highly migratory species	NMFS (2010b)
	Golden king crab (Pribilof)	King and Tanner crabs	NPFMC (2013b)
	Butter sole	Pacific groundfish	PFMC (2012)
	Scamp	South Atlantic snapper-grouper	SAFMC (2011)
	Guam precious coral	Mariana Ecosystem	WPFMC (2011a,b)
Catch scalar > mean/median	Angelfishes complex	Caribbean reef fish	CFMC (2011)
	Spanish mackerel	Gulf of Mexico reef fish	GMFMC (2011)
	Flathead sole	Pacific groundfish	PFMC (2012)
	Knobbed porgy	South Atlantic snapper-grouper	SAFMC (2011)
	Spiny lobster	Mariana ecosystem	WPFMC (2011b)
DB-SRA	Olive rockfish south	Pacific groundfish	Dick and MacCall (2011)
DCAC	Mexican rockfish south	Pacific groundfish	MacCall (2009)
Prohibited landings	Speckled hind	South Atlantic snapper-grouper	SAFMC (2011)
	Goliath grouper	Gulf of Mexico reef fish	GMFMC (2011)
	Blue parrotfish	Caribbean reef fish	CFMC (2010)
	Basking shark	Atlantic highly migratory species	NMFS (2010b)
	Great white shark	Pacific highly migratory species	PFMC (2010)
	Blue king crab (Pribilof)	King and Tanner crabs	NPFMC (2013b)
	Bottomfish complex (NW HI)	Hawaii archipelago ecosystem	WPFMC (2013)
Zero contribution to complex	Great hammerhead shark	Atlantic highly migratory species	NMFS (2010b)
	Calico rockfish	Pacific groundfish	PFMC (2012)
% habitat of related stock	Kona crab (Guam)	Mariana ecosystem	WPFMC (2011b)
MSY from old assessment	Au'Au bed black coral complex	Hawaii ecosystem	WPFMC (2011b)
% co-occurring stock ABC	Offshore hake	Northeast multispecies	NEFMC (2012)
Estimate from scientific literature	Jack mackerel	Pacific coastal pelagics	PFMC (2011a)
Exempt	**Examples**	**FMPs**	**Sources**
International Management	Atlantic bluefin tuna	Atlantic highly migratory species	NMFS (2010a,b)
	Snonomish river Coho	Pacific salmon	PFMC (2011b)
	Chinook salmon East. N. Pac.	N. pacific salmon EEZ	NPFMC (2012)
	Albacore tuna	Pelagic fisheries of the Western Pacific	WPFMC (2011c)
Ecosystem component species	Bank sea bass	South Atlantic snapper-grouper	SAFMC (2011)
	Dusky rockfish	Pacific groundfish	PFMC (2012)
	Pacific herring	Arctic	NPFMC (2009)
Endangered Species Act	Atlantic salmon	Atlantic salmon	NEFMC (1987)
	California coastal Chinook	Pacific salmon	PFMC (2011b)
Life history < 1 year	Longfin squid	Mackerel, squids, and butterfish	MAFMC (2011)
	White shrimp	South Atlantic shrimp	SAFMC (1991)
	Brown shrimp	Gulf of Mexico shrimp	GMFMC (2011)
	Market squid	Pacific coastal pelagics	PFMC (2011a)
Hatchery stock	Columbia river hatchery Coho	Pacific salmon	PFMC (2011b)

* Proposed for 2015

scientific innovations that continue to advance the management of data-limited fisheries in the U.S., with potentially broad application for data-limited fisheries around the world. (Bentley, 2014)

Given the limited data, resources, and time available to support conventional data-rich assessments for most previously unassessed stocks, data-limited methods are currently used to calculate more OFLs/ABCs than data-rich methods nationally, a result previously reported (Berkson and Thorson, 2014). To set ACLs for these stocks, stock assessment scientists focused their attention on developing a number of new data-limited methods (Cope, 2013; Cope et al., 2013; Dick and MacCall, 2011; MacCall, 2009) and reviving the use of older methods (Cope et al., 2012; Gulland, 1971; NPFMC, 2013a; Taylor et al., 2013; Walters and Martell, 2002). The ACL mandate, and the resulting methodological windfall, has also led to a number of other developments, including: comprehensive management strategy evaluation of the relative efficacy and applicability of many data-limited methods (Carruthers et al., 2014;

Table 3
2015 OFL/ABC-Setting methods by region (proposed as of April 2014).

	NEFMC	MAFMC	SAFMC	GMFMC	CFMC	HMS	PFMC	NPFMC	WPFMC	National
Data-rich	28	9	18	9	0	3	45	39	4	155
Data-moderate	1	–	–	–	–	–	29	47	9	86
F_{MSY}/M	–	–	–	–	–	–	12	45	–	57
Biomass-augmented catch MSY	–	–	–	–	–	–	–	–	9	9
Piggyback related assessed stock	–	–	–	–	–	–	7	1	–	8
XDB-SRA	–	–	–	–	–	–	6	–	–	6
exSSS	–	–	–	–	–	–	4	–	–	4
Median catch/current biomass	1	–	–	–	–	–	–	–	–	1
Predation model	–	–	–	–	–	–	–	1	–	1
Data-poor	2	1	42	25	23	37	95	13	33	271
Catch scalar > mean/median	–	–	38	20	3	–	2	1	2	66
DB-SRA	–	–	–	–	–	–	47	–	–	47
Catch scalar = mean/median	1	1	1	3	13	17	2	3	0	41
Prohibited landings	–	–	3	2	5	18	4	1	8	41
Zero contribution to complex ABC	–	–	–	–	–	2	28	–	–	30
% Habitat of indicator stock habitat	–	–	–	–	–	–	–	–	18	18
DCAC	–	–	–	–	–	–	11	–	–	11
Catch scalar < mean/median	–	–	–	–	2	–	–	8	–	10
MSY estimate from old assessment	–	–	–	–	–	–	–	–	5	5
% of Assessed co-occurring stock ABC	1	–	–	–	–	–	–	–	–	1
Estimate from scientific literature	–	–	–	–	–	–	–	–	–	1
Exempt stocks	1	2	15	7	–	11	86	25	18	165
International management	–	–	–	–	–	11	37	1	18	67
Ecosystem component species	–	–	6	–	–	–	11	24	–	41
Endangered species act listed	1	–	–	–	–	–	24	–	–	25
Life history < 1 year	–	2	9	7	–	–	1	–	–	19
Hatchery stock	–	–	–	–	–	–	13	–	–	13

Wiedenmann et al., 2013; Wetzel and Punt, 2011; Wilberg et al., 2011), the creation of a user-friendly software package for rapid application of data-limited methods (Carruthers, 2014), and collaborative workshops on data-limited methodologies. This focus on data-limited fisheries science, and the tools and knowledge it has spurred, illustrates the significant impact that the ACL mandate has had on this area of fisheries science.

4.2. Regional differences

The response to meeting the ACL requirement for data-limited stocks has been varied across the country. The development of new data-limited methods has been almost entirely limited to the Pacific and North Pacific regions that together contain approximately half of all stocks and stock complexes for which data-limited methods are used to calculate OFLs/ABCs. These two regions also contain 95% of all stocks and stock complexes using data-moderate methods. Nearly all of the other data-limited stock and stock complexes are contained in the Southeast U.S. (Gulf of Mexico, South Atlantic, and U.S. Caribbean regions), Atlantic HMS, and the Western Pacific. Catch scalars and prohibited landings (i.e., ACL = 0) are the dominant approaches in these regions. Recent management strategy evaluation concluded that catch scalars lead to high probabilities of overfishing and stock depletion if biomass is already below B_{MSY} (Carruthers et al., 2014). Knowledge of catch alone provides little to no basis for an assessment of a stock's population dynamics without requiring highly influential assumptions based on expert judgment. The Only Reliable Catch Stocks (ORCS) approach (Berkson et al., 2011) seeks to incorporate additional biological and ecological theory over earlier scalar approaches, but has proven problematic to apply, as it requires a larger number of subjective decisions based on expert judgment.

There are various reasons for the regional disparities in data-limited method development and implementation. There are fundamental regional differences in the number of stocks being managed, the data types and lengths of the time series available, and the resources dedicated to data processing and stock assessment. Regions such as the Northeast and Mid-Atlantic manage relatively fewer stocks due to a historical focus on species directly targeted by fishing. For most of the stocks managed by these Councils, there are significant sources of data available, including fishery independent surveys with long time series.

Another difference is that in some regions with large numbers of data-limited stocks, dedicated efforts have been directed toward assembling and processing existing data, such as the historical catch reconstruction project in the Pacific region (Ralston et al., 2010), and developing methods that make use of the newly-available data, such as DB-SRA (Dick and MacCall, 2011). Such data assembly efforts take substantial resources that have not been available in all regions, such as the Southeast, where a single NMFS Science Center supports three fishery management Councils and NMFS's Atlantic HMS office. By comparison, the Pacific Council, alone, is supported by two Science Centers. The Southeast is the only region where data-limited OFLs/ABCs continue to be set by the Council SSC's with little to no input from a Science Center. The development of more sophisticated data-limited methods and their broad implementation in the Pacific and North Pacific regions is largely due to data and resource availability, which impacts the amount of data that can be collected, the ability to process and analyze the data, and the construction and implementation of stock assessment methods.

In addition to resource variations, regions also administer stock assessment and ACL-setting processes in distinct ways that have important implications for the efficiency and volume of work that can be managed. For example, the Southeast region has historically prioritized repeated assessments of a small fraction of high value stocks. Other regions with a longer history of setting fishing quotas predating the ACL mandate, such as the Pacific and North Pacific regions, have implemented a regularly-scheduled process for routinely updating ACLs in a one or two-year cycle. This regular ACL specification cycle allows for data processing and stock assessments to be scheduled in concert with the management needs of the Councils.

4.3. Moving forward

While it is clear that a large fraction of managed stocks in the U.S. will never progress to having conventional stock assessments, there is considerable opportunity to identify and apply assessment methods that take full advantage of existing data and to identify cost-effective ways of collecting relevant new data to improve assessment precision and support sustainable management and optimum yield. Ideally, each regional science center and council should establish efficient, routine procedures to promote this process, including: establishing a complete inventory of all available data, dedicating resources and expertise to method development and method evaluation, and potentially developing a more streamlined assessment process to handle the expanded volume of stocks requiring ACLs. Lastly, improved coordination among offices within NMFS and between state agencies would facilitate all of the above.

First, a comprehensive review of existing data is essential, as more data is likely available than is currently being used. The existence of data such as fishery-dependent and -independent indices, effort, and mean length could be used immediately to improve knowledge and management of a fishery. Where such reviews have been conducted, informative data was found for some previously unassessed stocks, allowing more robust assessment methods to be used (Cope, 2013; Cope et al., 2013). Other data-poor methods incorporate additional information, such as knowledge of historical depletion deduced from reconstruction of historical catch records (DB-SRA, Dick and MacCall, 2011), and have been shown to perform well for certain life histories (e.g., long-lived species) (Carruthers et al., 2014). This demonstrates that more data-rich and data-limited assessments are possible without the need to collect additional data in some cases. In other cases, additional information may be required, but could likely be collected at reasonable cost if limited resources were targeted based on a systematic analyses of the value of different data types.

Second, there should be an increased use of management strategy evaluation to test the effectiveness of alternative OFL/ABC-setting methods for stocks and stock complexes depending on stock type, fishery, and data-availability. The application of management strategy evaluation can also help identify the relative value of collecting various types of data, thus enabling a quantitative way to systematically prioritize and focus data collection efforts. The continued development of user-friendly software to test and implement data-limited methods has the potential to greatly expand their application, both nationally and internationally.

Third, streamlining regional stock assessment processes to improve efficiency without sacrificing transparency or inclusiveness will free up much needed resources.

Lastly, improved coordination among NMFS Regional Offices, Headquarters, and Science Centers, state agencies, Councils and their SSCs would bring great benefits. A good example of this is the National SSC meetings held in 2008 through 2011 (Seagraves and Collins, 2012), which allowed SSCs to learn from each other's experience for topics such as data-limited methodologies. Given the wide regional disparities in the application of different data-limited methods described in this paper, and NMFS's requirement to base management decisions on the best scientific information available, it is imperative that NMFS, the Councils, and other stakeholders improve coordination among regions and work to identify and disseminate best practices for data-limited fisheries management across the country.

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