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### **Operationalizing Thresholds to Serious Harm: Existing Guidance and Contemporary Canadian Practices**

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## Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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## ABSTRACT

Revisions to Canada's *Fisheries Act* result in a need for a single limit reference point (LRP) and metric of stock status for major fish stocks to be prescribed by regulation. LRPs are triggers for rebuilding plans under the *Act*, but remain part of precautionary approach harvest strategies where they serve multiple roles. LRPs are principally seen as reference points representing thresholds to states at risk of serious harm, but also often as operational control points in harvest control rules. The Science Sector has identified a need to provide guidance to estimate LRPs and stock status for scenarios that presently do not meet the "one stock, one LRP" requirement and a more general need for guidance on methods to estimate and report both LRP and stock status across the data and knowledge spectrum. To inform this guidance, we reviewed Canadian approaches to operationalizing LRPs and stock status, and conducted a literature review of existing Canadian and international guidance for LRP and stock status estimation. From this review, we proposed a consolidated definition of serious harm, a set of six common best-practice principles concerning indicators, LRPs and stock status metrics, and identified topics on which technical guidance for LRPs and stock status should expand.

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# 1. INTRODUCTION

## 1.1. CONTEXT

Canada's *Fisheries Act* (R.S.C., 1985, c. F-14) was revised on June 21, 2019, resulting in new considerations and Fish Stocks Provisions (FSPs) that relate to the management of fisheries. The requirements of the FSPs are being interpreted through the lens of the Fisheries and Oceans Canada's (DFO) Sustainable Fisheries Framework suite of policies, in particular the Fishery decision-making framework incorporating the precautionary approach (PA Policy, DFO 2009a). The FSPs came into force in April 2022 with the prescription of the first batch of major fish stocks and associated regulations for rebuilding plan requirements.

The FSPs identify objectives for conservation in light of sustainable use. These include objectives to maintain stocks at or above the "level necessary to promote sustainability of the stock", s 6.1(1); or "above [the limit reference point or LRP; bolded, italicized key terms in glossary in Appendix 1]", s 6.1(2); "rebuild [stocks above LRP]", s 6.2(1); as well as "minimizing further [stock] decline" and mitigating "adverse socio-economic or cultural impacts", s 6.1(2), 6.2(2)). The FSPs also reference required management actions (setting LRPs, implementing measures, and developing and implementing rebuilding plans). The FSPs are understood to require advice pertaining to:

- Support for the prescription of major fish stocks that are of one species, can be defined geographically or by management area, and for which there is a single LRP/stock status;
- A single LRP for each candidate or prescribed major fish stock (the "one-stock-one-LRP" requirement); and,
- A single stock status relative to the LRP (part of the objective for s 6.1(2) and, when breached, a monitoring metric that triggers a rebuilding plan under s 6.2).

### 1.1.1. Multiple LRP Roles

In Canada, the LRP is intended to help operationalize an objective to avoid serious harm to fish stocks, a central objective of the PA Policy (DFO 2009a). In the PA Policy, the LRP serves multiple roles. As a limit, it is part of fisheries management objectives. As part of stock status metrics, the LRP separates the Cautious and Critical Zones. The LRP further serves as an inflection point for the removal reference (limit fishing mortality rate), and often as an operational control point for management measures. Lastly, the LRP now has a legislated role in triggering the need for rebuilding plans when breached. Fisheries managers have a leading role for most aspects of fisheries management objectives and therefore the PA Policy (including most reference points, risk tolerance and timeframes over which objectives are evaluated, and measures to achieve the objectives), however the responsibility for setting LRPs (and the estimation of stock status) lies with DFO's Ecosystems and Oceans Science Sector (Science Sector; DFO 2009a).

### 1.1.2. A Ubiquitous Challenge

Estimating reference points and assigning stock status in relation to those reference points is a challenge faced in many jurisdictions; regardless of how they measure success in stock status estimation, none have entirely achieved it (Figure 1). Where status information is available for Canadian stocks, diverse approaches to estimate LRPs and associated stock status metrics have been employed (Marentette et al. 2021).

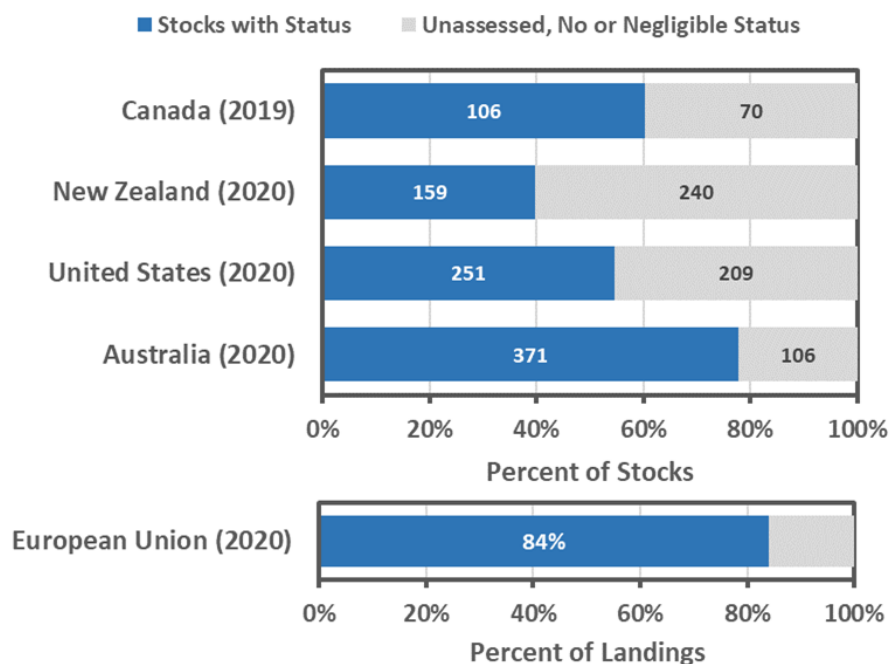


Figure 1: The percentage of stocks (or percentage of landings from stocks) with and without 'status' according to harvest strategy or precautionary approach policies in different jurisdictions that also report on fisheries sustainability indicators for important stocks, as of June 2022. Note that the European Union uses landings instead of stocks, which may come from disproportionately fewer stocks; and also pools landings from stocks with status based on either stock biomass or fishing mortality, so the two metrics are not directly comparable. Numbers in bars indicate the number of stocks or the percentage of landings reported by each jurisdiction. Negligible status (Australia): Catches are so low as to be considered negligible and inadequate information exists to determine stock status. Data from DFO 2021a, FRDC 2022, European Environment Agency 2022, MPI 2022, NOAA Fisheries 2022.

The Science Sector has identified a need to provide guidance to address scenarios that presently do not meet the “one stock, one LRP” requirement or for which there is insufficient knowledge of status relative to the LRP. There is also a more general need for guidance on methods to determine and report both LRP and stock status across the spectrum from data (or information) rich to poor. Guidance will take into account international practices and be supported by Canadian case studies where applicable. Such guidance will assist the Department in the prescription of major fish stocks by regulation by accelerating the development of LRPs and determination of stock status; and also contribute to operational guidelines for the Science Sector. The Science guidelines are being developed to support fisheries science practitioners in the provision of a nationally consistent approach to providing scientific advice to support management of Canada’s fish stocks.

## 1.2. GOALS OF THIS PAPER

The goals of this paper are to:

- Review and propose a consolidated definition of the concept of serious harm;
- Identify a set of commonly applied best-practice principles concerning indicators, LRPs and stock status metrics, forming a guidance framework; and,
- Identify current approaches, challenges and needs of the Science Sector in providing advice on LRPs and stock status metrics, on which technical guidance should expand.

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To achieve these goals:

- We reviewed past and present approaches to estimating LRPs and stock status from the broader Canadian “community of practice” (Section 3, Appendix 3). Specifically, we explored rationales for choice of LRPs, and various factors that had been or could be considered when providing advice on LRPs and stock status. Factors we explored included the operational context in which advice was provided, available information, species biology and stock structure. We supplemented this review by conducting a semi-quantitative survey of information poverty of stock assessment staff across the country (Appendix 2).
- We conducted a literature review of existing Canadian and international guidance for best practices concerning reference points and stock status estimation and reporting, further refining those principles via a workshop on LRPs (Marentette et al. 2022).
- We conclude this paper with guidance on best practice principles and recommendations for technical guidance for DFO’s Science Sector moving forward.

### 1.2.1. What Was Not Included?

#### 1.2.1.1. Whether Forage Fish Merit Different Guidance

DFO’s Policy on New Fisheries for Forage Species (the “Forage Fish Policy”, DFO 2009b) applies to only new fisheries on forage fish, an undefined category, and is thus out of scope for this paper. The Forage Fish Policy adjusts the meaning of the LRP to serious harm experienced by both target and ecologically dependent species: “The indicators used as limit reference points in management should ensure **both** that future recruitment of the target species is not impaired, **and** that food supply for predators is not depleted.” This is an important contrast to the PA Policy, where LRPs are defined for target stocks recognizing that impacts to other species **may** occur when target stocks are below their limits. [emphasis added] The Forage Fish Policy further suggests that stock status of predators can be used as a proxy indicator for stock status of forage fish.

#### 1.2.1.2. Non-Stationarity in LRPs

Guidance for full consideration of the multiple ways in which non-stationarity in environmental conditions can and should be accounted for in PA harvest strategies, including all reference points, is needed, but beyond the scope of this paper. Australian guidelines for Commonwealth fisheries recognize this as an active area of research (DAWR 2018b). Options can include F-based reference points (DFO 2013), which can be fine-tuned to account for changes in environmental drivers (ICES 2021b).

## 2. SERIOUS HARM

While the *Fisheries Act* imparts an obligation to set LRPs, the meaning of the LRP in Canada is set in policy, not law. In general, limits represent thresholds to undesirable states (e.g., stock size, fishing pressure; Sainsbury 2008). As a reference point, the (Canadian) LRP is part of how a measurable objective to avoid **serious harm** to a target stock is operationalized, although it also has other roles as noted above (Section 1.1). This objective is central to the Canadian framework for incorporating the precautionary approach to fisheries management (DFO 2009a, DFO 2009c) as well as the broader Canadian federal framework for precaution (PCO 2003), but it is not exclusive to Canada as similar objectives and LRPs are applied elsewhere in fisheries (e.g., NAFO 2004, DAWR 2018a, MF 2011, MSC 2018, ICES 2021a) and serious harm is also referenced in international agreements such as the Convention on Biological Diversity (1992).

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Definitions of serious harm are generally consistent throughout existing DFO literature but vary somewhat in technical detail and it is helpful to pool the different descriptions into a single, more comprehensive explanation of the term (grey box below).

## 2.1. CONSOLIDATED DEFINITION OF SERIOUS HARM

### Serious Harm

In the context of fisheries, serious harm is an undesirable state that may be irreversible or only slowly reversible over the long-term (Shelton and Rice 2002). It may be directly or indirectly due to fishing, other human-induced impacts, or other natural causes, and occurs at states before extirpation is a concern (DFO 2006, DFO 2004). These states can be associated with:

- Impaired productivity or reproductive capacity (Shelton and Rice 2002, DFO 2006, DFO 2004, DFO 2016a, Smith et al. 2012, DFO2009a, DFO 2021b, DFO 2021c), resulting from changes to biological processes such as recruitment, growth, maturation and survival (DFO 2006, DFO 2004, DFO 2016a).
- A loss of resilience (Smith et al. 2012), defined as an impaired ability to rebuild, exceed replacement (Shelton and Rice 2002) or to recover from perturbation (DFO2009a);
- An elevated risk of depensation or Allee effect (DFO 2006, DFO 2021b) (i.e., negative density dependence, in which the intrinsic rate of increase for a stock decreases, rather than increases, as abundance declines); and/or,
- States where population dynamics are generally poorly understood (DFO 2006).

When a stock is estimated to be at risk of serious harm, there may also be resultant impacts to the broader socio-ecological system, such as the ecosystem, associated or dependent species, or a long-term loss of fishing opportunities (DFO 2006). However, economic inefficiencies such as growth overfishing or reduced yield do not in and of themselves constitute serious harm to the stock (Shelton and Rice 2002).

#### 2.1.1. Relationship to the Limit Reference Point

The LRP represents the upper bound of stock states that should be avoided in order to prevent serious harm to the stock and is the boundary between the Critical and Cautious zones of DFO's PA Policy (DFO 2009a). Under that Policy and the FSPs, breaching the LRP is a trigger for a rebuilding plan.

One key refinement proposed by DFO (2016a; but also used in DFO 2004) is that the LRP marks states at **increasing risk of** serious harm, whereas other descriptions are more deterministic (i.e., that the LRP marks states below which serious harm **is** occurring; DFO 2009a). Similarly, the Marine Stewardship Council defines the point of reproductive impairment (PRI) as “the point below which there is an **increased risk** that recruitment may be substantially impaired” and recognizes this point will be neither exact nor constant (MSC 2018). Risks to stocks are generally not discontinuous and furthermore they may be hard to estimate precisely until serious harm is observed, which may be an undesirable, irreversible, and/or unattainable burden of proof (Sainsbury 2008). Similarly, LRPs are recommended to be placed above Allee thresholds, and not at them (DFO 2021b). This risk distinction is important from a technical perspective, and also underlies some differing views in the literature as to what points to use from stock-recruitment relationships to best address risks of recruitment overfishing (Sainsbury 2008).

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## 2.1.2. Stock Structure and Serious Harm

Loss of target stock structure (e.g., depletion of subunits) is not typically included in conventional descriptions of serious harm, although such losses may meet the definition of serious harm, e.g., as a loss of resilience or productivity.

The Forage Fish Policy explicitly recognizes objectives for preserving target stock (or even species) structure, but does not require such objectives to be part of the meaning of the LRP; rather, this objective is to be addressed by the harvest strategy as a whole: “Forage species should be managed in ways which ensure local depletion of population components does not occur” (DFO 2009b).

Objective 1 of *Canada's Policy for Conservation of Wild Pacific Salmon* (“Wild Salmon Policy,” DFO 2005) is to “safeguard the genetic diversity of wild Pacific salmon” and this is accomplished “through the protection of ‘Conservation Units’ (CUs),” defined as “group[s] of wild salmon sufficiently isolated from other groups that, if extirpated is very unlikely to recolonize naturally within an acceptable timeframe” and which contain one or more populations. The Wild Salmon Policy has an analogue to the LRP of the PA Policy in the form of a lower benchmark that delineates a Red Zone from an Amber Zone (Holt and Irvine 2013). Like LRPs, “there is no single rule to use” and lower benchmarks are determined on a “case-by-case basis” depending on “available information” at levels “high enough to ensure there is a substantial buffer between it and any level of abundance... considered at risk of extinction” (DFO 2005). Guidance to translate the concept of PA Policy LRPs to the salmon context for stock management units (SMUs) has been developed elsewhere (DFO 2022), and thus to avoid redundancies with that work, Pacific salmon are not addressed further here.

## 3. REVIEW OF CANADIAN PRACTICES

### 3.1. GENERAL FINDINGS

The vast majority of LRPs reviewed below (Appendix 3) were set after the publication of Canada’s PA Policy in 2009 (Figure 2a). A slim majority of stock indicators (n = 81) were estimated with models rather than derived from empirical data (n = 72; Figure 2b), but almost all indicators were estimates of, or proxies for, either stock size or egg production (Table 1, Table A.3.3). Exceptions to this were Goose Barnacle – Clayoquot Sound, where the amount of protected potential habitat was treated as an indicator of stock size and distribution, and five assessment units of Snow Crab – CFA 1-12, for which composites of egg clutches, CPUE and discards were used.



Figure 2: a) Number of LRPs established per year, according to the year of the meeting in which the LRP was selected for assessment units examined in this study. A dashed vertical line indicates the year in which the PA Policy was introduced (2009). Older LRPs (gray vertical bars) are those that were set but have since been updated. b) Number of assessment units with model-based LRPs (theoretical, or historical proxies) or empirical LRPs (x-axis) grouped by the intended meaning of the reference point and LRP categories as described in Table A.3.1 (y-axis). Two of the LRPs were intended to represent both recruitment thresholds and  $B_{MSY}$  proxies while one was considered an “other” theoretical proxy for  $B_{MSY}$ , and so all three were counted twice, in both applicable categories.

In most cases, stock status and trends were monitored by comparing the most recent estimate of the model-based or empirical indicator(s) to the reference point; however, running averages of empirical indices were used to account for inter-annual variability in estimating stock status for 19 assessment units, including American Lobster (LFAs 27-33, 35, 36, 38, and 41), Atlantic Herring (NAFO 4VWX – SWNS/Bay of Fundy), Cusk – 4VWX5Z, Longhorn Sculpin – St. Mary’s Bay, Pollock (4X5 Western Component), Redfish (Unit 3) and White Hake (NAFO 4VW and 4X5Zc). The running average (or median) was computed over three years for all but Redfish (Unit 3; five years).

Table 1: Indicators that may be associated with various stock attributes, with the number of assessment units with LRPs based on those indicators in parentheses. CPUE = catch per unit effort.

Stock Attribute	Model-Based Indicators	Empirical Indicators
Stock Size and/or Egg Production	Spawning Stock Biomass, both sexes or one sex only [weight] (44)	Survey index (34)
	Other Biomass, such as total, vulnerable or commercial [weight] (41)	Composite survey index (7)
	Abundance [numbers] (5)	CPUE (20)
	Fecundity [Eggs in Spawners] (1)	Landings (3)
		Returns, Spawners (3)
Stock Size and Distribution	--	Amount of Protected Potential Habitat (1)
Multiple Attributes	--	Composite of eggs clutches, CPUE and discards (5)

Several stocks were assessed with composite indicators to establish stock status. Four Northern Shrimp stocks (Gulf SFA 8, 9, 19 and 12) had a single LRP and stock status derived from a composite indicator combining four survey indices. Five stocks of Snow Crab (CFA 1-12) and two stocks of American Lobster (LFAs 34 and 41) were assessed with a set of three to four indices in a “traffic light” approach to stock status designation, where each indicator is

associated with its own threshold(s) and overall stock status is dependent on the number of thresholds breached across indicators.

As reported previously for domestically assessed *Survey* stocks (Marentette et al. 2021), the most common type of LRP in Canada is a fraction of biomass at maximum sustainable yield ( $B_{MSY}$ ) (or of various historical or empirical proxies for  $B_{MSY}$ ), as might be expected given that PA Policy provisional default guidance for reference points is based on  $B_{MSY}$ . Model-based or empirical versions using  $B_0$  (unfished biomass) or  $K$  (carrying capacity) were the second most commonly chosen approach, followed closely by  $B_{recover}$  (grouped with related reference points like  $B_{loss}$ , the lowest observed spawning stock biomass (SSB), and  $B_{min}$ , the lowest observed biomass from which the stock subsequently recovered to  $B_{average}$ ; Starr and Haigh 2021). Least common were thresholds directly related to recruitment, and other LRPs that did not fit into those categories (Figure 2b). Except for eight LRPs set to 30%  $B_{MSY}$  (or proxy), a PA Policy provisional default of 0.4  $B_{MSY}$  (or proxy) was most commonly used ( $n = 74$ ), while fractions of  $B_0$  or  $K$  (or proxy) were more diverse, ranging from 10-50%. The length or number of years considered for reference time periods used to develop historical or empirical reference points ranged widely, from 2-42 years for  $B_{MSY}$  proxies, 1-8 years for  $B_0$  or  $K$  proxies, and 1-5 years for  $B_{recover}$ . Descriptions of reference periods (such as  $B_{average}$ ) corresponded generally with provisional default guidance for historical proxies for  $B_{MSY}$  (and implicitly  $B_0$ ) in DFO (2009a), which provided options for historical proxies such as the average biomass or index over a productive period, and 50% of the maximum historical biomass (Table 2, Table A.3.4).

*Table 2: Descriptions used to characterize the time periods or years used in historical or empirical reference points, with the number of assessment units with LRPs using those descriptions in parentheses. Note that descriptions are not exclusive and multiple descriptions in the table below could be associated with each LRP. \*Considered for American Lobster stocks (Tremblay et al. 2012).*

LRP Category	Descriptions of Time Periods/Years Used in Reference Points
Fractions of $B_{MSY}$ Historical or Empirical Proxies (36)	Periods of high stock productivity (15)
	Periods encompassing two generations* (11)
	Periods encompassing both high and low productivity conditions (8)
	Representing entire available time series (6)
	Periods where stock indicator is stable and/or has no trend (4)
	Periods where stock subjected to a range of harvest levels (2)
	Periods with recruitment in large numbers (2)
	Periods before observed declines (2)
Fractions of $B_0$ or $K$ Historical or Empirical Proxies (15)	Periods of high spawning biomass (1)
	Maximum indicator value (including distribution) observed in time series (10)
	Stock under high productivity conditions (3)
$B_{recover}$ or Empirical Proxies (23)	Periods representing exploratory or early data from fishery/stock (1)
	Lowest from which a recovery or sustained recovery was observed (11)
	Lowest from which a recovery was observed under different predator regimes (4)
	Lowest with good recruitment, i.e., large cohorts or 90 <sup>th</sup> percentile deviations (4)
	Lowest non-zero indicator value (2)
	Recovery occurred during low productivity conditions (1)

LRPs based on recruitment thresholds (including spawners associated with egg deposition rates) associated with achieving 50% of maximum recruitment, can be derived in various ways (Atlantic Cod – NAFO 4RS-3Pn and 4X5Y, Atlantic Halibut – NAFO 3NOPS4VWX+5, Atlantic Salmon in Gulf, Maritimes and Newfoundland and Labrador Regions, American Plaice – NAFO 4T, Striped Bass - Gulf). These can include historical thresholds associated with medium levels

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of recruitment, below which poor recruitment was observed (Atlantic Cod – NAFO 2J3KL), or be derived from break-point analyses (Atlantic Cod – NAFO 3Ps).

Fourteen stocks had LRPs categorized as “other,” including thresholds that could be broadly linked to loss of stock attributes such as resilience, productivity and/or the ability to recover from perturbation. One stock (Atlantic Mackerel – NAFO 3+4) employed a dynamic pool ( $B$  at  $F_{40\%}$ -based) LRP, considered a theoretical proxy for  $B_{MSY}$ . Other LRPs included half the density associated with the ability to increase without management intervention in Green Sea Urchin (PMA 12 and 19), densities representing persistence under high levels of predation in Red Sea Urchin, densities associated with impaired productivity of legal-size clams (Intertidal Clams - Depuration), historical time periods representing evidence of states of serious harm (associated with an survey index approximating spawning stock biomass – Atlantic Herring – NAFO 4VWX (SWNS/Bay of Fundy) or agreed-upon states to avoid (Pacific Cod – PFMA 5ABCD), or with composites of other indices – Snow Crab-CFA 1-12), and fractions of historical periods not outright described as a proxy for  $B_{MSY}$  but otherwise linked to periods of desirably high productivity (Pollock – NAFO 4X5 (Western Component), Sea Scallop – SFA 20).

### 3.2. RATIONALES FOR LRP CHOICES

Reference points are to be selected based on the “best information available” (DFO 2009a), and in the context of this review, this may be inferred retrospectively from what was considered at the time a choice of LRP was made. While not all preliminary analyses pertinent to indicator or reference point selection may ultimately be included in advice, advisory documents typically provided some rationale for choice of (or rejection of) an LRP (Table 3), and multiple options were considered and contrasted for at least 62 of the assessment units examined in this review (Table A.3.5).

Model and information poverty appeared to constrain choices. Multiple LRP options were more likely to have been considered for assessment units paired with model-based LRPs than empirical (48 versus 32%; Table A.3.4). LRPs based on a fraction of  $B_{MSY}$ , as per PA Policy guidance in the absence of stock-specific choices, were also the most likely (71%) to have been the only option considered or documented when chosen. This was not the case for LRPs based on other methods (where multiple options had been considered or documented for 50-60% of assessment units).

Institutionally, alignment with PA Policy provisional default guidance of  $0.4 B_{MSY}$  was a common statement made in support of choices for the majority of  $B_{MSY}$ -based LRPs, but also some LRPs based on fractions of  $B_0$  or  $K$  (Table 3). In other cases, choices were based on alignment with or consideration of other criteria, such as Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (pinnipeds), and international best practices (Pacific Herring, Orange-Footed Sea Cucumber in Maritimes Region, and pinnipeds).

Table 3: A summary of statements made in support of, or against, various choices of reference points as LRPs, with the number of assessment units associated with those statements in parentheses. Note that statements are not exclusive and multiple reasons could be associated with each decision or assessment unit. \*Considered for American Lobster stocks (Tremblay et al. 2012).

LRP Category	Statements in Support of Choices	Reasons Against Choices
Fractions of $B_{MSY}$	<p>Consistent with PA Policy (68)</p> <p>Estimates consistent with past evidence of ability to recover (5)</p> <p>Suitable for data poverty (4)</p> <p>Uses the most information on stock production (2)</p> <p>Facilitates selection of policy provisional default USR (1)</p> <p>Supported by fishery interests (1)</p>	<p>Estimates sensitive to or are implausible due to assumptions regarding life history parameters (10)</p> <p>Concerns with stationarity (5)</p> <p>Poor stock-recruitment relationship (5)</p> <p>Estimates differed from other options or other concerns about appropriateness given data poverty (3)</p> <p>Associated with past declines (2)</p> <p>Cannot be estimated or poor model fit (2)</p> <p>Data issues or requirements (2)</p>
Fractions of $B_0$ or $K$	<p>Consideration of or based on best practices from other jurisdictions (11)</p> <p>May be more robust to model assumptions than <math>B_{MSY}</math> (9)</p> <p>Estimates consistent with past evidence of low surplus production (8) or where recovery was observed (1)</p> <p>Supported by analogies to similar stocks or meta-analysis (6)</p> <p>Feasible to estimate (5)</p> <p>Suitably equivalent to 0.4 <math>B_{MSY}</math> or PA Policy (4)</p> <p>Relative depletion more suitable for management and/or COSEWIC (4)</p>	<p>Sensitive to model assumptions (3)</p> <p>Other data challenges (1)</p>
$B_{recover}$	<p>Only viable method and/or <math>B_{MSY}</math> or <math>B_0</math> were not feasible to estimate (6)</p> <p>Supported by fishery interests (4)</p> <p>Suitable for spasmodic stocks (3)</p> <p>Historical reference points scale with biomass and fishing mortality (1)</p> <p>Acceptable performance in simulation (1)</p>	<p>Change in productivity regime (3)</p> <p>Implausibly high or low estimates compared to other options (2)</p> <p>Used primarily to validate other options (2)</p> <p>Data problems or high variability (2)</p> <p>Doesn't use all information available (2)</p> <p>Subsequently information improved around undesirable states (1)</p> <p>Could not be identified (1)</p> <p>Represents chance event (1)</p>
Recruitment	<p>Acceptable fit of stock-recruitment method (4)</p> <p>Acceptable performance in simulation (3)</p> <p>Supported by analogies to similar stocks or meta-analysis (3)</p> <p>Data requirements considered (4)</p> <p>Eggs considered best indicator of productivity (1)</p>	<p>Poor stock-recruitment relationship and/or extrapolation required (7)</p> <p>Implausibly low due to high natural mortality (5)</p>

LRP Category	Statements in Support of Choices	Reasons Against Choices
Other	<p>Estimates consistent among several options and/or multiple lines of evidence of serious harm (7)</p> <p>Consistent with meta-analysis (3)</p> <p>Acceptable performance in simulation or modelling (2)</p> <p>Supported by analogies to similar stocks or meta-analysis (1)</p> <p>Represents an agreed-upon undesirable state (1)</p>	<p>Stationarity concerns (5)</p> <p>Highly variable indices (1)</p> <p>Higher data requirements (1)</p>

Technical considerations generally predominated in rationales (Table 3). LRPs based on  $B_{MSY}$  were rejected where model-based estimates of  $B_{MSY}$  were considered unreliable due to challenges with stock-recruitment relationships or sensitive to various life history parameters. In other cases,  $B_{MSY}$ -based LRPs were deemed implausible due to non-stationarity in parameters including high natural mortality. In some cases, particular fractions of  $B_{MSY}$  were considered too low or questionable given data poverty or association with past stock declines. LRPs based on  $B_0$  or  $K$  were generally considered more robust to model assumptions but sometimes rejected when estimates, like those for  $B_{MSY}$ , were considered implausible or unreliable due to data issues or sensitivity to various priors.

LRPs based on  $B_{recover}$  were most likely to be rejected when estimates were implausibly high or low (compared to other options), were considered too vulnerable to stationarity assumptions, or could not be associated with a year representing a particular desired level of demonstrated recovery. In some cases, other LRP rationales were preferred and  $B_{recover}$  was considered for these assessment units as a means by which to evaluate the plausibility of alternatives. LRPs representing recruitment thresholds were rejected when thresholds were undetectable due to poor stock-recruitment relationship fits, estimates were considered implausible or were below the lowest level observed, or were based on methods considered not well understood or insufficiently peer-reviewed. Lastly, LRPs based on other rationales were rejected variously due to inadequate data, implausibility of estimates in comparison to alternatives, non-stationarity concerns, or other data issues such as high variability.

**Plausibility** (or credibility) of LRP options played a role in LRP choice for several assessment units, and decisions appeared to have been approached in two ways:

- An examination of whether different candidate LRPs had **similar estimates**, which could be used to validate a choice preferred for other technical reasons (e.g., a dynamic pool proxy for  $B_{MSY}$  that does not require a stock-recruitment relationship; Atlantic Mackerel – NAFO 3+4); or to select a defensible deterministic (fixed) LRP value, usually an average or composite of several equally plausible options (e.g., American Plaice – NAFO 4T, Atlantic Cod – 4RS-3Pn and 4TVn, five assessment units of Snow Crab – CFA 1-12)); and/or,
- An examination of whether estimates were **biologically plausible**, i.e., whether LRPs or the reference points from which they were derived were consistent with, or at odds with:
  - Non-stationarity,
  - Past **recoveries**, where  $B_{recover}$  was not used outright (e.g., Giant Red Sea Cucumber, Northern and Striped Shrimp stocks in the Eastern and Western Assessment Zones and in SFA 13-15 (Scotian Shelf)),
  - Past states associated with **low surplus production** (e.g., five assessment units of Pacific Herring),

- **Plausible estimates (or fractions)** of  $B_{MSY}$  or  $B_0$  in light of the history of the stock (e.g., five assessment units of Pacific Herring, Striped Bass – Gulf),
- Past **declines** (e.g., Monkfish – NAFO 3NLOPs, Witch Flounder – NAFO 3Ps),
- Otherwise historically **undesirable stock states** (e.g., Atlantic Herring – NAFO 4VWX (SWNS/Bay of Fundy), Pacific Cod – PFMA 3CD and 5ABCD, Snow Crab – Scotian Shelf).

Life history considerations and linkages to similar stocks were sometimes used to inform choice of LRP as an intermediary step between defaulting to policy guidance or having suitable stock-specific information. Meta-analyses of life history or productivity information, and/or extrapolation of LRPs among similar stocks was used to help support and extend LRP choices in diadromous fishes (Gaspereau – Maritimes (Alewife), Atlantic Salmon – Gulf, Maritimes and Newfoundland and Labrador Regions), among five Pacific Herring assessment units, for Sea Scallop – SFA 28 (Scallop Production Area or SPA 6) in relation to other SPAs in SFA 28, and for choice of LRP in Spot Prawn and Red Sea Urchin.

### 3.2.1. History of Depletion

The impact of historical stock depletion on the choice of LRP can be approximated by the total number of years assessment units were estimated to have been below the LRP at the time the LRP was set (whether continuously or intermittently). LRPs based on  $B_0$  or  $K$  were more likely to have been used when historical depletion was less than 10 years, absent, or uncertain (Table 4). LRPs representing recruitment thresholds were most common for assessment units with a greater history of depletion ( $\geq 10$  years below the LRP). Exceptions included LRPs for Spot Prawn and for Atlantic Salmon, where LRPs derived from recruitment thresholds were extrapolated from specific study areas to analogous assessment units.

In general, more LRPs were considered for stocks with at least some history of depletion, which could reflect greater information richness.

*Table 4: Number of LRPs according to the number of years the stock was previously below the LRP in the available time series at the time the LRP was chosen.*

LRP Category	History of Depletion when LRP Chosen		
	No or Uncertain	< 10 years below LRP	$\geq 10$ years below LRP
$B_{MSY}$	58	10	13
$B_0$ or $K$	19	5	-
$B_{recover}$	7	12	3
Recruitment	4	-	9
Other	6	7	1
% where multiple LRPs considered	36.2%	50%	42.3%
Mean No. LRPs considered	1.5	1.9	1.8
<b>Total</b>	<b>94</b>	<b>34</b>	<b>26</b>

## 3.3. OPERATIONAL CONTEXT

### 3.3.1. Advice Frameworks

Presently, traditional stock assessments, whether based on empirical indices or “single best model” frameworks, predominate over multiple-model stock assessment and management

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strategy evaluation (MSE) approaches in Canadian fisheries science advice. Indicators and LRPs reflect what is generally possible to estimate given the overall advice and management framework; empirical indicators and LRPs are mostly used in index-based assessments (86%), and model-based indicators and LRPs where one or more assessment or operating models are in use (93%). Most, but not all, LRPs were operational control points in harvest control rules (Marentette et al. 2021). All would be operational control points for rebuilding plan requirements under both the PA Policy and the FSPs.

Estimates of  $B_{MSY}$  were derived by various methods (outlined by Punt et al. 2014), including:

- Combining estimates of stock-recruitment relationship parameters with yield and spawning biomass-per-recruit as a function of fishing mortality in age, length or stage-based assessments to estimate  $SSB_{MSY}$  (22 assessment units), in forward projections of delay difference models assuming stock-recruitment relationships (e.g., Smith et al. 2016; 4 assessment units) or by a direct application of the Sissenwine-Shepherd (1987) approach in virtual population analysis (VPA)-based assessments (1 assessment unit);
- Surplus production models fitted to catch and abundance indices without requiring stock-recruitment relationships (largely Schaefer; 12 assessment units); and,
- Data-poor assessment methods (i.e., Catch-MSY and depletion-corrected average catch; 3 assessment units).

Estimates of  $B_0$  were derived from stock-recruitment relationships in statistical catch-at-age models, fitted to long-term average trends in weight-at-age and natural mortality (5 assessment units) while  $K$  was estimated from Schaefer surplus production models (3 assessment units). Recruitment thresholds were derived from stock-recruitment relationships or other analyses fitted to spawning biomass and recruitment estimates from VPA (3 assessment units), statistical catch-at-age or integrated state space models (1 assessment unit each).

### 3.3.2. Frequency of LRP Estimate Updates

Empirical LRP estimates are by definition deterministic or fixed values that do not change from one assessment to the next, unless the methods by which empirical indices are calculated are changed. In contrast, estimated values of model-based LRPs (whether theoretical values or historical proxies) are often updated with each assessment and the inclusion of new data, such that they scale with model estimates of biomass and fishing mortality. Exceptions may include assessment units with deterministic model-based LRPs (e.g., as per ICES 2021a) based on  $B_{recover}$  (used for Atlantic Cod – 4TVn and Haddock – 4X5Y) or various recruitment thresholds (Atlantic Cod – 3Ps, 4RS-3Pn, and 4X5Y; Atlantic Halibut – 3NOPs4VWX+5; and American Plaice – 4T).

### 3.3.3. Advice on Stock Status with Non-Traditional Paradigms

Traditional stock assessments, whether via indices or a single best assessment model, estimate a single stock status whether it is computed for monitoring purposes (i.e., current and past stock status), or for forward-looking advice to support selection of management measures (e.g., status as a performance metric for projected catch limits). Advice on stock status can be more complex for multi-model or MSE-based frameworks, where multiple assessment or operating models are often used to capture key uncertainties as per PA Policy intent. As a result, multiple current/past stock statuses may be estimated, or stock status may be primarily or exclusively used in performance metrics evaluating management procedures. Across 26 assessment units with non-traditional advisory paradigms, stock status reporting was addressed through the methods summarized in Table 5.

Table 5: Methods by which stock status advice is provided for assessment units with non-traditional paradigms.

Method	Example Assessment Units
Only <b>one operating model</b> was used (or was chosen from the suite used) in the most recent assessment, evaluation or update, so a single status estimate was produced	Atlantic Halibut – 3NOPs4VWX+5, Canary Rockfish; Pacific Herring – five assessment units; Sablefish
A single status (i.e., by stock status zone) was estimated by <b>seeking consistency in status estimation</b> across models (i.e., weight-of-evidence)	Atlantic Herring – NAFO 4T (Fall Spawners); Yelloweye Rockfish – Inside and Outside, Yellowmouth Rockfish
A single status was estimated by <b>integrating results</b> (i.e., via a composite base case or scenario averaging)	Arctic Char – Cambridge Bay; Bocaccio Rockfish, Pacific Lingcod – PFMA 4B (Inside); Pacific Cod – PMFA 3CD and 5ABCD, Roughey Rockfish – PFMA 3CD5AB and 5DE, Shortspine Thornyhead, Walleye Pollock – PFMA 3CD5AB and 5CDE, Widow Rockfish
An <b>empirical</b> reference point and indicator were used to assess stock status outside of the operating model framework	Pollock – NAFO 4X5 (Western component))
<b>Multiple statuses</b> were provided	Striped Bass – Gulf

### 3.3.4. Advice on Stock Status Between Assessments

Fisheries science advice may be provided annually or according to a multi-year schedule via CSAS. For some stocks in traditional best-assessment paradigms, updates may be provided in years between more intensive assessments or evaluations. Advice for most assessment units ( $n = 141$ ) is provided on a multi-year basis, and advice for nearly half of these ( $n = 63$ ) are supplemented with interim updates. A review of the most recent published updates for each stock indicated that most contained the same type of (updated) stock status and trends information relative to the LRP as might be found in full assessments or evaluations (e.g., model-based when full assessments were model-based, etc.). Updates for six stock/subunits, however, included empirical proxies of both the model-based indicator and LRP in interim advice (Atlantic Halibut – 3NOPs4VWX+5, Winter and Witch Flounders – 4RST, American Plaice – 4T, Atlantic Cod – 4TVn, Haddock – 4X5Y). In these cases, a change in the perceived “empirical proxy” status of the stock (e.g., from below to above the empirical version of the LRP) was advised to signify an exceptional circumstance triggering an earlier assessment than scheduled, but not necessarily a change in stock status, which would be established only during full assessments or evaluations.

### 3.3.5. Changes to Indicators and LRPs Over Time

Advice frameworks for fish stocks evolved with the incorporation (or loss) of information over time or with changing management priorities. This occasionally drove large (or small) changes to choice of indicators, reference points or status, such as:

- **Methodological adjustments** to calculations associated with empirical indicators (e.g., Atlantic Herring – NAFO 4VWX (SWNS/Bay of Fundy), Northern Shrimp – SFAs 4, 5 and 6; Snow Crab – CFA 12 (12, 18, 25, 26), 12E, 12F 19) or adjustments to reference periods (Sea Scallop – SFA 27, Georges “a”);
- **New models** with updated estimates of indicators, LRPs and thus status (e.g., Atlantic Herring – 4T (Fall and Spring spawners), Witch Flounder – NAFO 4RST, and Yelloweye Rockfish – Inside and Outside, resulting in a change in estimated status from Critical to Healthy);

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- **New indicators or LRPs**, as part of a broader evolution of the advisory framework (American Lobster – LFAs 27, 28, 29, 30, 31A, 31B, 32, 33, 34, 35, 36, 38 and 41; American Plaice – NAFO 4T; Atlantic Cod – NAFO 3Ps and 4X5Y, with the former resulting in a change in perceived status from Cautious to Critical; Redfish in Units 1&2 (two assessment units); Spiny Dogfish – NAFO 4VWX+5), including:
    - Specifically **preserving** a former LRP rationale in a new framework (e.g., switching between model-based and empirical versions of the same reference point: Arctic Surfclam – Banquereau, Geoduck, or Redfish – Unit 3; or maintaining reference points with new model frameworks: Yelloweye Rockfish – Inside and Outside, resulting in a change in estimated status from Critical to Healthy, and Yellowtail Flounder – NAFO 4T);
    - **Aligning** with policy guidance, such as where reference points pre-dated the PA Policy (Green Sea Urchin (two assessment units), Pacific Lingcod – PFMA 4B (Inside), Rock Sole – PFMA 5AB and 5CD; Northern and Striped Shrimp in Eastern Assessment Zones); and
    - Moving away from policy guidance to more **stock-specific** options (American Lobster – LFA 34 (Inshore), Haddock – NAFO 4X5Y, Redfish – Unit 1&2 (two assessment units)).

### 3.4. COMMUNICATION OF INDICATORS, LRPS AND STOCK STATUS

The most recent indicator and reference point estimates, along with the method or rationale for the LRP, were broadly included in recent advice for most assessment units, regardless of whether empirical or model-based indicators were used. Estimates of uncertainty, however, and reporting stock status as a ratio (indicator: LRP) were more commonly provided for model-based indicators (Figure 3a). Use of stock status in figures or tables varied with assessment frameworks, emphasizing trends over time (with or without fishing mortality) in empirical contexts and forward-looking advice in various guises for model-based indicators (Figure 3b). LRPs were sometimes referred to as  $B_{lim}$ , lower reference points, critical reference levels, conservation egg requirements, and in the context of recovery potential assessments, sometimes used as recovery targets. Thresholds within composite indicators used to designate stock status were sometimes called LRIs (limit reference indicators). Advice for ten assessment units qualified their stated LRPs as “suggested”, “recommended”, “interim”, or “proxy”.

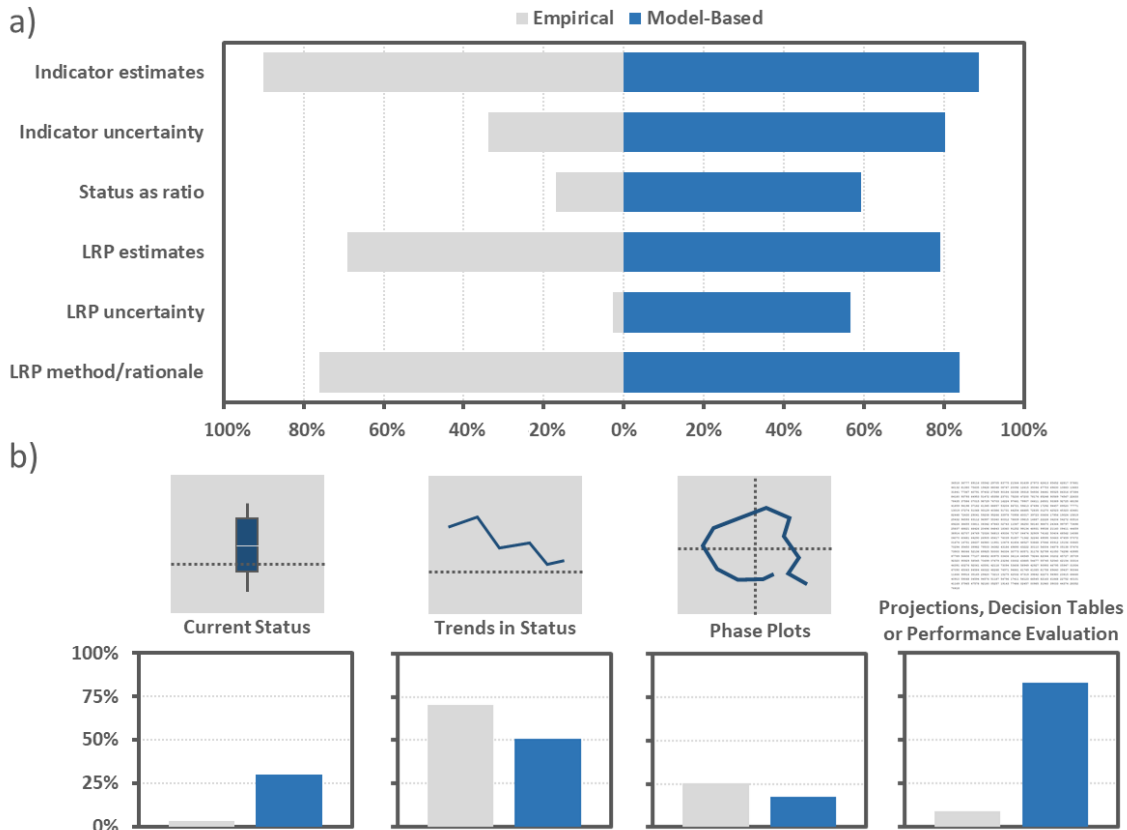


Figure 3: a) The percentage of assessment units with either empirical (grey bars,  $n = 71$ ) or model-based (blue bars,  $n = 81$ ) indicators of stock status that communicated estimates, uncertainties or other information around indicators and reference points in the most recent science advice (science advisory report, research document or update) available. b) The percentage of assessment units with empirical or model-based indicators for which visualizations of current status, trends in status, phase plots or forward-looking advice were provided.

### 3.5. LRP-STOCK SCENARIOS

The scale at which LRPs were set and at which stock status was estimated is pertinent to assessment units which may be candidates for prescription under the Fish Stocks Provisions. Most stocks named on the *Sustainability Survey for Fisheries* that were associated with LRPs and were included in this study ( $n = 63$ ) had one LRP and one status metric and were considered to each represent a single assessment unit. Exceptions ( $n = 26$ ) are described in Table 5.

Table 15: A description of methods by which stock status advice is provided for assessment units in different scenarios without a single indicator and single LRP.

LRP-Stock Scenario	Stocks
Status assignment in the <i>Survey</i> is by expert judgement in lieu of reference points.	American Lobster – LFA 3-14c Dolly Varden – North Slope

LRP-Stock Scenario	Stocks
One LRP and one status metric overall but could contain multiple subunits pending further data collection or focus on subunits, because LRPs and status are estimated for 3-5 subunits within each stock and for the overall stock. These stocks were not disaggregated for the purposes of this paper.	Red Sea Urchin Arctic Surfclam – Banquereau
LRPs are set for all or most of a “tractable” number of assessment units. These stocks were disaggregated into assessment units for the purposes of this paper.	American Lobster – LFA 27-33 (8 units) and LFA 35-38 (3 units units) Arctic Char – Cumberland Sound (3 of 5 commercially fished units have LRPs and stock status) Green Sea Urchin (2 units) Grey Seal (3 units) Pacific Lingcod – Outside (4 units) Snow Crab – CFA 1-12 (5 units) Rougheye Rockfish (2 units) Sea Scallop – SFA 28 and 29W (5 units each)
Stocks have multiple subunits, but only one subunit (often a dominant one in terms of landings and available information) has an LRP either set or proposed.	Herring – NAFO 4WVX Beluga – Northern Quebec (Nunavik) Sea Scallop in Area 20, SFA 26 and SFA 27
<b>Stocks with a large number of subunits (tens to thousands) at which scale limits were set</b>	
Anadromous fishes, where limits derived from a meta-analysis or an analogous stock and are aimed to be extrapolated across numerous rivers and/or lakes, which may be considered reproductively distinct. Stock status is reported as Uncertain on the 2019 <i>Survey</i> .	Gaspereau – Maritimes (two species) Atlantic Salmon in Gulf and Newfoundland and Labrador Regions
Sessile or poorly mobile invertebrates with dispersed larvae, where limits for closure are applied at the scale of individual beds or beaches that are not considered reproductively isolated. In the case of Geoduck, a single stock status is reported by aggregating the stock status indicator (survey index of biomass) across beds. Both were reported as Healthy on the 2019 <i>Survey</i> based on expert judgement.	Geoduck (>2000 beds) Giant Red Sea Cucumber (67 quota management areas)
Mobile invertebrates with multiple species and/or a less “tractable” number of management or assessment units. Shrimp Trawl and Spot Prawn were reported as Cautious and Healthy on the 2019 <i>Survey</i> , respectively.	Shrimp Trawl (3 species, 36 management areas) Spot Prawn (403 survey subareas)

## 4. REVIEW OF EXISTING GUIDANCE

### 4.1. CHOOSING INDICATORS OF STOCK STATUS

The PA Policy states that the LRP should “normally be described using units that relate directly to stock productivity” but that “where necessary, other metrics can and should be considered” and that reference points should be “demonstrably appropriate for the stock and be consistent with the intent” of the policy (DFO 2009a).

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#### 4.1.1. Proportionality

Indicators should have a linear relationship with (i.e., be proportional to) the stock attribute they are intended to measure, including proxies (Campbell 2010). Even common indicators such as model-based estimates of abundance or spawning stock biomass are themselves proxies for stock productivity (e.g., production of eggs or recruits; Shelton and Rice 2002), and productivity can in turn be seen as a proxy for stock resilience (MF 2011). Assumptions around the relationship between fecundity and stock size can impact reference point estimates and perceptions of stock status (Marshall et al. 2021).

Evidence should be provided to show that the selected indicator(s) exhibit a constant or proportional relationship with the stock attribute they are intended to approximate. Fishery-dependent empirical indices such as CPUE, catches or landings are often not proportional to stock size (i.e., biomass or abundance) and should be used with caution (DFO 2016a, Gabriel and Mace 1999, MSC 2018). For example, CPUE may be impacted by hard-to-test assumptions around changes in catchability (i.e., coefficient  $q$ ) over time (Hoggarth et al. 2006). Trends in empirical indicators may have alternative interpretations (McKown et al. 2008, Sainsbury 2008) such as changes in the fishery affecting catchability or serial depletion of subunits (Hoggarth et al. 2006).

#### 4.1.2. Representativeness

Data should be representative of the whole stock area, including areas of lower abundance, and consistent types of data should be available for all stock units (Lynch et al. 2018, McKown et al. 2008). **Indicator stocks** with measurable reference points can be used to manage more poorly known stocks in the same complex, so long as there is a good basis to expect that none of the component stocks are reduced below their respective limits when indicators are above their limits (MSC 2018, USA Code of Federal Regulations [CFR] 2022a). For example, an indicator stock could be one that is more vulnerable than, or typical of the average vulnerability of the components, and information on the non-indicator components is regularly collected to ensure the complex is sustainably managed (USA CFR 2022a). For salmon SMUs, the Marine Stewardship Council notes that LRPs (and hence stock status metrics) can be aggregated across components, but should reflect overall productivity in the sense of a high probability of persistence in the presence of directed fishing and recovery to high production in the absence of fishing (MSC 2018).

In less structurally complex scenarios, proposed best practices for empirical indicators to help ensure representativeness of the stock include the following (DFO 2016a):

- Acceptable scale match between the fishery management area, the assessment area, and/or the (biological) stock area;
- For fishery-independent indices, research survey design should be consistent over time, or changes documented and the effects of change on estimation of stock status have been taken into account;
- For fishery-dependent indices, acceptably low variation in spatial scale of fishery or effort distribution over time, and relatively constant spatial distribution of landing proportions.

#### 4.1.3. Less Common Indicators

Indices of early-life stage survival, sex ratios, changes in size, age or maturity profiles, or reduction in population structure (e.g., reductions in density of spawners or juveniles per area, spatial distribution, number of spawning groups with acceptable indices of stock size) might be useful proxies for stock productivity (Shelton and Rice 2002, DFO 2016a). These indices may

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provide a more comprehensive or robust view of stock states, particularly when multiple indicators show similar trends (DFO 2016a, McKown et al. 2008), or where no stock-recruit data are available (e.g., the mean size of fish relative to the size at maturity; Hoggarth et al. 2006). Less common indicators may be more tractable compared to biomass estimation or more meaningful to fishery interests (Hoggarth et al. 2006). Multiple indicators can be combined into a 'traffic light' type of approach (Dowling et al. 2015, McKown et al. 2008, Shelton and Rice 2002), or used for essential ground-truthing of management outcomes and promoting timely reactions to unexpected changes in stock condition (Smith et al. 2012).

One challenge with less common indicators is that it may be more difficult to identify defensible thresholds of serious harm (DFO 2016a, Shelton and Rice 2002, NAFO 2004). Boundaries among stock states in traffic light approaches may also be harder to define, although this may be less important if used only for stock status reporting, and combining indicators may be less useful if they represent different time series (McKown et al. 2008). At minimum, less common indicator(s) should still be suitably representative of the "stock" (Dowling et al. 2015) and linkage between the indicator to the concept of stock productivity should be clearly explained (USA CFR 2022a).

## **4.2. CHOOSING LIMIT REFERENCE POINTS**

### **4.2.1. Best Available Information**

"Best available information" will vary and is determined by experience, judgement and knowledge of stock-specific circumstances (DFO 2006). Some jurisdictions, like the USA, provide criteria for evaluating scientific information as "best" that include such factors as relevance, inclusiveness, objectivity, transparency and openness, timeliness, verification and validation, and peer-review, as appropriate (USA CFR 2022b).

The use of best available information does not require there to be direct evidence of serious harm for each stock before an LRP is set. A state of serious harm is generally difficult to define for a stock until it has become quite severe (resulting in highly contrasting observations at large and small stock sizes), which is precisely the management outcome to be avoided (Kronlund et al. 2018, Sainsbury 2008). Data-limited fisheries, and even well-managed fisheries that are effective at controlling fishing mortality, may be associated with less contrast in the data (Lynch et al. 2018). Less informative data may in turn limit not only the ability to diagnose stock-specific states of serious harm but also the use of some stock assessment approaches such as surplus production models and thus estimates of certain reference points (Hoggarth et al. 2006). Therefore, while information on stock-specific thresholds to serious harm might be available in some situations, for the majority of stocks, LRPs and indicators will need to be selected in the absence of direct observations, based instead on sound scientific evidence and rationales.

The number of LRP alternatives that may be considered may expand as stock-specific information increases. Some approaches to setting reference points, such as Spawner Per Recruit (SPR) analyses, are empirical methods based on life history parameters. When such information is available from different regions in a species' distribution, reference points could be tailored to those areas (DFO 2016a). States from which secure recoveries have been demonstrated under similar conditions might be the only scientific basis for estimating an LRP (DFO 2009a).

### **4.2.2. Generic Policy Default Recommendations**

In the absence of stock-specific reference points, a provisional default of 0.4  $B_{MSY}$  is recommended to be used in Canada (DFO 2009a). In a similar vein, many guidelines specify

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(and/or constrain) the use of generic policy defaults in the absence of stock-specific LRPs, based on  $B_0$  and/or  $B_{MSY}$  (DAWR 2018b, MF 2011, MSC 2018, USA CFR 2022a).

In the US, the minimum stock size threshold is constrained between 0.5 and 1  $B_{MSY}$  (USA CFR 2022a). Some jurisdictions (New Zealand, Australia) as well as the Marine Stewardship Council provide guidance that appears to constrain choice among generic defaults such that (soft) limits,  $B_{lim}$  or PRIs do not go below 0.2  $B_0$ , but can be higher when appropriate (DAWR 2018b, MF 2008, MSC 2018). In Australia, a  $B_{lim}$  of 0.5  $B_{MSY}$  is a possible alternative to a policy default  $B_{lim}$  of 0.2  $B_0$ , but only if  $B_{MSY}$  is both reliably estimated and above 0.4  $B_0$  (DAWR 2018b). New Zealand's harvest policy also recommends to use either 0.2  $B_0$  or 0.5  $B_{MSY}$ , whichever is higher, as a soft limit (and half that again as a hard limit). Marine Stewardship Council guidance for fisheries seeking certification advises a default PRI of 0.2  $B_0 = 0.5 B_{MSY}$  in the absence of a stock-specific choice (Agnew et al. 2014). If  $B_{MSY}$  is estimated to be greater than 0.4  $B_0$ , then 0.5  $B_{MSY}$  is advised, and if  $B_{MSY}$  is lower than 0.4  $B_0$ , then 0.2  $B_0$  is preferred (unless  $B_{MSY} < 0.27 B_0$ , in which case 0.75  $B_{MSY}$  is recommended; MSC 2018). For Pacific? salmon SMUs, however, 0.5  $S_{MSY}$  escapement or  $S_{gen}$  is recommended as a default (MSC 2018).

ICES (2021a) recommends options for  $B_{lim}$  based on the qualities of the stock-recruitment data available for the stock (grouped into six types), or the biomass equivalent to 0.5 MSY for stocks assessed with biomass dynamic models. Not all stock types are paired with recommended  $B_{lim}$ , however. For some stocks with evidence of recruitment impairment and a wide range of SSB,  $B_{lim}$  may be derived from a segmented regression inflection point. The lowest biomass observed ( $B_{loss}$ ) and from which there has been a recovery (often specifically designated as  $B_{recover}$  or  $B_{rec}$ ) is a commonly used historical LRP (DFO 2016a, ICES 2021a, Rivard and Rice 2003). Under ICES (2021a/b?), this reference point may be recommended for stocks with occasional large year classes (spasmodic stocks) or that have shown no evidence of impaired recruitment (non-informative stock-recruitment data), but not for stocks where recruitment appears to increase with stock size, nor stocks with narrow ranges of estimated biomasses. If used, the reference point should be estimated from a stable part of the assessment and not taken from recent years if the stock is declining (ICES 2021a). Consideration should be given as to whether the time periods correspond to favourable environmental conditions and/or low risk of excessive exploitation (DFO 2009c), and alternatives considered where there is strong evidence of such considerations (DFO 2016a).

For those stocks with evidence that recruitment is currently impaired, or was previously impaired, and where there is no clear asymptote in the recruitment at the highest SSB then the highest SSB observed may be close to a candidate limit pending an evaluation of the historical fishing mortality (ICES 2021a).

#### 4.2.3. Policy Proxy Recommendations

DFO's PA Policy suggests  $B$  at  $F_{0.1}$  as a possible dynamic pool proxy for  $B_{MSY}$  (DFO 2009a), although this may not be suitable for benthic invertebrates with complex spatial structure (Smith and Sainte-Marie 2004). Where  $K$  or  $B_0$  cannot be estimated, the maximum population size (estimated or inferred) can be used as an historical proxy (e.g., marine mammals; Stenson et al. 2012, DFO 2016a) and 50% of this can be used as a proxy for  $B_{MSY}$  (DFO 2009a). Specific time periods for empirical indices or model-based estimates of biomass or abundance are also sometimes used to approximate stock levels capable of producing MSY, and it is often recommended that this be from a productive period (DFO 2009a). However, the choice of productive period can be subjective (Smith et al. 2012). If both biomass estimates and catch data are available, estimates of surplus production can be investigated for evidence of MSY (DFO 2016a). As long a time period as possible should be used, and a mean or median calculated from that (DFO 2016a).

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#### 4.2.4. Choosing From Among Multiple Alternatives

Choice among multiple options should first be guided by a consideration of feasibility and reliability of estimation, ideally via simulation testing (DFO 2016a, NAFO 2004, van Deurs et al. 2021), as this takes into account uncertainty and the risk of a false positive or negative LRP breach.

Best practice recommendations for LRPs from Sainsbury (2008) have suggested picking the greatest of three very different quantities or their proxies, when available:

- A stock-specific limit - the biomass below which average recruitment declines or stock dynamics are highly uncertain;
- The maximum of 30% dynamic  $B_0$  ( $B_{\text{unfished}}$ ), or 20% of  $B_0$ ;
- The biomass from which the target reference point could be achieved in a period that provides for human intergenerational equity (20-30 years).

One concern however is that even when multiple such options as recommended by Sainsbury (2008) are available, they may give very different performances in evaluation or implementation. This still suggests that when feasible, simulation testing in the context of the management system should also be performed in such cases.

To reconcile plausible alternative LRPs, recommendations have sometimes been made to average them or select an intermediate value (DFO 2016a), which may be mostly applicable when working with candidate LRPs that are fixed estimates, including empirical LRPs. Rice and Rivard (2003) suggested choosing the highest estimate when working with disparate plausible fixed alternatives in situations where data are particularly uninformative. Disparate estimates are also, however, suggestive of issues with reliability of estimation (Rice and Rivard 2003), which may more significantly affect the choice and consequences of any selected LRP and as noted above should be considered first.

Some guidance suggests that certain LRPs may be better used as a baseline to compare against other LRPs that may normally be preferred, including LRPs based on recovery estimates (which depend on how the recovered state and time period are defined, and assumptions of productivity; Rice and Rivard 2003), and dynamic pool reference points when a stock-recruitment relationship is considered acceptably estimated (Shelton and Rice 2002).

#### 4.3. OPERATIONAL CONSIDERATIONS

The choice of indicator or reference point is often constrained by what is possible to measure or estimate (Campbell 2010, Smith and Sainte-Marie 2004, Curtis et al. 2015). This can be true of empirical indices, which are commonly used when model-based estimates of biomass or abundance are simply not available (e.g., many invertebrate stocks; DFO 2016). Some indicators, such as those regarding spatial distribution or other stock structure-related objectives, may require more information than is currently available (Kronlund et al. 2018). Similarly, some reference points can only be estimated if certain data are available, if there is sufficient contrast in the data, or if serious harm has already been observed for the stock. For example, various approaches to estimate LRPs based on  $SSB_{50\%R_{\text{max}}}$  generally require informative data regarding poor recruitment at low stock sizes (Sainsbury 2008).

Indicators and LRPs should be easily implemented (Campbell 2010). Empirical indicators and LRPs can be seen as operationally “cheaper” to use than their model-based counterparts and may be preferable to use especially in data-poorer fisheries (Kelly and Codling 2006 in Sainsbury 2008). Proxies may be easier to calculate, require fewer data, or be more robustly estimated and so may be preferred even if estimates of the “intended” reference points are

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technically possible (Gabriel and Mace 1999). Generally, annually measured indices are preferable, although less frequently measured indices may be suitable for longer-lived or lower-priority species (Hoggarth et al. 2006).

Indicators and reference points should provide information that managers need, and be useful for guiding decisions (Campbell 2010). Lags in changing indicators in relation to impacts on stock productivity and the resulting reactivity for management measures should also be considered; for this reason, many marine mammal stocks are assessed with total abundance and not young of year (Stenson et al. 2012). Some may convey redundant information (Kronlund et al. 2018) and thus an objective to avoid serious harm may be suitably operationalized, at less cost, via only one indicator.

Choices should also be stock-appropriate. Some indicators are used more often than others in certain species groups, such as abundance for marine mammals and empirical indices for invertebrates (DFO 2016a), and these may reflect the management regimes or preferences in place for these stocks.

Empirical indices can be seen as easier to understand by those without extensive quantitative training than model-based estimates (Sainsbury 2008, McKown et al. 2008) and there is some evidence to show that they can lead to similar effectiveness when used as inputs in harvest strategies, e.g., as demonstrated via simulation testing (Sainsbury 2008). It may be helpful to separate out indicators used to evaluate stock status (i.e., those that serve as the basis for reference points), versus those used to inform management strategies (i.e., serve as HCR inputs and form operational control points, DFO 2021c). A drawback is that performing projections may be difficult or even impossible with empirical indicators (McKown et al. 2008). Model-based approaches, on the other hand, integrate a variety of data sources (both fishery-dependent and independent) and have the advantage of quantitatively relating fishing pressure to indicators such as biomass. As such, they can more readily be represented in risk-based projections under different harvest scenarios (McKown et al. 2008).

A balance between feasibility, usefulness and reliable estimation (discussed in the next section) may also come into play for the process of updating reference point and/or stock status estimates. It is sometimes the practice that an estimate of a reference point is “fixed” for a period of years, against which updated indicators are compared to estimate stock status; and then the estimate of the reference point is updated and “fixed” again (DFO 2016a, ICES 2021a, Hoggarth et al. 2006). While potentially less accurate over time (Stenson et al. 2012), fixed estimates may be easier to communicate and preferred by managers (DFO 2016a, McKown et al. 2008), and empirical reference points in particular are likely to remain fixed for long periods unless the methods by which the indices are calculated are revised at some later date. In other cases, reference points may be re-estimated and compared with stock status indicators each time a stock is assessed, such as when reference points are internally estimated in stock assessment models (McKown et al. 2008, Hoggarth et al. 2006), in stocks with highly variable abundance, or in data-poorer scenarios and emerging fisheries where new data represent a significant addition to the assessment (Stenson et al. 2012, DFO 2016a).

#### **4.4. ESTIMATION CONSIDERATIONS**

In general, indicators and reference points should be estimated reliably (Campbell et al. 2010) and be robust to uncertainties (Curtis et al. 2015). Reliable estimation invokes consideration of both precision and accuracy (NAFO 2004) and may be impacted by insufficient contrast in the data, insufficient or poor-quality data, or inadequate models (McKown et al. 2008, Restrepo et al. 1998). Other uncertainties in indicators such as estimated biomass, highly variable

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recruitment, or uninformative data can impact LRPs which ideally would be robust to such uncertainties (Maunder and Deriso 2014).

It may be useful to check scaling across stocks (i.e., whether estimates are plausible given what is known about stock productivity, catch history, structure, etc.) and how sensitive estimates are to changes in input data (Rice and Rivard 2003). It is highly desirable to evaluate the robustness of LRPs and other reference points through simulations in conjunction with HCRs (NAFO 2004).

Proxies may be preferable in “data-richer” situations where estimates of the reference points they are aiming to approximate (like MSY reference points) are technically estimable, but are deemed to be unreliable (extremely low precision due to insufficient contrast in the data, or inadequate models; Gabriel and Mace 1999).

It is common practice to evaluate the most recent estimate (or the median, 50<sup>th</sup> percentile) of the stock status indicator against the reference point for the purposes of reporting stock status (DFO 2021b), but this may not always be desirable or appropriate, particularly with empirical indices and reference points. This is because a general challenge with empirical approaches is that it may not be possible to separate out inter-annual variation in indices from observation error (Kronlund et al. 2018). Inter-annual variation is usually not indicative of management success or failure, and various techniques can be used to visualize trends in empirical indices and avoid “noise,” including running averages. The choice of time period on which to base the running average will depend on the periodicity of the indicator, the biology of the species, and the implications of truncation at either tail of the time series. Longer time frames can be used when looking for trends related to environmental change, while short-term trends due to recruitment or management measures would use a shorter-time frame (McKown et al. 2008).

#### **4.5. WHEN TO MAKE CHANGES**

New data may result in changing perceptions of stock population dynamics, that may affect the underlying assumptions and/or the rationale or methods of estimating stock status indicators or reference points (e.g., evidence of depensation; DFO 2016a). Updating approaches (indicators and LRPs) may be particularly important as data accrues in data-poor or emerging fisheries (Dowling et al. 2015). In such data-limited cases, it is recommended to set time periods for re-evaluation of indicators and reference points (DFO 2016a).

Entirely new data sources or methodologies (e.g., the onset of a new fishery-independent survey) or the development or revision of a new stock assessment model may necessitate the selection of new stock status indicators or rationales for reference points (DFO 2016a, McKown et al. 2008).

#### **4.6. WHAT TO COMMUNICATE**

A rationale should be provided for a proposed LRP, accompanied by the method by which it is estimated (DFO 2021c, van Deurs et al. 2021), including the reason for choosing various reference periods where appropriate (DFO 2016a).

Conveying the precision of estimates of reference points and stock status indicators is important to effectively present risk to managers and provides a more realistic view of stock status and is a regulatory requirement in the USA. It enables managers to understand the probability of exceeding reference points and adjust harvest strategies accordingly (McKown et al. 2008, USA CFR 2022a).

Uncertainty estimates are often associated with model-based reference points; these may be in the form of assumed statistical distributions or for Bayesian approaches, a joint posterior density function (McKown et al. 2008, Cooper 2006). Quantifying uncertainty allows for consideration of

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precision and accuracy in reference point estimators (NAFO 2004) and for example, the calculation of confidence intervals. Bayesian methods readily allow for quantification of uncertainties associated with reference points (DFO 2016a), including an estimate of the probability that current biomass exceeds a given reference point.

Stock status relative to the LRP should always be reported in science advice (DFO 2021b). This should include the indicator estimate and the probability or qualitative likelihood that the stock is above or below the LRP (DFO 2021b). Where possible, the ratio of the stock status indicator to the reference point (e.g.,  $B_{\text{current}}:B_{\text{reference}}$ ) should be reported as this has better statistical properties than absolute estimates (NAFO 2004), such as robustness to changes in scale.

Secondary indicators (e.g., survey indices) may be selected as supports or proxies for the “true” or primary stock status indicator (e.g., model-estimated biomass) to provide advice on stocks in interim updates in between stock assessments. These secondary indicators may be associated with trigger values that suggest re-assessment ahead of schedule may be warranted, and should be based on information that is feasible to provide during interim years (DFO 2016b).

#### **4.7. WHEN ALL ELSE FAILS: USE OF ALTERNATIVE PARADIGMS**

For some stocks, there will simply be no clear indication of compensation in recruitment or an ability to determine a stock production function (NAFO 2004). This may be true in emerging fisheries or other data-poor (or information-poor) contexts. The PA Policy recommends that in such cases, priority should go to data collection to support the identification of an LRP (DFO 2009a).

In the absence of an LRP, alternative approaches to providing harvest advice may be and are used, such as management by limit reference points for fishing mortality (NAFO 2004, ICES 2021a). For the Marine Stewardship Council, indicators of fishing mortality (e.g.,  $F$ ) can be an allowable proxy evaluating stock status relative to the PRI (MSC 2018), and this may be done by considering the length of time  $F$  is likely to have been at or below  $F_{\text{MSY}}$  (e.g., for one-two generation times, or four years, whichever is greater). Advice in support of the application of generic data-poor harvest control rules may also be employed, such as Potential Biological Removals (PBRs) for marine mammals classified as data-poor (DFO 2016a), or management procedures for Pacific groundfishes (Anderson et al. 2021), that collectively aim to meet management objectives even in the absence of knowledge of stock status.

### **5. HOW PRACTICE COMPARES TO GUIDANCE**

International and Canadian guidance and literature supporting the selection of reference points often starts with first principles, such as the intended meaning of “serious harm” or analogous concepts (e.g., ICES, New Zealand, Australia) and how various reference point methodologies attempt to operationalize the concept. In practice, guidance on the choice of reference point seems to start (and often end!) with generic policy recommendations, with occasional forays to the nearest accessible common “rule of thumb” practice when that guidance is not appropriate or cannot be followed.

A fairly broad collection of common reference points (e.g., fractions of theoretical values related to  $B_{\text{MSY}}$ ,  $B_0$ ,  $K$ ,  $B_{\text{recover}}$  or thresholds from stock-recruitment relationships) exist that reflect long-standing, conceptually overlapping and widely accepted ways to establish an LRP. This conceptual overlap, to the extent that various candidate LRPs are considered to be suitable thresholds to serious harm in their own right while also serving as accepted proxies for other LRPs (e.g., fractions of  $B_{\text{MSY}}$  replacing fractions of  $B_0$  and vice versa), underscores that there is no one right or universal choice of “correct” LRP based on broad conceptual grounds.

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Generic policy guidance for more specific details of LRPs (such as the acceptable fraction of  $B_{MSY}$  or  $B_0$ ) does, however, differ among jurisdictions and may lead to different management outcomes, depending on how LRPs are operationalized in harvest strategies. Although the lead responsibility for setting LRPs in Canada is assigned to scientists (DFO 2009a), it seems there is not usually enough *biological* reason to deviate from generic policy guidance. The vast majority of LRPs in Canada were set after the issuance of such guidance in the PA Policy in 2009. This pattern is expected given that policy issuance represents an institutional driver to set LRPs, but also suggests broader benefits of having provisional default choices for LRPs available. We further observed that many of the technical reasons that scientists might accept or reject various LRP options would apply broadly to reference points and potentially the entire harvest strategy as well (i.e., USRs, targets and fishing mortality reference points, accompanied by harvest control rules; DFO 2009a). This suggests that roles and responsibilities for PA implementation, and the intersection of scientific practices with policy choices, may be more complex in practice than current guidance might suggest.

### **5.1. LRP SELECTION IN PRACTICE**

In sum, current practices suggest that choosing LRPs generally occurs by:

- Beginning with generic policy guidance;
- Ruling options in or out on technical grounds (feasibility, reliability of estimation, ability to serve as proxy for generic policy guidance);
- When possible, evaluating plausibility or appropriateness of options; and/or,
- Considering extrapolation of LRPs from meta-analyses or from similar stocks or subunits in the absence of stock-specific information.

### **5.2. SINGLE STOCK STATUS ESTIMATION IN PRACTICE**

In most cases, advice on a single stock status appears straightforward (in that there is already one indicator, one LRP, and one stock status metric). In other cases, multiple indicators or statuses are estimated, and this occurs for several reasons:

- Stock status is considered best characterized by more than one indicator;
- The “stock” consists of multiple biological and/or management units; and,
- Key uncertainties in the assessment impact the estimation of stock status and are explored with multiple assessment or operating models.

In these situations, a single stock status has been estimated by:

- Composite indicators (multiple indicators combined into one, with a single threshold);
- Composite status metrics (multiple indicators each with their own threshold; status is determined from a “traffic light” approach);
- Estimating indicators and thresholds at multiple spatial scales, so there is one overall status as well as a status for each subcomponent;
- Monitoring a single dominant subunit or subcomponent;
- Using a single representative model-estimated stock status;
- Averaging across model estimates of status; or,
- Applying more qualitative approaches such as weight-of-evidence or expert judgement.

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### 5.3. WHAT TECHNICAL GUIDANCE IS NEEDED?

To support the process of choosing LRPs and estimating stock status, technical guidance should be focused on:

- Different methods with which to estimate  $B_{MSY}$  and  $B_0$  suitable across the data spectrum;
- Theoretical, historical and empirical proxies for model-based indicators and for  $B_{MSY}$  and  $B_0$  or  $K$ ;
- Generic “rules of thumb” for other common LRPs used in Canada (e.g., fractions of  $B_0$  or  $K$ ,  $B_{recover}$ , recruitment thresholds);
- Examples of less common indicators, LRPs, and stock status estimation methods that may be applicable across the data spectrum (including composites, “traffic light” systems, and expert judgement);
- Different approaches with which to address volatility in stock status indicators;
- Use of basic life history information and meta-analyses (including extrapolation from other stocks) to inform LRP selection;
- Operational and technical considerations as a basis from which to select or reject various candidate indicators and LRPs, for example:
  - pros and cons,
  - diagnostics to evaluate reliability of estimation, including sensitivity analyses, and
  - considerations for evaluating the plausibility of candidate LRPs given the history of the stock, past evidence of serious harm, other biological information, or evidence from analogous stocks.
- Options and considerations for reporting a single status per stock, within and between assessments, and across advice and management paradigms.

### 5.4. PERSPECTIVES OF PRACTITIONERS

“Best practices” are demonstrated through use, and will evolve over time with experience (Sainsbury 2008). The following potential best-practice principles derived from the above review of literature and Canadian practice were examined in greater detail by DFO participants through a workshop titled “Limit Reference Points and the Fish Stocks Provisions: Joint Technical Expertise in Stock Assessment (TESA) / National Operational Guidelines (NOG) Task Force Workshop,” held virtually from 29 November - 3 December 2021 (Marentette et al. 2022).

#### 5.4.1. Best Available Information

Best available information, which provides the advice basis for choice of indicators, reference points or stock status, will vary from stock to stock. Broadly speaking, it can be described as information that is: relevant, appropriate, peer-reviewed, verified and validated, inclusive, objective, timely, transparent, open and accessible, accounts for uncertainties, accurate, consistently gathered, conflicting or alternative information considered, adequate, representative, reproducible (repeatable), clear and complete.

Basing a choice of LRP on the “best available” information means doing the best that can be done with what is available and choices will be ultimately constrained by data poverty. When possible, stock-specific information regarding evidence of serious harm, basic biological information, traditional knowledge of the stock or in comparison with similar stocks may be preferred rationales on which to base a choice of LRP. However, evidence of serious harm is

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rare and "best available" may often be what is consistent with policy guidance ( $0.4 B_{MSY}$ ) or common practice.

#### **5.4.2. Serious Harm**

"Serious harm" (and "stock") can be elusive or intractable concepts and as a result there is no single universal choice of indicator or LRP. While the responsibility for setting LRPs lies with Science under the PA Policy, in the absence of scientific evidence of serious harm (e.g., depensation or persistent periods of low productivity), LRPs are based more on the art of best practices, including generic policy guidance. A wide range of stock status indicators could be considered by which to define LRPs as thresholds to increased risk of serious harm.

Under a default assumption that loss of stock structure is serious harm and is to be avoided, the configuration of indicator(s) chosen should typically be representative of the entire "stock." This could include scenarios where representative—or index—subcomponents are monitored or combined in various ways to represent the entire "stock." Indicators should also exhibit proportionality with stock attributes they are intended to measure (e.g., CPUE should be an acceptable proxy for stock size), but the relative importance of these characteristics in driving the choice of indicator may be context dependent.

#### **5.4.3. Operational Utility**

LRPs are only one part of harvest strategies. As such, the success in achieving an objective to avoid serious harm to the stock and more broadly the sustainability of the fishery will depend on other elements such as target reference points, risk tolerance for breaching limits or achieving targets, and the timeframes over which risk is evaluated.

At minimum, indicators, LRPs and therefore status should be feasible to measure or estimate. Other operational reasons to consider when selecting indicators, LRPs or status metrics include cost-effectiveness, communicability, and simplicity. Cost-effectiveness may influence the ease and frequency of estimating stock status. Ease of understanding affects how readily an LRP may be accepted and implemented. Simplicity is linked to both cost-effectiveness and communicability. How indicator and LRPs are applied is also relevant to their utility, e.g., the role that LRPs play in triggering a legal or policy requirement for stock rebuilding, in evaluating management performance over time, or as an input to HCRs. These reasons are not mutually exclusive and the priority of the reasons will be context dependent.

#### **5.4.4. Reliable Estimation**

Reliable estimation of LRPs or stock status metrics can mean acceptable accuracy or precision of estimates (i.e., acceptably low variance or low bias) and robustness to a range of possible uncertainties. Reliability of reference points or status may also depend on consistent data collection over time and the historical trajectory of the stock over the period of data collection (e.g., lack of contrast in a stock's history may make it difficult to determine stock scale and productivity). Reliability may be evaluated by any combination of examining uncertainty in estimates, sensitivity tests, evaluating the reasonableness of assumptions given data on the stock, simulation testing and/or by comparison to estimates from similar stocks.

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## 6. CONCLUSIONS

### 6.1. LRPS ARE PART OF FISHERIES MANAGEMENT SYSTEMS

- The principal role of the LRP is to serve as a threshold to stock states at increased risk of serious harm.
- Under Canada's PA Policy, the LRP also has other roles: it is the boundary between the Critical and Cautious zones for stock status metrics, it is the trigger for rebuilding plans, and also often functions as an inflection point for the removal reference and as an operational control point (i.e., a point at which management measures change) in harvest strategies.
- Reference points such as LRPs are only one component of measurable fisheries management objectives, which also comprise risk tolerance and timeframes.
- The effectiveness of harvest strategies in avoiding undesirable outcomes (like serious harm) will also depend on the choice of management measures and their operational control points, other reference points, acceptable risk of LRP breaches, and the timeframes over which risk is evaluated.

In the absence of LRPs...

- Advice for fisheries management may still be provided to support the selection of management measures that aim to achieve objectives either directly, via data-limited methods that can provide advice on candidate harvest or fishing mortality rates (e.g., in relation to a generic harvest control rule or  $F$ -based reference points); or indirectly, via directional trends in stock and fishery indices. A review of these methods and the objectives they aim to achieve are, however, beyond the scope of this paper.
- Advice should be provided that identifies and prioritizes data collection and analyses that could help to reduce or account for information poverty that pose one or more barriers to setting LRPs. This advice may vary from stock to stock but points to the value of information studies.

### 6.2. BEST PRACTICE PRINCIPLES

The following represent suggested best-practice principles for indicators, LRPs and stock status derived from existing Canadian and international guidance and informed by Canadian requirements and existing practice. Each principle is expanded upon by sub-bullets. These principles may change over time (in keeping with the definition of "best practices" by Sainsbury 2008) as more experience with them is accrued.

#### **Principle 1: Indicators, LRPs and stock status metrics should be selected based on the best available information for the stock.**

- "Best available" should be interpreted as the best of what is available to Science at the time of consideration. The lack of optimal information should not be an impediment to choosing indicators and LRPs.
- Best available information will vary from stock to stock and may change over time.
- Generic provisional policy guidance of  $0.4 B_{MSY}$  should be used if it is both technically feasible and if there is no stock-specific LRP or other rationale upon which to base a different choice.
- Consider alternatives based on proxies (theoretical, historical or empirical), and their assumptions, if the policy guidance is not feasible or appropriate.

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**Principle 2: Indicators, LRPs and stock status metrics should be consistent with an objective to prevent serious harm to the stock.**

- Consistency with an objective to prevent serious harm can be demonstrated by:
  - Indicators and LRPs that are at least conceptually linked to the definition of serious harm.
  - A stock status that is acceptably representative of the entire stock.
- Consider the extent to which assumptions around the relationship between indicators and the stock attributes they are intended to represent (e.g., proportionality) impacts both estimates of LRPs and stock status.
- Loss of stock structure (e.g., depletion of subunits) is not typically included in conventional descriptions of serious harm, although such losses may meet the definition and should be considered where stocks act as management units contain more than one biological unit.

**Principle 3: Indicators, LRPs and stock status metrics should be feasible and relevant.**

- Consider the role of stock status in the management system:
  - At minimum, it should be feasible (i.e., capable of being done or carried out) to monitor indicators and estimate stock status relative to the LRP on time scales and frequencies relevant to its role as the trigger for a rebuilding plan.
  - Stock status indicators should be relevant to management (i.e., closely connected or appropriate to what is being done or considered), but harvest strategies may also take into account a variety of secondary indicators, including indicators at multiple spatial scales or indicators for the size- or age-composition of the stock, which may assist in avoiding serious harm where scale mismatch occurs between biological and management units.
  - LRPs are often incorporated into harvest control rules, but harvest strategies may have operational control points distinct from reference points.
- Consider whether and how interim indicators should be used to support continuity of stock status advice in between assessments, including whether empirical proxies of stock status should be used to trigger earlier assessments.
- Consider whether indicators, LRPs and stock status are easy to communicate and understand.

**Principle 4: Indicators, LRPs and stock status metrics should take into account reliability, plausibility and uncertainty.**

- Reliability means estimates should be acceptably robust (considering consistency, variance and bias) to key uncertainties and assumptions in the advice framework.
  - Consider how often estimates will be updated and the sensitivity of stock status to changes in scale of abundance or biomass with new data at each update.
  - Consider whether historical or empirical reference points may provide more reliable or plausible options than theoretical reference points.
  - Consider the quality (i.e., reliability and consistency) of data inputs required to estimate indicators, LRPs or stock status.
  - Consider the costs and benefits of smoothing methods to dampen volatile stock status estimates because of high inter-annual variability in indicators.
- Plausibility means estimates should be consistent with empirical data and, where possible, ecosystem and population dynamics theory, taking into account the best available information about the stock.

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- Consider any evidence of serious harm to the stock, other knowledge of the history of the stock, life history information, meta-analyses across stocks, or choices made for analogous stocks.
  - A weight-of-evidence approach can be used to evaluate and select the most plausible LRP or stock status.
  - When applicable, consider the costs, including loss of information, and the benefits of different methods for combining or selecting from equally plausible alternatives for LRPs or for stock status.
- Consider evaluation of risks in light of uncertainty (e.g., with simulation), when requested.

**Principle 5: The rationale for choice of indicator, LRP or stock status metric may change over time.**

- Consider whether new information accrued for a stock represents a substantial change in the best available information underlying the choice of indicator or LRP rationale used to estimate stock status.
- Reconsider rationales for indicators and LRPs (and re-estimate stock status) when a new advisory framework (e.g., a new assessment model) or management paradigm (e.g., initiation of a management strategy evaluation framework or closed-loop simulation) are undertaken.
- Where uncertainty is high and impactful to LRPs or stock status, such as in data-limited or emerging fisheries, or where stock structure is complex, consider value of information analyses, prioritizing data collection, and establishing timelines to re-evaluate LRP and indicator rationales and stock status once more informative data have accrued.

**Principle 6: Advice on indicators, LRPs and stock status metrics should be clearly communicated.**

- Avoid tentative language for the LRP and stock status in final advice such as “suggested,” “recommended,” “interim” or “proxy”. It should be clear whether the stock has an LRP and stock status determination in order to align with the structure of the FSPs.
- Technical specifications (e.g., model equations) and supporting rationales should be documented for the choice of indicator and reference point.
- Formal analyses, such as sensitivity analyses, or other explanations should be provided when some information available for the stock is not included in the “best available information” on which choices were based.
- Key uncertainties and assumptions in stock status indicators, LRPs, and stock status should be documented and communicated, where applicable, including those related to scale mismatch.
- Stock status should be communicated as a ratio of indicator to the LRP (or to  $B_{MSY}$ ,  $B_0$ , etc.) instead of absolute estimates, especially where estimated stock status is expected to be sensitive to changes in scale in successive assessments.
- Differentiate between the effects of new information accrued for a stock (e.g., longer time series), and other changes (e.g., a new assessment model), when estimated stock status changes because of a new advisory framework or management paradigm.

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## APPENDIX 1: GLOSSARY

**Abundance Index:** A quantitative measure of fish density or abundance, usually as a time series of (relative) values. An abundance index can be specific to an area or to a segment of the stock (e.g., mature fish), or it can refer to abundance stock-wide; the index can reflect abundance in numbers or in weight (biomass).

**Assessment Unit:** A group of animals with typically defined geographical boundaries for which data are collected and/or fisheries science advice is provided.

**Attribute:** A quality, characteristic of feature, e.g., of a stock.

**Beverton-Holt (BH):** A model of the stock-recruitment relationship between spawning biomass, spawners or eggs in one generation and resulting recruitment. See also Ricker.

**Biological Reference Point (BRP):** A benchmark against which the biomass or abundance of the stock, or the fishing mortality rate (or exploitation rate), can be measured in order to determine stock status. These reference points can be targets, thresholds or limits depending on their intended use.

**Biological Unit:** A population of a given species that shares common ecological or genetic features, forming a reproductive unit and spawns relatively little with other biological units.

**Biomass (B):** Biomass refers to the size of the stock in units of weight. Often, biomass refers to only one part of the stock (e.g., spawning biomass, vulnerable biomass or recruited biomass, the latter two of which are essentially equivalent).

**$B_0$ :** Virgin biomass, unfished biomass. This is the theoretical carrying capacity of the recruited or vulnerable or spawning biomass of a fish stock. In some cases, it refers to the average biomass of the stock in the years before fishing started. More generally, it is the average over recent years of the biomass that theoretically would have occurred if the stock had never been fished.  $B_0$  is often estimated from stock assessment modelling and various proportions of it (e.g.,  $0.4B_0$ ) are used as biological reference points (BRPs) to assess the relative status of a stock.

**$B_{current}$ :** Current (spawning) biomass in the year of the assessment but may be beginning of year, mid-year, or end of year depending on assessment model.

**$B_{escapement}$ :** A reference point used by ICES for short-lived species; a deterministic biomass limit below which a stock is considered to have reduced reproductive capacity, including any identified additional biomass need. It may be synonymous with  $B_{pa}$ .

**$B_{lim}$ :** Another term for LRP, and used for biomass limits under harvest policies for NAFO or ICES.

**$B_{loss}$ :** The lowest observed biomass.

**$B_{min}$ :** The lowest observed biomass from which the stock subsequently recovered to  $B_{average}$

**$B_{MSY}$ :** The average stock biomass that results from taking an average catch of MSY under various types of harvest strategies. Often expressed in terms of spawning biomass, but may also be expressed as recruited or vulnerable biomass.

**$B_{pa}$ :** In ICES advice frameworks, this is the stock status reference point above which the stock is considered to have full reproductive capacity, having accounted for estimation uncertainty.

**$B_{rebuilt}$ :** A biomass used as a rebuilding target.

**$B_{recover}$ :** The lowest observed biomass from which a recovery was observed.

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**$B_{REF}$ :** A reference average biomass usually treated as a management target.

**Carrying capacity (K):** The average stock size expected in the absence of fishing. Even without fishing the stock size varies through time in response to stochastic environmental conditions.

**Catch (C):** The total weight (or sometimes number) of fish caught by fishing operations including both retained (landed) and released fish (sometimes called discards).

**Catch per unit effort (CPUE):** The quantity of fish caught with one standard unit of fishing effort; e.g., the number of fish taken per 1000 hooks per day or the weight of fish taken per hour of trawling. CPUE is often assumed to be a relative abundance index, i.e., proportional to the portion of the stock biomass (or numbers) vulnerable to the gear.

**Committee on the Status of Endangered Wildlife in Canada (COSEWIC):** An independent advisory panel to the Minister of Environment and Climate Change Canada that meets twice a year to assess the status of wildlife species at risk of extinction. Members are wildlife biology experts from academia, government, non-governmental organizations, and the private sector responsible for designating wildlife species in danger of disappearing from Canada.

**Depleted:** Stocks that are below some limit are deemed to be depleted. Stocks can become depleted through overfishing, or environmental factors, or a combination of the two.

**Discards:** The portion of the catch thrown away at sea (called releases in some fisheries).

**Dynamic Pool:** A reference point derived from yield-per-recruit or spawning-biomass-per-recruit models, e.g., biomass, fishing mortality or harvest rates associated with various fishing mortality rates, i.e.,  $F_{0.1}$ ,  $F_{max}$ ,  $F_{40\%}$ ,  $F_{low}$ ,  $F_{med}$ ,  $F_{high}$  (Gabriel and Mace 1999, Restrepo et al. 1998).

**Equilibrium:** A theoretical model state that arises when the fishing mortality, exploitation pattern and other fishery or stock characteristics (growth, natural mortality, recruitment) do not change from year to year.

**Exploitable Biomass:** Refers to that portion of a stock's biomass that is available to the fishery. Also called the recruited biomass or vulnerable biomass.

**Exploitation Rate (U):** The proportion of the recruited or vulnerable biomass that is caught during a certain period, usually a fishing year. Note  $U=1-e^{-F}$ , where  $F$  is an instantaneous rate.

**$U_{MSY}$ :** The exploitation rate associated with the maximum sustainable yield. Usually expressed as an annual proportion.

**Feasibility:** The possibility that something can be made, done, or achieved, or is reasonable.

**Feed-forward:** The modification or control of a process, such as exploitation rate, using its anticipated results or effects. May occur in the form of a Harvest Control Rule.

**Feedback:** The modification or control of a process, such as exploitation rate, by its results or effects. See Harvest Control Rule.

**Fishing Intensity:** A general term that encompasses the related concepts of fishing mortality and exploitation rate. May also be referred to as fishing pressure.

**Fishing Mortality (F):** That part of the total mortality rate applying to a fish stock that is caused by fishing. Natural mortality ( $M$ ) is the other component of total mortality ( $Z$ ). Usually expressed as instantaneous rates as opposed to annual exploitation or harvest rates ( $U$ ). Note  $F=-\ln(1-U)$ .

**$F_{0.1}$ :** The fishing mortality rate at which the increase in equilibrium yield per recruit in weight per unit of effort is 10% of the yield per recruit produced by the first unit of effort on the

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unexploited stock (i.e., the slope of the yield per recruit curve for the  $F_{0.1}$  rate is only 1/10th of the slope of the yield per recruit curve at its origin).

**$F_{40\%B_0}$ :** The fishing mortality rate associated with a biomass of  $0.4 B_0$  at equilibrium or on average. Also appears as  $F_{40\%}$ .

**$F_{40\%SPR}$ :** The fishing mortality rate associated with a spawning potential ratio (SPR) of  $0.4 B_0$  at equilibrium or on average.

**$F_{MAX}$ :** The fishing mortality rate that maximizes equilibrium yield per recruit.  $F_{MAX}$  is a fishing mortality level that defines growth overfishing. In general,  $F_{MAX}$  is different from  $F_{MSY}$  (the fishing mortality that maximizes sustainable yield), and is always greater than or equal to  $F_{MSY}$ , depending on the stock-recruitment relationship.

**$F_{MEY}$ :** The fishing mortality corresponding to the maximum (sustainable) economic yield. Not often used in Canada.

**$F_{MSY}$ :** The fishing mortality rate that, if applied constantly, would result in an average catch corresponding to the Maximum Sustainable Yield (MSY) and an average biomass corresponding to  $B_{MSY}$ . Usually expressed as an instantaneous rate.

**$F_{REF}$ :** The fishing mortality that is associated with an average biomass of  $B_{REF}$ .

**Fishing year:** Varies by stock. For example, the fishing year for most Pacific groundfish starts on February 21 and ends the following February 20. Often shortened to terms like the 2015/16 fishing year.

**Forecasting:** See Projection.

**Generation Time:** Generation length is the average age of parents of the current cohort (i.e., newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population.

**Harvest Control Rule (HCR):** A pre-determined plan that adjusts fishing activity according to the biological and economic conditions of the stock and/or fishery (as defined by indicators from monitoring or assessment). Also called Harvest Decision Rules, HCRs can be feedback, feed-forward, or constant in nature. HCRs are a key tactical element of a harvest strategy.

**Harvest Decision Rule:** See Harvest Control Rule.

**Harvest Rate:** See Exploitation Rate.

**Harvest Strategy:** For the purpose of the PA Framework, a harvest strategy specifies target and limit reference points, a statement of risk, and management actions (tactics) associated with achieving the targets and avoiding the limits. More generally, a harvest strategy is a decision framework designed to pursue defined biological, ecological, social and/or economic objectives for fish stocks in a given fishery. Key elements include: objectives, performance metrics, reference points, acceptable levels of risk, a monitoring strategy, an assessment and harvest control rules. Also called a management strategy.

**Index:** See abundance index.

**Indicator:** A unit of measurement that provides information on the state of some item or attribute of interest; e.g., a single stock, or more broadly, major fish stocks worldwide. Stock status indicators may include estimates of biomass, fishing mortality or exploitation rate, or suitable proxies for these. See attribute, performance metric and abundance index.

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**Likelihood:** The extent to which a proposition (a hypothesis, or a model) explains available information (past events; e.g., the likelihood that habitat degradation or loss has contributed to a stock's decline).

**Limit:** A biomass or fishing mortality reference point that should be avoided with high probability.

**Limit Reference Point (LRP):** The name of the biomass limit in Canadian harvest strategies that also often serves as an operational control point. It is considered to be a threshold to a stock status at risk of serious harm.

**Management Procedure (MP):** An algorithm for managing a fishery, consisting of a combination of data collection, assessment method, and harvest control rule. Different MPs may be evaluated based on their performance relative to measurable objectives as part of a Management Strategy Evaluation.

**Management Strategy:** See harvest strategy.

**Management Strategy Evaluation (MSE):** An analytical approach that simulates the workings of a fisheries system (cycling from data collection to implementation of management measures and conduct of the fishery, then repeating) and tests whether potential harvest strategies can achieve pre-agreed management objectives.

**Management Unit:** A group of animals with typically defined geographical boundaries that are subject to the same fisheries management objectives, even if applicable fisheries operate or management measures are applied at either smaller or larger scales.

**MEY (maximum economic yield):** The catch or effort level for a fishery that allows net economic returns to be maximized. In this context, "maximized" equates to the largest positive difference between total revenue and total cost of fishing.

**Milestone:** An outcome that represents a significant change or new state of development or progress towards another outcome.

**Model:** A set of equations that represents the population dynamics of a fish stock (and associated fisheries); a hypothesis about the population dynamics of a fish stock (and associated fisheries).

**Monitoring Metric:** A measure that provides information on realized stock or management outcomes relative to an objective, often expressed as an indicator in relation to a reference point. See also: Performance metric.

**MSY (Maximum sustainable yield):** Is the largest or maximum long-term average catch or yield that can be taken from a stock under prevailing ecological and environmental conditions, and the current selectivity patterns exhibited by the fishery.

**MSY reference points:** MSY references points include  $B_{MSY}$ ,  $F_{MSY}$  and MSY itself; analytical and conceptual **proxies** for each of these quantities may be calculated.

**Natural mortality (rate) ( $M$ ):** That part of the total mortality rate applying to a fish stock that is caused by predation and other natural events. Usually expressed as an instantaneous rate.

**North Atlantic Fisheries Organization (NAFO):** A regional fisheries management organization in the North Atlantic in which Canada participates.

**Objective:** A statement of something that is desired and which can be affected by management measures. Measurable objectives consist of a specified outcome (e.g., target or limit), a period of time, and a desired probability or acceptable risk level. Desirable qualities of objectives are often summarized as SMART: specific, measurable, achievable, relevant and time-bound.

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**Operational control point:** A value of an indicator or other input variable that acts as a trigger for a change in management actions, as for example in a Harvest Control Rule.

**Overexploitation:** A situation where observed exploitation (or fishing mortality) rates are higher than target levels. Another term for overfishing.

**Overfishing:** A situation where observed fishing mortality (or exploitation) rates are higher than target or threshold levels. Internationally, overfishing is commonly defined to represent  $F > F_{MSY}$ .

**Pacific Fishery Management Area (PFMA):** Fishery management areas in the West Coast of Canada as defined as per the *Pacific Fishery Management Area Regulations, 2007*.

**Performance Metric:** A measure that provides information on (simulated or forecasted) management procedure performance relative to an objective, often expressed as an indicator in relation to a reference point. Sometimes called a performance measure or a performance statistic. See also: Monitoring metric.

**Plausibility:** Refers to whether estimates, assumptions or hypotheses are consistent with empirical data, ecosystem and population dynamics theory; e.g., past trajectories of stock indicators or productivity in light of fishing pressure and past or future environmental conditions.

**Point of Reproductive Impairment (PRI):** According to the Marine Stewardship Council, the point below which there is an increased risk that recruitment may be substantially impaired. Fisheries should be managed such that the risk of stocks falling below this level is very low.

**Population:** A group of fish of one species that shares common ecological and genetic features. The stocks defined for the purposes of stock assessment and management do not necessarily coincide with self-contained populations.

**Population dynamics:** In general, refers to the biological and fishing processes that result in changes in fish stock abundance over time.

**Potential Biological Removals (PBR):** A harvest control rule used for many marine mammal stocks with a wide range of life histories and data poverty levels.

**Probability:** The chance (statistical or relative frequency) that a given event or outcome has or will occur. It is typically used when uncertainty is associated with an outcome and can be quantified.

**Projection or forecasting:** A way to make predictions about trends in stock size and fishery dynamics in the future. Projections are made to address “what-if” questions of relevance to management. Short-term (1–5 years) projections are typically used in support of decision-making and typically apply a constant catch or fishing mortality rate. Longer term projections become much more uncertain in terms of absolute quantities, because the results are strongly dependent on recruitment, which is very difficult to predict. For this reason, long-term projections are more useful for evaluating overall management strategies than for making short-term decisions. See also simulation.

**Prospective evaluation:** Projections or simulations that compare the expected *future* performance of alternative management options relative to specified objectives.

**Proxy:** A surrogate for another value, such as  $B_{MSY}$ ,  $F_{MSY}$  or  $MSY$ , that has been demonstrated to approximate one of these metrics through theoretical or empirical studies.

**Recruitment:** The addition of new individuals to the fished component of a stock. This is determined by the size and age at which fish are first caught.

**Recruitment-overfished:** A situation in which the rate of fishing is, or has been, such that annual recruitment to the exploitable stock has become significantly reduced. The situation is

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characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year. If prolonged, exploitation rates associated with recruitment-overfishing can lead to stock collapse, particularly under unfavourable environmental conditions.

**Regional Fisheries Management Organization (RFMO):** International bodies established to manage and conserve fish stocks within specific regions of the world's oceans. Canada participates in several RFMOs, see 'North Atlantic Fisheries Organization' as an example.

**Reliability:** Refers to whether estimates have acceptable consistency, accuracy or precision of estimates (i.e., acceptably low variance or low bias), and robustness to a range of possible uncertainties (assumptions, stock scale, data points and/or model structure).

**Removal Reference:** The name of the fishing mortality limit in Canadian harvest strategies.

**Reference Point:** A benchmark against which an indicator (e.g., the biomass or abundance of the stock or the fishing mortality or exploitation rate) can be measured in order to determine its status. These reference points can be targets, thresholds or limits depending on their intended use.

**Retrospective evaluation:** Where projections or simulations are performed on retrospective peels (involving the removal of the most recent data point(s), followed by re-analysis of the iteratively truncated time series), to understand how different management measures *may have* performed in the past.

**Ricker (RK):** A model of the stock-recruitment relationship between spawning biomass, spawners or eggs in one generation and resulting recruitment. See also Beverton-Holt.

**Risk:** In general, the possibility of something undesirable happening, for example, of harm or loss, or of failing to meet fisheries management objectives. Risk occurs as a result of uncertainty, and is measured in terms of the consequences of an event and the probability of its occurrence.

**Simulation:** Like projection or forecasting, a way to make predictions about trends in stock size and fishery dynamics in the future in response to management measures. Closed-loop simulations can add more realism to projections by incorporating uncertainties related to implementation of management measures (i.e., realized fishing mortality that differs from intended mortality), observation (simulating errors in survey indices or reported catches), and/or assessment (simulating model results using observations to which simulated management measures will respond).

**Spawners (S):** The total abundance (number) of sexually mature fish in the stock.

**S<sub>gen</sub>:** Abundance of spawners that in one generation can produce  $S_{MSY}$  under conditions of no fishing ( $F = 0$ ).

**S<sub>MSY</sub>:** The average number of spawners that results from taking an average catch of MSY under various types of harvest strategies.

**Spawning stock biomass (SSB):** The total weight of sexually mature fish in the stock. This quantity depends on the abundance of year classes, the exploitation pattern, the rate of growth, both fishing and natural mortality rates, the onset of sexual maturity, and environmental conditions. Same as mature biomass. Often refers to females only.

**Spawning (biomass) Per Recruit (SBR):** The expected lifetime contribution to the spawning biomass for the average recruit to the fishery.

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**Spawning Potential Ratio (SPR):** The ratio of spawning biomass per recruit at some fishing mortality rate divided by the spawning biomass per recruit at the unfisher state, i.e.,  $F=0$ . For a given exploitation pattern, rate of growth, maturity schedule and natural mortality, an equilibrium value of SPR can be calculated for any level of fishing mortality. SPR decreases monotonically with increasing fishing mortality.

**Stock:** The term has different meanings. It can be considered as a semi-discrete group of aquatic animals (fish, invertebrate, marine mammals) with some definable attributes in common that are of interest to managers. It may be defined with reference to units for the purpose of fisheries management. Alternatively, a biological stock is a population of a given species that forms a reproductive unit and spawns little if at all with other units. However, there are many uncertainties in defining spatial and temporal geographical boundaries for such biological units that are compatible with established data collection systems. For this reason, the term “stock” is often synonymous with an assessment / management unit, even if there is migration or mixing of some components of the assessment / management unit between areas.

**Stock Complex:** Groups of multiple biological, management and/or assessment units clustered together for pragmatic reasons due to shared biological traits, including responses to management measures.

**Stock assessment:** The analysis of available data to determine stock status, usually through application of statistical and mathematical tools to relevant data in order to obtain a quantitative understanding of the status of the stock relative to defined management benchmarks or reference points.

**Stock-recruitment relationship:** An equation describing how the expected number of recruits to a stock varies as the spawning biomass changes. The most frequently used stock-recruitment relationship is the asymptotic Beverton-Holt equation, in which the expected number of recruits changes very slowly at high levels of spawning biomass.

**Stock status:** Refers to a determination made, on the basis of stock assessment results, about the current, past or future condition of the stock. Stock status is a metric that is often expressed relative to management benchmarks and biological reference points such as  $B_{MSY}$  or  $B_0$  or  $F_{MSY}$  or  $F_{%SPR}$ . For example, the current estimated biomass ( $B_{current}$ ) may be said to be above or below  $B_{MSY}$  or to be at some percentage of  $B_0$ . Similarly, fishing mortality may be above or below  $F_{MSY}$  or  $F_{%SPR}$ . See performance metric and monitoring metric.

**Strategy:** A plan of actions designed to achieve a major or overall goal or aim. Strategies inform the selection of tactics used to achieve measurable objectives in support of the overall plan goal.

**Tactic:** The specific measures or actions taken to achieve a particular objective, as part of a strategy.

**Target:** Generally, a biomass, fishing mortality or exploitation rate level or reference point that management actions are designed to achieve with a specified level of probability, usually 50% or “on average.”

**Threshold:** Generally, a biomass, fishing mortality or exploitation rate level or reference point that management actions are designed to achieve with a specified level of probability (usually >50%). Thresholds may also be used for reporting stock status. In some jurisdictions, thresholds are also called buffers, triggers or precautionary reference points. A limit is a type of threshold.

**$T_{min}$ :** The time the stock would take to rebuild to a specified target in the absence of fishing mortality ( $F = 0$ ) under prevailing productivity conditions.

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**Total Allowable Catch (TAC):** The sum of the catches from all sources. In some cases, it may refer to only the Total Allowable Commercial Catch (TACC).

**Total Mortality (Z):** Total mortality rate. The sum of natural ( $M$ ) and fishing mortality ( $F$ ) instantaneous rates.

**Trade-offs:** Situations where gains (or increasing probability of achieving desired outcomes) for one objective result in losses (or diminishing probability of achieving outcomes) for another objective. Decision-makers generally seek an acceptable balance in trade-offs when choosing what action to take.

**Upper Stock Reference (USR):** The name of the biomass threshold, target and/or operational control point in Canadian harvest strategies.

**Virtual Population Analysis (VPA):** A stock assessment approach that reconstructs (“back-calculates”) historical abundances of fish at different ages based on observed fish catches and assumptions about natural mortality rates across the different ages.

**Yield:** Catch expressed in terms of weight.

**Yield per Recruit (YPR):** The expected lifetime yield for the average recruit. For a given exploitation pattern, rate of growth, and natural mortality, an equilibrium value of YPR can be calculated for each level of fishing mortality. YPR analyses may play an important role in advice for management, particularly as they relate to minimum size controls.

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## APPENDIX 2: INFORMATION RICHNESS QUESTIONNAIRE

### INTRODUCTION

Information poverty (including data and model poverty) represents a persistent challenge in the provision of fisheries science advice. We want to understand Canadian challenges better.

The purpose of this questionnaire is to semi-quantify information richness across fish stocks and subunits that either have or do not have a Limit Reference Point. The information collected will be used to inform working papers for the forthcoming CSAS National Advisory Process on Limit Reference Points under the Fish Stocks Provisions, and potentially other advice addressing the information poverty spectrum in support of the development of National Operational Guidelines for the Science Sector in support of the Fish Stocks Provisions.

The basis of this questionnaire is NOAA Fisheries' Stock Assessment Classification System (Lynch et al. 2018). That system consisted of a series of six questions on stock assessment frameworks (model types) and input data with six possible responses for each (i.e., giving information richness scores from 0 to 5). We have refined and broken out these into 11 questions to better apply to the Canadian context.

If there are any questions about this questionnaire, please contact Julie Marentette (Julie.Marentette@dfo-mpo.gc.ca) or Mary Thiess (Mary.Thiess@dfo-mpo.gc.ca).

### References:

Lynch, P. D., Methot, R. D., & Link, J. S. (2018). Implementing a Next Generation Stock Assessment Enterprise: An Update to the NOAA Fisheries Stock Assessment Improvement Plan. NOAA Technical Memorandum MNFS-F/SPO-183. 127 pp.

Select The Name Of The Stock Or Subunit From The Following List: [Given]

1. Can you please verify whether this stock or subunit has a Limit Reference Point?

- Yes
- No
- Proposed or Provisional LRP but not Accepted
- Other (please explain)

2. Is the stock or subunit subject to a Management Strategy Evaluation?

- Yes
- No
- Other (please explain)

3. Assessment (or Operating Model) category (select as many as apply)

- Index-based (fishery-dependent indices only)
- Index-based (including fishery-independent indices)
- Delay difference
- Surplus production
- Virtual population analysis
- Statistical catch-at-length

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- Statistical catch-at-age
  - Other (please explain)
4. Catch Data
- 0 – None. No quantitative catch data.
  - 1 – Some catch data, but major gaps for some fishery sectors or for historical periods such that their use in assessments is not supported.
  - 2 – Major gaps but enough catch data to establish magnitude of catch and trends in catch for a major fishery sector in order to apply a data-limited or index assessment method.
  - 3 - Catch data is generally available for all fishery sectors to support quantitative stock assessment, but some gaps exist such as low observer coverage, high levels of self-reported catch, weak information on discard mortality.
  - 4 - No data gaps substantially impede assessment, but catch is not without uncertainty (e.g., recreational catches estimated from surveys).
  - 5 - Very complete knowledge of catch.
5. Size Composition Data
- 0 – No size composition data collected.
  - 1 – Some size composition data has been collected, but there are major gaps in coverage, and the data are not used in stock assessment.
  - 2 – Gaps but supports data-limited or index (etc.) assessments.
  - 3 - Gaps, but enough data over sufficient time series to be informative for size-structured assessment models.
  - 4 - Enough size composition data has been collected over a sufficient time series to enable assessment methods that need size composition data from the fishery.
  - 5 - Very complete size composition data, including, as needed on stock-specific basis, knowledge of precision, spatial patterns or other issues.
6. Age Composition Data
- 0 – No age composition data collected.
  - 1 – Some age composition data has been collected, but there are major gaps in coverage, and the data are not used in stock assessment.
  - 2 – Gaps but supports data-limited or index (etc.) assessments.
  - 3 - Gaps, but enough data over sufficient time series to be informative for age-structured assessment models.
  - 4 - Enough age composition data has been collected over a sufficient time series to enable assessment methods that need age composition data from the fishery.
  - 5 - Very complete age composition data, including, as needed on stock-specific basis, knowledge of precision, spatial patterns or other issues.
7. Abundance Data
- 0 – No indicator of stock abundance, or trend in stock abundance, over time.
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- 1 – Fishery-dependent catch rates (CPUE) are available, but there is high uncertainty about their standardization over time; or abundance is based on expert opinion on degree of stock depletion over time.
  - 2 – Fishery-dependent catch rates (CPUE) are sufficiently standardized to enable their use in full assessments; data from fishery-independent sources are not available or sufficient to estimate abundance trends.
  - 3 - Limited fishery-independent survey(s) provide estimates of relative abundance; however, the temporal or spatial coverage of the stock is limited or the sampling variability is high.
  - 4 - Complete fishery-independent survey(s) provide estimates of relative abundance, and the survey(s) cover a large proportion of the spatial extent of the stock with several years of tracking at a level of precision that supports assessments.
  - 5 - Calibrated fishery-independent survey(s) or tag-recapture provide estimates of absolute abundance.
8. Life History Data (Growth)
- 0 – No growth data.
  - 1 – Growth estimates are derived using proxies, meta-analyses, borrowed from other species, etc.
  - 2 – Estimates of growth based on stock-specific empirical data.
  - 3 - Data are sufficient to track changes in growth over time.
  - 4 - Growth data are comprehensive over time and space with no major gaps.
9. Life History Data (Natural Mortality)
- 0 – No natural mortality data.
  - 1 – Natural mortality estimates are derived using proxies, meta-analyses, borrowed from other species, etc.
  - 2 – Estimates of natural mortality based on stock-specific empirical data.
  - 3 - Data are sufficient to track changes in natural mortality over time.
  - 4 - Natural mortality data are comprehensive over time and space with no major gaps.
10. Life History Data (Reproductive Biology)
- 0 – No reproductive biology data.
  - 1 – Reproductive biology estimates are derived using proxies, meta-analyses, borrowed from other species, etc.
  - 2 – Estimates of reproductive biology based on stock-specific empirical data.
  - 3 - Data are sufficient to track changes in reproductive biology over time.
  - 4 - Reproductive biology data are comprehensive over time and space with no major gaps.
11. Ecosystem Linkages (General)
- 0 - No linkage to ecosystem dynamics or consideration of ecosystem properties (i.e., equilibrium conditions assumed for ecosystem).

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- 1 - Ecosystem-based hypotheses are informative or used for processing assessment inputs (e.g., abundance index), but there is no explicit linkage to any ecosystem drivers in the assessment.
  - 2 - Not mechanistic: the assessment explicitly accounts for unidentified ecosystem dynamic(s) (e.g., time/space “regimes”, time-varying parameters, random walks, or other approaches to changing features without direct inclusion of ecosystem data).
  - 3 - Direct linkage(s): One or more aspects of the assessment is linked to at least one ecosystem dynamic (i.e., environment, climate, habitat, predator-prey data) (e.g., co-variate for growth, maturity or recruitment)
  - 4 - Direct linkage(s) informed by process studies: The assessment is linked to at least one ecosystem dynamic, and one or more process studies directly support the manner in which ecosystem dynamics are incorporated (e.g., consumption rates measured and the co-variate is informed by results.)
  - 5 - Fully coupled: The assessment approach is coupled or linked with an ecosystem process (e.g., multi-species, coupled biophysical, or climate-linked models).

#### 12. Ecosystem Linkages (Growth)

- 0 - No linkage to ecosystem dynamics
- 1 - Ecosystem-based hypotheses are informative but no explicit linkage
- 2 - Not mechanistic: regimes, time-varying parameters, random walks or other approaches
- 3 - Direct linkages to ecosystem dynamics (e.g., covariates)
- 4 - Direct linkages to ecosystem dynamics informed by process studies

#### 13. Ecosystem Linkages (Natural Mortality)

- 0 - No linkage to ecosystem dynamics
- 1 - Ecosystem-based hypotheses are informative but no explicit linkage
- 2 - Not mechanistic: regimes, time-varying parameters, random walks or other approaches
- 3 - Direct linkages to ecosystem dynamics (e.g., covariates)
- 4 - Direct linkages to ecosystem dynamics informed by process studies

#### 14. Ecosystem Linkages (Reproductive Biology)

- 0 - No linkage to ecosystem dynamics
- 1 - Ecosystem-based hypotheses are informative but no explicit linkage
- 2 - Not mechanistic: regimes, time-varying parameters, random walks or other approaches
- 3 - Direct linkages to ecosystem dynamics (e.g., covariates)
- 4 - Direct linkages to ecosystem dynamics informed by process studies

15. You have completed this questionnaire for the stock/subunit you selected from the drop-down list above. Would you provide the same answers on information poverty for multiple other stock/subunits? (For the sake of economy you can identify those here, and then there is no need to re-do the information poverty questionnaire for all of them individually).

- Yes

- 
- No, I am only completing this for one stock/subunit
  - No, my answers will differ for other stocks/subunits
16. Select the name of the stocks or subunits that have the same information poverty from the following list: [given]
17. Any other comments on information poverty?
18. Your name (if we need to follow up with you)

## **RESULTS**

Responses from stock assessment practitioners provided information on information richness for data concerning catches, size composition, age composition, abundance, growth, natural mortality, reproductive biology, and ecosystem linkages for 285 assessment units (147 of which were associated with LRPs).

Overall, information quality was higher (i.e., median information richness scores were higher) for assessment units with LRPs compared to those without LRPs; this was also true for all individual data types (e.g., catch, age and size composition, etc.), with the exception of growth data (Figure A.2.1). However, the range of scores was similar for assessment units with and without LRPs, meaning information poverty in no one data type was clearly driving the lack of LRP across units.

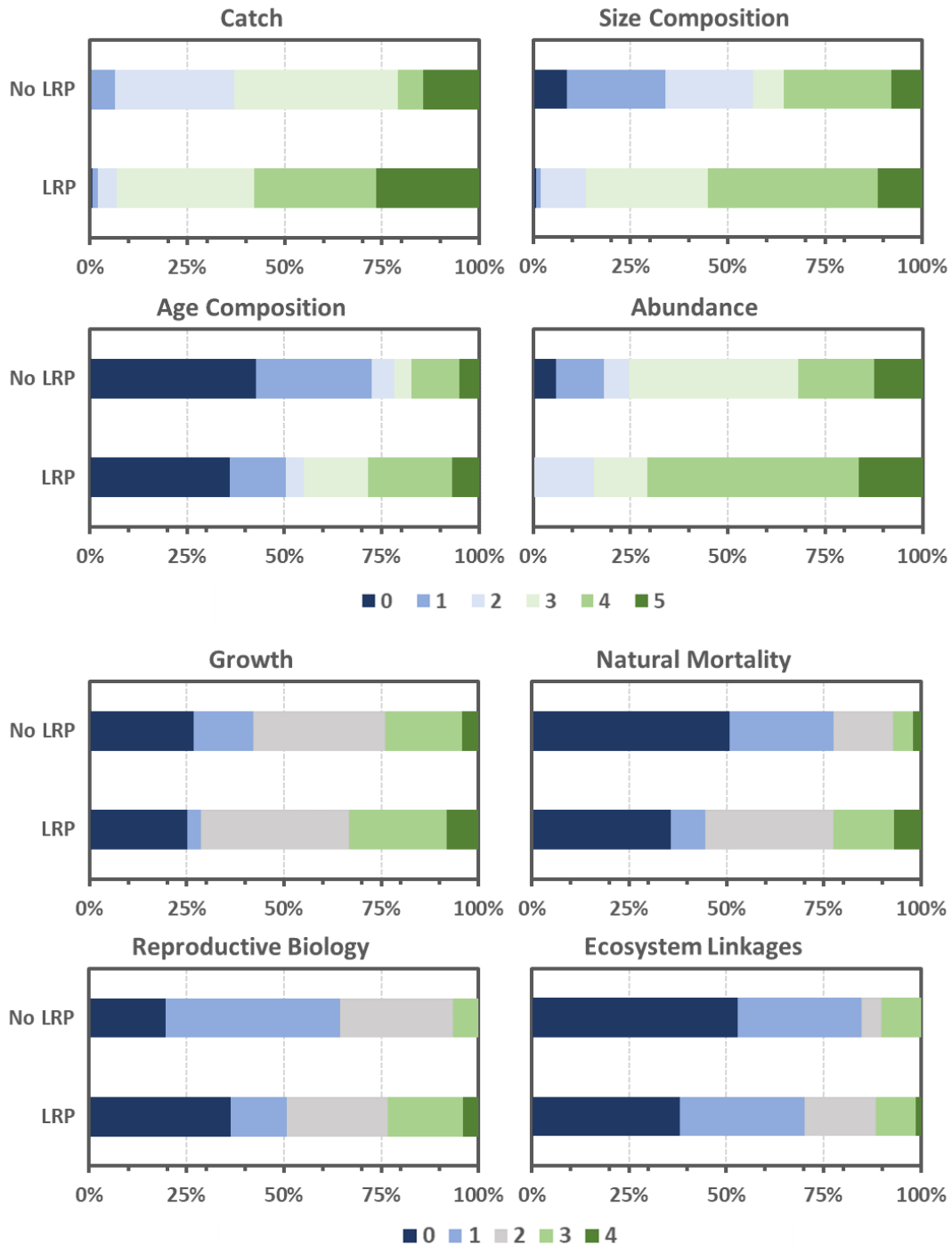


Figure A.2.1: Stacked bar plots showing the relative information richness scores across 285 assessment units with ( $n = 147$ ) and without ( $n = 138$ ) LRPs. Each panel represents a particular type of data (labeled in grey above each graph). Information richness scores range from 0 (extreme data poverty) to a maximum of 4 or 5 (no data poverty).

## APPENDIX 3: METHODOLOGY FOR REVIEW OF CANADIAN APPROACHES

### CATEGORIZATION OF REFERENCE POINTS

Reference points may be categorized in a variety of ways, as seen in both the primary literature as well as more general guidance and grey literature documents for stock assessment (Table A.3.1). Here we have categorized Canadian reference points into three basic types:

- Theoretical, where the reference point represents some estimated level of a stock attribute based on fish population dynamics theory, and which is model-estimated;
  - e.g.,  $K$ ,  $B_0$ ,  $B_{MSY}$ ,  $F_{40\%SPR}$ ,  $F_{0.1}$ ,  $B_{50\%Rmax}$ , segmented change points in stock-recruitment relationships
- Historical, where the reference point represents some estimated level of a stock attribute observed in the past, using an indicator which is model-estimated;
  - e.g.,  $B_{recover}$ ,  $B_{min}$ ,  $B_{loss}$ ,  $B_{max}$ , and historical proxies ( $B$  from reference periods used to approximate  $B_{MSY}$ ,  $B_0$  or part of the stock-recruitment relationship); and
- Empirical, where the reference point is set to some level or composite level of observed data, such as a survey index, instead of a model estimate. Many empirical reference points may also be based on reference periods used to approximate  $B_{MSY}$ ,  $B_0$  or part of the stock-recruitment relationship.

Indicators (from which reference points are selected as thresholds) may also be categorized according to the nature of their relationship to the objective they represent (Keeney 1992, Gregory et al. 2012). The indicator would therefore represent some attribute or characteristic of the stock, the LRP would represent a value of that indicator, and stock status (indicator : LRP) is a metric used in performance evaluation and/or in monitoring (Sloan et al. 2014). Indicators, reference points and stock status metrics can thus be classed as:

- natural, where the attribute(s) of a stock that represents serious harm or ‘health’ is directly measured or estimated (e.g., spawning stock biomass);
- proxy, where an alternative is used, possibly because the “true” attribute of interest for the objective cannot be estimated or is otherwise unsuitable (e.g., CPUE or a research vessel survey index); or,
- composite, where the indicator is constructed from one or more sub-components, potentially because individual natural or proxy indicators are considered unsuitable, unavailable or unfeasible.

*Table A.3.1: Categories or types of reference points found in the primary literature and in other guidance documents for stock assessment in different jurisdictions, compared with the major categories of reference points (theoretical, historical, empirical) used in this paper.  $B$  = biomass.  $BH$  = Beverton-Holt.  $CPUE$  = catch per unit effort.  $F$  = fishing mortality.  $G_{loss}$  = corresponds to the stock replacement line (recruits per spawner) at the lowest observed spawning stock size.  $S_{gen}$  = abundance in one generation that can produce  $S_{MSY}$  with no fishing.  $K$  = carrying capacity.  $MSY$  = maximum sustainable yield.  $R$  = recruitment.  $RK$  = Ricker.  $S$  = spawning abundance.  $YPR$  = yield per recruit.*

Reference	Theoretical	Historical	Empirical
Campbell 2010	MSY-based ( $B_{MSY}$ ) Yield per Recruit (YPR) Relative depletion ( $B_0$ )	Historical observations (minimum/average historical biomass)	Empirical [not further specified]

Reference	Theoretical	Historical	Empirical
DFO 2016a	MSY-based ( $B_{MSY}$ , $S_{MSY}$ ) YPR, SPR ( $F_{max}$ , $F_{0.1}$ , $F_{\%SPR}$ ) Stock-recruitment-based ( $S_{Rmax}$ , $SSB_{50\%Rmax}$ ) Carrying capacity ( $K$ ) $S_{gen}$	$B_{loss}$ $B_{recover}$ Mean or median of time series Maximum observed population size (N)	Empirical (survey indices, CPUE, landings)
Gabriel and Mace 1999	Spawner-recruit (semelparous) Dynamic Pool (Per-recruit; $F_{max}$ , $F_{0.1}$ , $F_{\%SPR}$ ) Stock-recruit ( $F_{med}$ , $F_{high}$ , $F_{low}$ , $G_{loss}$ ) Surplus production ( $B_{MSY}$ )	--	--
ICES 2021a	Segmented regression change point in stock-recruit $0.3 B_{MSY} = 0.15 K$ (Schaefer biomass dynamic models)	$B_{loss}$ Highest $B$ observed	--
Kronlund et al. 2018	Model-based LRPs estimated with equilibrium assumptions (fractions of $B_0$ , $B_{MSY}$ , and YPR) Model-based LRPs that dynamically track changes in productivity ( $B_{unfished}$ )	Historical LRPs (modelled estimates)	--
McKown et al. 2008	Model-based reference points ( $F_{40\%}$ proxies; $B_{MSY}$ )	--	Index-based reference points (catches, CPUE, survey indices)
Murawski 2010	MSY "Hybrid," heuristically-determined from stock-recruit relationships	--	Traffic light approach (notional or directional)
Rivard and Rice 2003	$Sb_{50/90}$ , $BH_{50}$ , $RK_{50}$ , $NP_{50}$	$B_{recover}$	--
Sainsbury 2008	MSY (static, dynamic) Per-recruit proxies for $F_{MSY}$ ( $F_{max}$ , $F_{0.1}$ , $F_{\%}$ ) Stock-recruit based methods (parametric: $B_{50\%Rmax}$ , segmented regression; and non- parametric: $F_{med}$ , $F_{high}$ , $F_{low}$ ) $20\% B_0$ (stationary), $0.3 B_{unfished}$ (dynamic) Biomass from which rebuilding to target can be achieved in one generation time or 10 years	--	Empirical (catch, catch rates, length distributions in catch, survey indices, range reductions, loss of spawning units/locations)
Shelton and Rice 2002	Dynamic pool ( $F_{0.1}$ , $F_{max}$ , $F_{35\%SPR}$ ), $20\% B_0$ , $B_{MSY}$ , stock- recruit ( $B_{50\%Rmax}$ , $B_{90/10}$ )	$B_{loss}$ , including concepts similar to $B_{recover}$	Traffic light approach

## IDENTIFYING STOCKS

In our review of Canadian approaches to LRPs, indicators and stock status metrics, we examined a wide range of stocks, derived from:

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- those named on the 2019 Sustainability Survey for Fisheries (hereafter, the Survey; DFO 2021a);
  - non-Survey stocks identified by each DFO region for internal departmental planning purposes (unpublished) in Fall 2018;
  - a stock list published by Oceana Canada in annual audits of Canadian fisheries (Archibald and Rangeley 2021); and,
  - other Canadian fish stocks for which LRPs and/or science advice was available on the Canadian Science Advisory Secretariat (CSAS) website.

We included non-Survey stocks only if they could be paired with advice provided and published via CSAS. We did however exclude Pacific salmon stocks from the review to avoid redundancy with ongoing work to develop methods for LRPs in relation to newly defined Pacific salmon stock management units (SMUs; DFO 2022). We also excluded several transboundary or other internationally managed stocks for which science advice may be provided via non-Canadian processes (i.e., RFMO, bilateral, etc.) and according to other policy requirements.

Living marine resources such as fish, invertebrates or marine mammals can defy easy categorization into “stocks.” Stocks on DFO’s Survey or for which advice is provided via CSAS sometimes have subunits for which distinct sets of science advice may be provided; however, neither named stocks nor their subunits necessarily correspond to distinct biological units (i.e., populations) or management units (i.e., managed under the same objectives or with the same measures). The former situation may occur because biological stock structure is unknown or unclear, while the latter may occur due to legacy practice, pragmatism, or political reasons. This represents a significant challenge when examining how an objective to avoid serious harm has been interpreted, especially in terms of stock structure. We thus undertook analyses from two lists of different units of analysis: assessment units and LRP-stock scenarios, as defined below.

### **Assessment Unit List**

We developed an assessment unit list (Table A.3.2) to examine Canadian practices for LRPs and stock status. Where feasible, we divided some named stocks on the Survey into multiple units based on the scale at which science advice is provided (i.e., where LRPs were set at the level of individual subunits, or advice is given separately for subunits regardless of how LRPs may be set in future). This resulted in a list of 153 assessment units (112 associated with the Survey) with either accepted LRPs or recovery targets set in accordance with the PA Policy guidance on LRPs. Nine of the assessment units with LRPs, however, might better be described as stock complexes, because it was not feasible to identify or separate the actual number of subunits for the purposes of setting an LRP (e.g., invertebrate or salmonid stocks with dozens to thousands of subunits). The assessment unit list enabled us to examine the factors and rationales that may have influenced the choice of LRP and to determine whether choices changed over time. It is important to note that assessment units developed for the purposes of this paper may not correspond to distinct biological and/or management units. Thus, this list should not be considered the list of “major fish stocks” that may be considered by Fisheries and Oceans Canada for prescription under the FSPs.

Stocks are also named differently, depending on the context in which they are being discussed or source from which they were derived. In seeking to standardize the way that assessment units are identified in this study, we named each assessment unit or stock complex with a combination of the common name of the species, the alphanumeric identifiers of the relevant management areas (e.g., NAFO, PFMA or other relevant fishing area designations), and any

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common or applicable descriptors afterwards (e.g., Atlantic Cod – NAFO 2J3KL (Northern Cod)).

## **LRP-Stock Scenarios**

Stocks were sorted into LRP-stock scenarios to better examine the challenges posed by the “one-stock-one-LRP” requirement using only named stocks from the Survey with accepted or proposed LRPs or a reported stock status (n = 79). These stocks were binned into several groups according to whether each name was associated with one or more LRPs, one or more status metrics, and with consideration as to the number of subunits.

### **“HAVING AN LRP”**

We considered an assessment unit or Survey stock to “have” an LRP (Tables A.3.2-A.3.5) if the following conditions were met:

- one or more published science documents regarding an LRP were available that
  - either proposed or mentioned an existing LRP, regardless of whether or not the LRP was characterized as “provisional”, and
  - did not state that the LRP or the advice framework from which the LRP or stock status was estimated was not accepted or infeasible to estimate; and/or,
- the Survey indicated the stock or assessment unit had an LRP; and,
- there was no contradicting information (subsequent advice or information received from assessment experts) to indicate that the Survey or most recent published documents were out of date with respect to the existence, acceptance or feasibility of the LRP, stock status or the advisory framework from which the LRP and status were estimated.

Assessment units or Survey stocks where LRPs are either not mentioned, identified as absent in science advice, and/or identified as not present in the Survey, with no contradicting information from assessment experts, were considered to have no LRP. Finally, assessment units where LRPs were variously either in development, proposed but not accepted, or accepted but infeasible due to challenges with the advice framework, were classed as “Other” and grouped with those assessment units with no LRPs for the purposes of this analysis.

## **Sources of Information**

Information on assessment units was first collected from stock assessment Science Advisory Reports (SARs) or comparable science advice documents (e.g., management strategy evaluations, stock updates, Recovery Potential Assessments (RPAs)<sup>1</sup>, Proceedings or Research Documents) published on the CSAS website and/or referenced in the 2019 Sustainability Survey for Fisheries (DFO 2021a). The most recent science advice that could be found as of December 2021 was used to determine the current operational context (assessment framework and paradigm<sup>2</sup>), reference point, status, other advice and the data available for each

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<sup>1</sup> As Designatable Units under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) do not always align spatially or temporally with stocks managed for fisheries purposes, RPAs were used only when no other recent or applicable information was available.

<sup>2</sup> For example, a traditional “single best assessment model”, or a procedural paradigm such as Management Strategy Evaluation or closed-loop simulation (which focus on evaluating candidate management procedures and often employ multiple operating models to do so).

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assessment unit. The presence of a multi-year assessment schedule was inferred from the past history of assessments, evaluations and/or updates for that stock available on CSAS since 2009, the year in which the PA Policy was published.

Additionally, we surveyed stock assessment experts to semi-quantify the extent of information poverty for assessment units in Canada, and correlated these responses to whether LRPs had been set for those assessment units. Questionnaires (Appendix 2) were distributed through division managers and section heads in all regions and answers for 285 assessment units (147 associated with LRPs) were collected between December 2021 and February 2022. Information poverty was scored on a qualitative Likert scale ranging from 0 (extreme poverty) to 4 or 5 (depending on the question; no poverty) for different data types.

Table A.3.2. List of stocks and subunits by source category, DFO administrative region from where science advice is provided, whether it was considered to have an LRP for the purposes of this study, and whether it was used in this study. LFA = lobster fishing area. NAFO = Northwest Atlantic Fisheries Organization. NYA = Not yet applicable. Survey = Sustainability Survey for Fisheries. Trans = transboundary.

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Albacore Tuna - North Pacific Ocean	Survey (trans)	Pac	Yes	-
American Eel	Survey	MAR	Proposed	-
American Lobster - LFA 17 (Anticosti)	Survey	QC	No	-
American Lobster - LFA 15, 16, 18 (North Shore)	Other Source	QC	No	-
American Lobster - LFA 19-21 (Gaspé)	Survey	QC	Yes	Yes
American Lobster - LFA 27-33 (Inshore)	Survey (broken out)	MAR	See subunits	-
American Lobster - LFA 27 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 28 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 29 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 30 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 31A (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 31B (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 32 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 33 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 34 (Inshore)	Survey	MAR	Yes	Yes
American Lobster - LFA 35-38 (Inshore)	Survey (broken out)	MAR	See subunits	-
American Lobster - LFA 35 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 36 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 38 (Inshore)	Survey - subunit	MAR	Yes	Yes
American Lobster - LFA 3-14c	Survey	NL	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
American Lobster - LFA 3-6 (Northeast)	Survey - subunit	NL	No	-
American Lobster - LFA 7-10 (Avalon)	Survey - subunit	NL	No	-
American Lobster - LFA 11-12 (South Coast)	Survey - subunit	NL	No	-
American Lobster - LFA 13-14 (West Coast)	Survey - subunit	NL	No	-
American Lobster - LFA 41 (Offshore)	Survey	MAR	Yes	Yes
American Lobster - LFA 23, 24, 25, 26A, 26B (Southern Gulf)	Survey	Gulf	Yes	Yes
American Lobster - LFA 22 (Îles-de-la-Madeleine)	Survey	QC	Yes	Yes
American Plaice - NAFO 2+3K	Other Source	NL	Yes	Yes
American Plaice - NAFO 3LNO	Other Source (NAFO)	NL	Yes	-
American Plaice - NAFO 3Ps	Other Source	NL	Yes	Yes
American Plaice - NAFO 4VWX (Scotian Shelf)	Other Source	Mar	Yes	Yes
American Plaice - NAFO 4T (Southern Gulf of St. Lawrence)	Survey	Gulf	Yes	Yes
Arctic Char - Cambridge Bay	Survey (complex)	C&A	Yes	Yes
Arctic Char - Cumberland Sound	Survey (broken out)	C&A	See subunits	-
Arctic Char - Ijaruvung Lake	Survey - subunit	C&A	Yes	Yes
Arctic Char - Iqalujuaq Fiord	Survey - subunit	C&A	Yes	Yes
Arctic Char - Irvine Inlet	Survey - subunit	C&A	Yes	Yes
Arctic Cod	Other Source	-	-	-
Arctic Surfclam - Banquereau	Survey	MAR	Yes	Yes
Arctic Surfclam - Grand Bank	Survey	MAR	Yes	Yes
Arctic Surfclam - Quebec Coastal Waters (Stimpson's Surfclam)	Survey	QC	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Arrowtooth Flounder	Other Source	Pac	Yes	Yes
Atlantic Cod - NAFO 2GH (Labrador)	Other Source	-	-	-
Atlantic Cod - NAFO 2J3KL (Northern Cod)	Survey	NL	Yes	Yes
Atlantic Cod - NAFO 3NO (Southern Grand Banks)	Other Source (NAFO)	NL	Yes	-
Atlantic Cod - NAFO 3Ps (St. Pierre Bank)	Survey	NL	Yes	Yes
Atlantic Cod - NAFO 4RS3Pn (Northern Gulf)	Survey	QC	Yes	Yes
Atlantic Cod - NAFO 4Vn (Resident)	Other Source	MAR	-	-
Atlantic Cod - NAFO 4VsW (Eastern Scotian Shelf)	Other Source	MAR	Yes	Yes
Atlantic Cod - NAFO 4X5Y (Scotian Shelf and Bay of Fundy)	Survey	MAR	Yes	Yes
Atlantic Cod - NAFO 4TVn (Southern Gulf)	Survey	Gulf	Yes	Yes
Atlantic Cod - NAFO 5Zjm (Eastern Georges Bank)	Survey (trans)	MAR	Yes	-
Atlantic Halibut - NAFO 3NOPs4VWX+5	Survey	MAR	Yes	Yes
Atlantic Halibut - NAFO 4RST	Survey	QC	Proposed	-
Atlantic Herring - NAFO 2J3IKLPs	Survey (broken out)	NL	No	-
Atlantic Herring - 2J3IKLPs (White Bay - Notre Dame Bay)	Survey - subunit	NL	No	-
Atlantic Herring - 2J3IKLPs (Bonavista Bay - Trinity Bay)	Survey - subunit	NL	No	-
Atlantic Herring - 2J3IKLPs (Conception Bay - Southern Shore)	Survey - subunit	NL	No	-
Atlantic Herring - 2J3IKLPs (St. Mary's Bay - Placentia Bay)	Survey - subunit	NL	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Atlantic Herring - 2J3IKLPs (Fortune Bay)	Survey - subunit	NL	No	-
Atlantic Herring - 4R (Fall Spawner) / (Spring Spawner)	Survey (broken out)	QC	No	-
Atlantic Herring - NAFO 4R (Fall Spawner)	Survey - subunit	QC	Lost	(counted in past LRPs)
Atlantic Herring - NAFO 4R (Spring Spawner)	Survey - subunit	QC	Lost	(counted in past LRPs)
Atlantic Herring - 4S	Survey (broken out)	QC	No	-
Atlantic Herring - NAFO 4S (Fall Spawner)	Survey - subunit	QC	No	-
Atlantic Herring - NAFO 4S (Spring Spawner)	Survey - subunit	QC	No	-
Atlantic Herring - NAFO 4T (Fall Spawner)	Survey	Gulf	Yes	Yes
Atlantic Herring - NAFO 4T (Spring Spawner)	Survey	Gulf	Yes	Yes
Atlantic Herring - 4VWX	Survey (broken out)	MAR	See subunits	-
Atlantic Herring - NAFO 4VWX (Southwest Nova Scotia/Bay of Fundy)	Survey - subunit	MAR	Yes	Yes
Atlantic Herring - NAFO 4VWX (Offshore Scotian Shelf Banks)	Survey - subunit	MAR	No	-
Atlantic Herring - NAFO 4VWX (Coastal Nova Scotia)	Survey - subunit	MAR	No	-
Atlantic Herring - NAFO 5YZ (weirs)	Survey (trans)	MAR	No	-
Atlantic Mackerel - NAFO 3+4	Survey	QC	Yes	Yes
Atlantic Salmon - Gulf	Survey (complex)	Gulf	Yes (complex)	Yes
Atlantic Salmon - Maritimes	Other source (complex)	MAR	Yes (complex)	Yes
Atlantic Salmon - NL	Survey (complex)	NL	Yes (complex)	Yes
Atlantic Surfclam	Other Source	QC	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Atlantic Walrus - Baffin Bay (High Arctic)	Survey	C&A	No	-
Atlantic Walrus - Foxe Basin (Central Arctic)	Survey	C&A	No	-
Atlantic Walrus - Hudson Bay-Davis Strait (Central Arctic)	Survey	QC	No	-
Atlantic Walrus - Penny Strait-Lancaster Sound (High Arctic)	Survey	C&A	No	-
Atlantic Walrus - South and East Hudson Bay	Survey	QC	No	-
Atlantic Walrus - West Jones Sound (High Arctic)	Survey	C&A	No	-
Beluga - Cumberland Sound	Survey	C&A	No	-
Beluga - Northern Quebec (Nunavik)	Survey (broken out)	QC	See subunits	-
Beluga - Northern Quebec (Nunavik) - Eastern Hudson Bay	Survey - subunit	QC	Proposed	-
Beluga - Northern Quebec (Nunavik) - James Bay	Survey - subunit	QC	No	-
Beluga - Northern Quebec (Nunavik) - Ungava Bay	Survey - subunit	QC	No	-
Beluga - Western Hudson Bay	Other Source	C&A	No	-
Big Skate - PMFC 3CD (West Coast Vancouver Island)	Other Source	Pac	No	-
Big Skate - PMFC 5AB (Queen Charlotte Sound)	Other Source	Pac	No	-
Big Skate - PMFC 4B (Strait of Georgia)	Other Source	Pac	No	-
Big Skate - PMFC 5CD (Hecate Strait)	Other Source	Pac	No	-
Bluefin Tuna - Western Atlantic Ocean	Survey (ICCAT)	MAR	No	-
Bocaccio Rockfish	Survey	Pac	Yes	Yes
Bowhead Whale - Eastern Canada - West Greenland (ECWG)	Survey	C&A	Proposed	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Canary Rockfish	Survey	Pac	Yes	Yes
Capelin - NAFO 2+3KLPs	Survey	NL	No	-
Capelin - NAFO 4RST	Survey	QC	No	-
Chinook Salmon - Alsek	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Central Coast	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Fraser Fall 41	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Fraser Spring 42	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Fraser Spring 52	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Fraser Summer 41	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Fraser Summer 52	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Haida Gwaii	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Lower Strait of Georgia	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Mainland Inlet	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Middle Strait of Georgia	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Nass	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Okanagan	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Porcupine	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Skeena	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Stikine	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Taku	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Upper Strait of Georgia	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - West Coast Vancouver Island	Pac Sal SMU	Pac	NYA	-
Chinook Salmon - Yukon	Pac Sal SMU	Pac	NYA	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Chum Salmon - Central Coast	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Fraser	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Haida Gwaii	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Nass	Pac Sal SMU	Pac	NYA	-
Chum Salmon - non-Fraser - Inner South Coast	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Porcupine	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Skeena	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Transboundary	Pac Sal SMU	Pac	NYA	-
Chum Salmon - West Coast Vancouver Island	Pac Sal SMU	Pac	NYA	-
Chum Salmon - Yukon	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Alsek	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Central Coast	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Haida Gwaii	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Interior Fraser	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Johnstone Strait	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Lower Fraser	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Nass	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Porcupine	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Skeena	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Stikine	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Strait of Georgia	Pac Sal SMU	Pac	NYA	-
Coho Salmon - Taku	Pac Sal SMU	Pac	NYA	-
Coho Salmon - WCVI	Pac Sal SMU	Pac	NYA	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Cusk - NAFO 4VWX5Z	Other Source	MAR	Yes	Yes
Dolly Varden - North Slope	Survey (broken out)	C&A	See subunits	-
Dolly Varden - Big Fish River	Survey - subunit	C&A	No	-
Dolly Varden - Rat River	Survey - subunit	C&A	No	-
Dolly Varden - Firth River	Survey - subunit	C&A	No	-
Dolly Varden - Vittrekwa River	Survey - subunit	C&A	No	-
Dolly Varden - Babbage River	Survey - subunit	C&A	No	-
Dover Sole - PMFC 3CD	Other Source	Pac	No	-
Dover Sole - PFMC 5AB	Other Source	Pac	No	-
Dover Sole - PFMC 5CDE	Other Source	Pac	No	-
Dungeness Crab	Survey	Pac	Proposed	-
English (Lemon) Sole - PMFC 3CD5AB	Other Source	Pac	No	-
English (Lemon) Sole - PMFC 5CD	Other Source	Pac	No	-
Eulachon - Fraser River	Survey	Pac	Proposed	-
Euphausiids	Survey (complex)	Pac	No	-
Gaspereau - Maritimes	Survey (broken out)	MAR	See subunits	-
Gaspereau - Maritimes - alewife	Survey - subunit (complex)	MAR	Yes	Yes
Gaspereau - Maritimes - blueback herring	Survey - subunit (complex)	MAR	No	-
Gaspereau - Gulf	Other source (complex)	Gulf	Unclear/complex	-
Geoduck	Survey (complex)	Pac	Yes	Yes
Giant Red Sea Cucumber	Survey (complex)	Pac	Yes	Yes
Goose Barnacle - Clayoquot Sound	Other Source	Pac	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Green Sea Urchin (Pacific)	Survey (broken out)	Pac	See subunits	-
Green Sea Urchin - PMA 12 (Northeast Vancouver Island)	Survey - subunit	Pac	Yes	Yes
Green Sea Urchin - PMA 19 (Southeast Vancouver Island)	Survey - subunit	Pac	Yes	Yes
Green Sea Urchin (NL)	Other Source	NL	No	-
Green Sea Urchin (Quebec)	Other Source	QC	No	-
Greenland Halibut - NAFO 4RST	Survey	QC	Yes	Yes
Greenland Halibut - Cumberland Sound	Survey	C&A	No	-
Greenland Halibut - NAFO 0AB	Survey (NAFO)	C&A	Lost	(counted in past LRPs)
Greenland Halibut (Turbot) - NAFO 2+3KLMNO	Survey (NAFO)	NL	Proposed	-
Grey Seal	Survey (broken out)	QC/MAR	See subunits	-
Grey Seal - Gulf of St. Lawrence	Survey - subunit	QC/MAR	Yes	Yes
Grey Seal - Sable Island and Southwest Nova Scotia	Survey - subunit	QC/MAR	Yes	Yes
Grey Seal - Scotian Shelf	Survey - subunit	QC/MAR	Yes	Yes
Haddock - NAFO 3LNO	Other Source	NL	Proposed	-
Haddock - NAFO 3Ps	Other Source	NL	Yes	Yes
Haddock - NAFO 4X5Y	Survey	MAR	Lost	(counted in past LRPs)
Haddock - NAFO 5Zjm	Survey (trans)	MAR	Lost	(counted in past LRPs)
Hagfish - NAFO 4VWX5Z	Other Source	MAR	No	-
Hagfish - NAFO 3OPs	Other Source	NL	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Hagfish - NAFO 4T (Southern Gulf of St. Lawrence)	Other Source	Gulf	No	-
Harp Seal - Northwest Atlantic Ocean	Survey	QC	Yes	Yes
Iceland Scallop - SFA 16EF-18A	Survey (complex)	QC	No	-
Iceland Scallop - NAFO 4R (Strait of Belle Isle)	Other Source	NL	No	-
Iceland Scallop - St. Pierre Bank	Other Source	NL	No	-
Inconnu - Great Slave Lake (Buffalo River)	Other Source	C&A	No	-
Inconnu - Great Slave Lake (Marian River)	Other Source	C&A	No	-
Inconnu - Great Slave Lake (Slave River)	Other Source	C&A	No	-
Inconnu - Lower Mackenzie (Fort Simpson/Liard)	Other Source	C&A	No	-
Inconnu - Lower Mackenzie (Peel River)	Other Source	C&A	No	-
Inconnu - Lower Mackenzie (Ramparts Rapids)	Other Source	C&A	No	-
Inconnu - Lower Mackenzie (Red River)	Other Source	C&A	No	-
Intertidal Clams - Central Coast-Heiltsuk Manila	Survey (complex)	Pac	No	-
Intertidal Clams - Depuration	Former Survey? (complex)	Pac	Yes	Yes
Intertidal Clams - North Coast Haida Gwaii Razor	Survey (complex)	Pac	Proposed	-
Intertidal Clams - South Coast-Vancouver Island	Survey (complex)	Pac	No	-
Jonah crab - LFA 41 (Offshore)	Other Source	MAR	No	-
Lake Trout - Great Slave Lake	Survey	C&A	No	-
Lake Whitefish - Great Slave Lake	Survey	C&A	No	-
Longhorn Sculpin - St. Mary's Bay	Other Source	MAR	Yes	Yes
Longnose Skate - PMFC 5AB	Other Source	Pac	No	-
Longnose Skate - PFMC 4B (Strait of Georgia)	Other Source	Pac	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Longnose Skate - PFMC 3CD (West Coast Vancouver Island)	Other Source	Pac	No	-
Longnose Skate - PMFC 5CD	Other Source	Pac	No	-
Longspine Thornyhead	Survey	Pac	No	-
Lumpfish - NAFO 2GHJ	Other Source	NL	No	-
Lumpfish - NAFO 3KLPs	Other Source	NL	Yes	Yes
Lumpfish - NAFO 3Pn4RST	Other Source	QC	No	-
Monkfish - NAFO 3LNOPs	Other Source	NL	Yes	Yes
Narwhal - Admiralty Inlet	Survey	C&A	No	-
Narwhal - East Baffin	Survey	C&A	No	-
Narwhal - Eclipse Sound	Survey	C&A	No	-
Narwhal - Northern Hudson Bay	Survey	C&A	No	-
Narwhal - Smith/Jones/Parry	Survey (broken out)	C&A	No	-
Narwhal - Smith Sound	Survey - subunit	C&A	No	-
Narwhal - Jones Sound	Survey - subunit	C&A	No	-
Narwhal - Perry Sound	Survey - subunit	C&A	No	-
Narwhal - Somerset Island	Survey	C&A	No	-
Northern Abalone - Pacific	Other Source	Pac	No	-
Northern Shrimp - Eastern Assessment Zone	Survey	C&A	Yes	Yes
Northern Shrimp - SFA 1	Survey (NAFO)	C&A	Yes	-
Northern Shrimp - SFA 4	Survey	NL	Yes	Yes
Northern Shrimp - SFA 5	Survey	NL	Yes	Yes
Northern Shrimp - SFA 6	Survey	NL	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Northern Shrimp - SFA 7	Survey (NAFO)	NL	Yes	-
Northern Shrimp - SFA 8 (Gulf, Esquiman)	Survey	QC	Yes	Yes
Northern Shrimp - SFA 9 (Gulf, Anticosti)	Survey	QC	Yes	Yes
Northern Shrimp - SFA 10 (Gulf, Sept-Iles)	Survey	QC	Yes	Yes
Northern Shrimp - SFA 12 (Gulf, Estuary)	Survey	QC	Yes	Yes
Northern Shrimp - SFA 13-15 (Scotian Shelf)	Survey	MAR	Yes	Yes
Northern Shrimp - Western Assessment Zone	Survey	C&A	Yes	Yes
Orange-Footed Sea Cucumber - Inshore Waters (Quebec)	Other Source	QC	No	-
Orange-Footed Sea Cucumber - NAFO 3Ps	Survey (broken out)	NL	No	-
Orange-Footed Sea Cucumber - NAFO 3Ps (Northwest)	Survey - subunit	NL	No	-
Orange-Footed Sea Cucumber - NAFO 3Ps (Southeast)	Survey - subunit	NL	No	-
Orange-Footed Sea Cucumber - NAFO 4W Midshore Zone F	Other Source	MAR	Yes	Yes
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zone 1	Other Source	MAR	Yes	Yes
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zones 2	Other Source	MAR	Yes	Yes
Orange-Footed Sea Cucumber - NAFO 4Vs Area of Access 2	Other Source	MAR	Yes	Yes
Orange-Footed Sea Cucumber - Southwest New Brunswick Zone 1	Other Source	MAR	Yes	Yes
Pacific Cod - 3CD (West Coast Vancouver Island)	Other Source	Pac	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Pacific Cod - PMFC 5ABCD (Queen Charlotte Sound and Hecate Strait)	Other Source	Pac	Yes	Yes
Pacific Hake - Inside (Gulf)	Other Source	Pac	No	-
Pacific Hake - Outside	Survey (trans)	Pac	Yes	-
Pacific Halibut	Survey (trans)	Pac	Yes	-
Pacific Herring - Central Coast	Survey	Pac	Yes	Yes
Pacific Herring - Haida Gwaii	Survey	Pac	Yes	Yes
Pacific Herring - Prince Rupert District	Survey	Pac	Yes	Yes
Pacific Herring - Strait of Georgia	Survey	Pac	Yes	Yes
Pacific Herring - West Coast Vancouver Island	Survey	Pac	Yes	Yes
Pacific Lingcod - PMFC 4B (Inside, Strait of Georgia)	Former Survey?	Pac	Yes	Yes
Pacific Lingcod - Outside	Survey (broken out)	Pac	See subunits	-
Pacific Lingcod - PMFC 5CDE (Outside, Hecate Strait and west coast Haida Gwaii)	Survey - subunit	Pac	Yes	Yes
Pacific Lingcod - PMFC 3D (Outside Northwest Vancouver Island)	Survey - subunit	Pac	Yes	Yes
Pacific Lingcod - PMFC 5AB (Outside Queen Charlotte Sound)	Survey - subunit	Pac	Yes	Yes
Pacific Lingcod - PMFC 3C (Outside Southwest Vancouver Island)	Survey - subunit	Pac	Yes	Yes
Pacific Ocean Perch - PMFC 3CD (West Coast Vancouver Island)	Survey	Pac	Yes	Yes
Pacific Ocean Perch - PMFC 5ABC (Queen Charlotte Sound)	Survey	Pac	Yes	Yes
Pacific Ocean Perch - PMFC 5DE-HS/DE/WHG	Survey	Pac	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Pacific Oyster	Survey	Pac	No	-
Petrale Sole	Other Source	Pac	No	-
Pink and Spiny Scallop	Survey (broken out)	Pac	See subunits	-
Pink Scallop	Survey - subunit	Pac	No	-
Spiny Scallop	Survey - subunit	Pac	No	-
Pink Salmon - Central Coast	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Coastal - Skeena/Nass	Pac Sal SMU	Pac	NYA	-
Pink Salmon - East Coast Vancouver Island/Mainland (even)	Pac Sal SMU	Pac	NYA	-
Pink Salmon - East Coast Vancouver Island/Mainland (odd)	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Fraser (odd)	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Haida Gwaii	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Nass	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Skeena	Pac Sal SMU	Pac	NYA	-
Pink Salmon - Transboundary	Pac Sal SMU	Pac	NYA	-
Pink Salmon - West Coast Vancouver Island	Pac Sal SMU	Pac	NYA	-
Pollock - NAFO 3Ps	Other Source	NL	No	-
Pollock - NAFO 4VWXmn (Eastern Component)	Other Source	MAR	Yes	Yes
Pollock - NAFO 4X5 (Western Component)	Survey	MAR	Yes	Yes
Porbeagle Shark	Other Source	MAR	No	-
Quillback Rockfish - Inside	Survey	Pac	Yes	Yes
Quillback Rockfish - Outside	Survey	Pac	Yes	Yes
Razor Clam	Other Source	QC	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Red Sea Urchin	Survey (complex)	Pac	Yes	Yes
Redbanded Rockfish	Other Source	Pac	No	-
Redfish - NAFO 2+3K ( <i>S. fasciatus</i> )	Other Source	NL	No	-
Redfish - NAFO 2+3K ( <i>S. mentella</i> )	Other Source	NL	No	-
Redfish - NAFO 3LN	Survey (NAFO, complex)	NL	Yes	-
Redfish - NAFO 3O	Survey (NAFO, complex)	NL	No	-
Redfish - Unit 1+2 ( <i>S. fasciatus</i> )	Survey	QC/NL	Yes	Yes
Redfish - Unit 1+2 ( <i>S. mentella</i> )	Survey	QC/NL	Yes	Yes
Redfish - Unit 3	Survey	MAR	Yes	Yes
Redstripe Rockfish - PMFC 3CD5ABC (BC South)	Other Source	Pac	Yes	Yes
Redstripe Rockfish - PMFC 5DE (BC North)	Other Source	Pac	Yes	Yes
Rock Crab - NL	Other Source	NL	No	-
Rock Crab - Quebec	Other Source	QC	No	-
Rock Crab - CFA 23, 24, 25, 26A	Survey (broken out)	Gulf	No	-
Rock Crab - CFA 23	Survey - subunit	Gulf	No	-
Rock Crab - CFA 24	Survey - subunit	Gulf	No	-
Rock Crab - CFA 25	Survey - subunit	Gulf	No	-
Rock Crab - CFA 26A	Survey - subunit	Gulf	No	-
Rock Crab - CFA 26B	Survey - subunit	Gulf	No	-
Rock Sole - PMFC 3CD	Other Source	Pac	No	-
Rock Sole - PMFC 5AB (Queen Charlotte Sound)	Other Source	Pac	Yes	Yes
Rock Sole - PMFC 5CD (Hecate Strait)	Other Source	Pac	Yes	Yes
Rougheye Rockfish	Survey (broken out)	Pac	See subunits	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Rougheye Rockfish - PMFC 3CD5AB (REBS south)	Survey - subunit	Pac	Yes	Yes
Rougheye Rockfish - PMFC 5DE (REBS north)	Survey - subunit	Pac	Yes	Yes
Roughhead Grenadier - Atlantic and Arctic	Other Source	-	No	-
Roundnose Grenadier - NAFO 2JKL	Other Source	-	No	-
Sablefish	Survey	Pac	Yes	Yes
Sardine - Pacific Ocean	Survey	Pac	No	-
Scallop - SFA 17A1, 17A2, 18B1, 18B2, 18C, 19A (Gaspé Peninsula )	Other Source (complex)	QC	No	-
Scallop - SFA 15, 16A1, 16A2, 16B, 16C, 16D, 16E, 16F, 16G, 16H, 16I, 18A, 18D (Magdalen Islands)	Other Source (complex)	QC	No	-
Sea Scallop - SFA 21a, b, c, 22, 23, 24 (Southern Gulf of St. Lawrence)	Survey	Gulf	No	-
Sea Scallop - NAFO 3Ps	Other Source	NL	No	-
Sea Scallop - SFA 20	Survey	QC	Yes	Yes
Sea Scallop - Inshore SFA 28 (Bay of Fundy)	Survey (broken out)	MAR	See subunits	-
Sea Scallop - SFA 28 - SPA 1a (Inshore Bay of Fundy)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 28 - SPA 1b (Inshore Bay of Fundy)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 28 - SPA 3 (Inshore Bay of Fundy)	Survey - subunit	MAR	Yes	Yes
Sea Scallop -SFA 28 - SPA 4 + 5 (Inshore Bay of Fundy)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 28 - SPA 6 (Inshore Bay of Fundy)	Survey - subunit	MAR	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Sea Scallop - Inshore SFA 29W	Survey (broken out)	MAR	See subunits	-
Sea Scallop - SFA 29W - Subarea A (Inshore)	Survey - subunit	MAR	No	-
Sea Scallop - SFA 29W - Subarea B (Inshore)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 29W - Subarea C (Inshore)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 29W - Subarea D (Inshore)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 29W - Subarea E (Inshore)	Survey - subunit	MAR	No	-
Sea Scallop - Offshore SFA 26 German, Browns	Survey (broken out)	MAR	See subunits	-
Sea Scallop - SFA 26 (Browns South, Offshore)	Survey - subunit	MAR	No	-
Sea Scallop - SFA 26 (Browns North, Offshore)	Survey - subunit	MAR	Proposed	-
Sea Scallop - SFA 26 (German Bank, Offshore)	Survey - subunit	MAR	No	-
Sea Scallop - Offshore SFA 27, Georges	Survey (broken out)	MAR	See subunits	-
Sea Scallop - SFA 27, Georges 'a' (Offshore)	Survey - subunit	MAR	Yes	Yes
Sea Scallop - SFA 27, Georges 'b' (Offshore)	Survey - subunit	MAR	No	-
Shortraker Rockfish	Other Source	Pac	No	-
Shortspine Thornyhead	Other Source	Pac	Yes	Yes
Shrimp Trawl	Survey (complex)	Pac	Yes	Yes
Silver Hake - NAFO 4VWX	Survey	MAR	Yes	Yes
Silvergray Rockfish	Other Source	Pac	Yes	Yes
Smooth Skate - NAFO 2J3K (Northeastern Newfoundland and Labrador)	Other Source	NL	Yes	Yes
Smooth Skate - NAFO 4T (Southern Gulf of St. Lawrence)	Other Source	Gulf	No	-
Snow Crab - CFA 1-12	Survey (broken out)	NL	See subunits	-
Snow Crab - NAFO 2HJ	Survey - subunit	NL	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Snow Crab - NAFO 3K	Survey - subunit	NL	Yes	Yes
Snow Crab - NAFO 3L (Inshore)	Survey - subunit	NL	Yes	Yes
Snow Crab - NAFO 3LNO (Offshore)	Survey - subunit	NL	Yes	Yes
Snow Crab - NAFO 3Ps	Survey - subunit	NL	Yes	Yes
Snow Crab -NAFO 4R3Pn	Survey - subunit	NL	No	-
Snow Crab - 12A	Survey	QC	No	-
Snow Crab - 12B	Survey	QC	No	-
Snow Crab - 12C	Survey	QC	No	-
Snow Crab - 13	Survey	QC	No	-
Snow Crab - 14	Survey	QC	No	-
Snow Crab - 15	Survey	QC	No	-
Snow Crab - 16	Survey	QC	No	-
Snow Crab - 16A	Survey	QC	No	-
Snow Crab - 17	Survey	QC	No	-
Snow Crab - CFA 12 (12, 18, 25, 26), 12E, 12F, 19	Survey	Gulf	Yes	Yes
Snow Crab - NAFO 4X (Scotian Shelf)	Survey	MAR	Yes	Yes
Snow Crab - CFA 20-22 (Northeastern Nova Scotia)	Survey	MAR	Yes	Yes
Snow Crab - CFA 23-24 (Southeastern Nova Scotia)	Survey	MAR	Yes	Yes
Sockeye Salmon - Alsek	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Central Coast	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon – early Stuart - Fraser	Pac Sal SMU	Pac	NYA	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Sockeye Salmon – early summer - Fraser	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - ECVI/Mainland	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Haida Gwaii	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - late - Fraser	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Nass	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Okanagan	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Rivers/Smith	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Skeena	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Stikine	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - summer - Fraser	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - Taku	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - West Coast Vancouver Island (Barkley)	Pac Sal SMU	Pac	NYA	-
Sockeye Salmon - West Coast Vancouver Island (Other)	Pac Sal SMU	Pac	NYA	-
Softshell Clam (Common Clam)	Survey (complex)	QC	No	-
Spider Crab	Other Source	QC	No	-
Spiny Crab	Other Source	QC	No	-
Spiny Dogfish - NAFO 4VWNX + 5 (Atlantic)	Survey (trans)	MAR	Lost	(counted in past LRPs)
Spiny Dogfish - Inside	Survey	Pac	No	-
Spiny Dogfish - Outside	Survey	Pac	No	-
Spot Prawn	Survey (complex)	Pac	Yes	Yes
Striped Bass - Bay of Fundy	Survey	MAR	No	-

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Striped Bass - Gulf	Other Source	Gulf	Yes	Yes
Striped Shrimp – Eastern Assessment Zone	Survey	C&A	Yes	Yes
Striped Shrimp - SFA 4	Survey	NL	No	-
Striped Shrimp - Western Assessment Zone	Survey	C&A	Yes	Yes
Surf Clam - Iles de la Madeleine	Other Source	-	No	-
Swordfish - North Atlantic	Survey (ICCAT)	MAR	Proposed	-
Thorny Skate - NAFO 3LNOPs	Survey (NAFO)	NL	Yes	-
Thorny Skate - NAFO 4T (Southern Gulf of St. Lawrence)	Other Source	Gulf	No	-
Toad Crab	Other Source	NL	No	-
Walleye Pollock - PMFC 5CDE (BC North)	Other Source	Pac	Yes	Yes
Walleye Pollock - PMFC 3CD5AB (BC South)	Other Source	Pac	Yes	Yes
Walleye Pollock - Inside (Gulf)	Other Source	Pac	No	-
Waved Whelk - NAFO 2J3KL4R	Other Source	NL	No	-
Waved Whelk - NAFO 3Ps	Survey	NL	No	-
Waved Whelk - NAFO 4VxW	Other Source	MAR	No	-
Waved Whelk - Inshore Waters (Quebec)	Other Source	QC	No	-
White Hake - NAFO 3NOPs	Survey (NAFO)	NL	Proposed	-
White Hake - NAFO 4RST* (Northern Gulf)	Other Source	QC	Yes	Yes
White Hake - NAFO 4T (Southern Gulf)	Survey	Gulf	Yes	Yes
White Hake - NAFO 4VW (Eastern Scotian Shelf)	Other Source	MAR	Yes	Yes
White Hake - NAFO 4X5Zc (Western Scotian Shelf, Bay of Fundy and northern Georges Bank)	Other Source	MAR	Yes	Yes
Widow Rockfish	Other Source	Pac	Yes	Yes

Name	Source Category	Region (Science Advice)	Considered to have LRP?	Used in this Study?
Winter Flounder - NAFO 23KL	Other Source	NL	No	-
Winter Flounder - NAFO 4RST (Gulf of St. Lawrence)	Survey	Gulf	Yes	Yes
Winter Flounder - NAFO 4X	Other Source	MAR	No	-
Winter Skate - NAFO 3LNOP	Other Source	NL	No	-
Winter Skate - NAFO 4VW	Other Source	MAR	Yes	Yes
Winter Skate - NAFO 4T (Southern Gulf of St. Lawrence)	Other Source	Gulf	Yes	Yes
Witch Flounder - NAFO 23KL	Other Source	NL	Yes	Yes
Witch Flounder - NAFO 3NO	Survey (NAFO)	NL	Yes	-
Witch Flounder - NAFO 3Ps	Survey	NL	Yes	Yes
Witch Flounder - NAFO 4RST	Survey	Gulf	Yes	Yes
Yelloweye Rockfish - Inside	Survey	Pac	Yes	Yes
Yelloweye Rockfish - Outside	Survey	Pac	Yes	Yes
Yellowmouth Rockfish	Survey	Pac	Yes	Yes
Yellowtail Flounder - NAFO 3LNO	Survey (NAFO)	NL	Yes	-
Yellowtail Flounder - NAFO 4T	Other Source	Gulf	Yes	Yes
Yellowtail Flounder - NAFO 5Z	Survey (trans)	MAR	No	-
Yellowtail Rockfish	Other Source	Pac	Yes	Yes

Table A.3.3. Details of LRPs, indicators and stock status metrics for 153 assessment units used in this study. CPUE = catch per unit effort. MSE = management strategy evaluation (inclusive of closed-loop simulation). RD = Research Document, RPA = Recovery Potential Assessment, SAR = Science Advisory Report, SR = Science Response. SRR = stock recruitment relationship. SSB = spawning stock biomass.

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
American Lobster - LFA 19-21 (Gaspé)	40% of the average landings from 1985-2009, a proxy for $B_{MSY}$	$B_{MSY}$ - Empirical	Landings (biomass proxy)	Index	2019: SAR 2019/060
American Lobster - LFA 27 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/016)
American Lobster - LFA 28 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/017)
American Lobster - LFA 29 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/018)
American Lobster - LFA 30 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/019)
American Lobster - LFA 31A (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/020)
American Lobster - LFA 31B (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026 (2020: SR 2021/021)
American Lobster - LFA 32 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2020/026, - (2020: SR 2021/022)
American Lobster - LFA 33 (Inshore)	40% of the CPUE from 1990 to 2016 as a $B_{MSY}$ proxy, against which the 3-year running median is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2018: SAR 2020/022, - (2020: SR 2021/019)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
American Lobster - LFA 34 (Inshore)	Status is a composite metric from four survey indices; LRP is breached when 2 or more survey biomasses are below their respective LRIs and less than 2 survey biomasses are above their respective USIs. LRIs are the median of the 5 lowest biomasses from which the stock has been observed to rebuild (a $B_{recover}$ proxy)	$B_{rec}$ - Empirical	Composite index (biomass proxy)	Index	2019: SAR 2021/015 (2020: SR 2021/018)
American Lobster - LFA 35 (Inshore)	20% of the CPUE from 2011 to 2018 as a K proxy, against which a 3-year running median is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/020 (2021: SR 2022/005)
American Lobster - LFA 36 (Inshore)	20% of the CPUE from 2011 to 2018 as a K proxy, against which a 3-year running median is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/020 (2021: SR 2022/006)
American Lobster - LFA 38 (Inshore)	20% of the CPUE from 2011 to 2018 as a K proxy, against which a 3-year running median is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/020 (2021: SR 2022/006)
American Lobster - LFA 41 (Offshore)	Status is a composite metric; the LRP is composed of the medians of the five lowest nonzero biomasses in the time series (1970-present?) for four survey indicators of biomass. A breach of the LRP would occur with 3 of 4 survey indices being below their respective limits. A three-year running median is used.	$B_{rec}$ - Empirical	Composite index (biomass proxy)	Index	2017: SAR 2018/004, RD 2018/034 (2020: SR 2021/017)
American Lobster - LFA 23, 24, 25, 26A, 26B (Southern Gulf)	40% of median landings from 1974-2009, against which the most recent landings are compared	$B_{MSY}$ - Empirical	Landings (biomass proxy)	Index	2013: SAR 2013/029, Multiple: RD 2014/031 and RD 2014/036 (2018: SR 2019/008)
American Lobster - LFA 22 (Îles-de-la-Madeleine)	40% of mean landings from 1985-2009, against which the most recent landings are compared	$B_{MSY}$ - Empirical	Landings (biomass proxy)	Index	2019: SAR 2019/061

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
American Plaice - NAFO 2+3K	70,000 t of SSB index, a level associated with generally lower recruitment, to which the most recent SSB index is compared	SRR-Empirical	Survey index (biomass proxy)	Index	2014: SAR (RPA) 2011/030, RD 2011/047 (2020: SR 2021/043)
American Plaice - NAFO 3Ps	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2019: SAR 2020/017, RD 2020/019
American Plaice - NAFO 4VWX (Scotian Shelf)	0.4 female $SSB_{MSY}$ from a stage-based state-space model, against which the most recent estimate is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2002: SSR A3-34 (2002)
American Plaice - NAFO 4T (Southern Gulf of St. Lawrence)	SSB that produced 50% of maximum recruitment at age 4 years, from Beverton-Holt model, to which the most recent SSB is compared.	SRR-Theoretical	Biomass (SSB)	Model	2016: SAR 2016/031, RD 2016/057 (2021: SR 2021/011)
Arctic Char - Cambridge Bay	0.4 $B_{msp}$ , against which the most recent estimated commercial biomass is compared (model-averaging)	$B_{MSY}$ - Theoretical	Biomass	Multiple Models	2011: SAR 2014/051, RD 2014/096
Arctic Char - Ijaruvung Lake	0.4 $B_{MSY}$ , against which the most recent standing stock biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Other	2017: SAR 2018/021
Arctic Char - Iqalujjuaq Fiord	0.4 $B_{MSY}$ , against which the most recent standing stock biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Other	2017: SAR 2018/021
Arctic Char - Irvine Inlet	0.4 $B_{MSY}$ , against which the most recent standing stock biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Other	2017: SAR 2018/021
Arctic Surfclam - Banquereau	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2017: SAR 2017/047, RD 2018/063 (2020: SR 2020/057)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Arctic Surfclam - Grand Bank	0.4 of $B_{ref}$ , which is B at $F = 0.33M$ , consider a proxy for $B_{MSY}$ , estimated from biomass per recruit analysis, against which the most recent estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Index	2010: SAR 2010/063, RD 2011/052 (2020: SR 2020/057)
Arrowtooth Flounder	0.4 $B_{MSY}$ , against which the most recent spawning female biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2015: SAR 2015/055, RD 2017/025
Atlantic Cod - NAFO 2J3KL (Northern Cod)	Average SSB from 1983-1989, the last to produce medium levels of recruitment, to which the most recent estimated SSB is compared.	SRR- Historical	Biomass (SSB)	Model	2019: SAR 2019/050 (2020: SR 2021/004)
Atlantic Cod - NAFO 3Ps (St. Pierre Bank)	Fixed value, SSB from a breakpoint analysis in SRR data, 1959 to 2008 (SSB) or to 2010 (recruitment)), against which the most recent estimate is compared	SRR- Theoretical	Biomass (SSB)	Model	2020: SAR 2021/031
Atlantic Cod - NAFO 4RS3Pn (Northern Gulf)	Fixed value, average SSB of two Stock-Recruit methods; HS50 (hockey-stick) and NP50 (non-parametric), against which the most recent estimate is compared	SRR- Theoretical	Biomass (SSB)	Model	2019: SAR 2019/032, RD 2019/075 (2021: SR 2021/006)
Atlantic Cod - NAFO 4VsW (Eastern Scotian Shelf)	0.4 $B_{MSY}$ , estimated from a productive period (up to 1990), against which the most recent estimate is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2011: SAR (RPA) 2011/028, RD 2011/138
Atlantic Cod - NAFO 4X5Y (Scotian Shelf and Bay of Fundy)	SSB representing the intersection between the 50th percentile of the recruitment observations and the replacement line for which 10% of the Stock-Recruit points are above the line (the sb50/90 method), against which the most recent SSB estimate is compared. It represents the point below which the population is unlikely to produce average recruitment under good ELS survival conditions.	SRR- Theoretical	Biomass (SSB)	Model	2018: SAR 2019/015, none (2020: SR 2021/023)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Atlantic Cod - NAFO 4TVn (Southern Gulf)	$B_{\text{recover}}$ , against which the most recent estimate is compared	$B_{\text{rec}}$ -Historical	Biomass (SSB)	Model	2019: SAR 2019/021, RD 2019/038 (2020: SR 2021/011)
Atlantic Halibut - NAFO 3NOPs4VWX+5	Minimum SSB from 1982-2013 that produced 50% of maximum recruitment, against which the most recent SSB is compared. Only one operating model is used.	SRR-Historical	Biomass (SSB)	MSE	2014: SAR 2015/012, RD 2015/042, RD 2015/051, RD 2016/001 (2019: SR 2020/017)
Atlantic Herring - NAFO 4T (Fall Spawner)	$B_{\text{recover}}$ , average SSB from 1980-1983 (two model scenarios). Single status is from a consensus between models.	$B_{\text{rec}}$ -Historical	Biomass (SSB)	Multiple Models	2020: SAR 2020/029, RD 2021/030 (and 029)
Atlantic Herring - NAFO 4T (Spring Spawner)	$B_{\text{recover}}$ , average SSB from 1980-1983	$B_{\text{rec}}$ - Historical	Biomass (SSB)	Model	2020: SAR 2020/029, RD 2021/030 (and 029)
Atlantic Herring - NAFO 4VWX (Southwest Nova Scotia/Bay of Fundy)	Average acoustic survey biomass index from 2005-2010, against which a 3-year running median is compared	Other-Empirical	Survey index (biomass proxy)	Index	2018: SAR 2018/052, RD 2020/062 (2021: SR 2021/040)
Atlantic Mackerel - NAFO 3+4	40% of SSB at F40%, a proxy for $B_{\text{MSY}}$ , against which the most recent SSB is compared	Other/ $B_{\text{MSY}}$ -Theoretical	Biomass (SSB)	Model	2021: SAR 2021/029
Atlantic Salmon - Gulf	Spawners corresponding to an egg deposition density in fluvial habitat with a < 25% probability that recruitment will be < 50% its maximum (Beverton-Holt model) and taking into account the proportion of eggs from large salmon. Values are extrapolated from a subset of rivers and applied to a large number of rivers.	SRR-Empirical	Returns or Spawners	Other	2014: SAR 2014/057, Multiple: RD 2015/019, RD 2015/043, RD 2015/049 (2020: SR 2020/028 (and SR 2020/010))

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Atlantic Salmon - Maritimes	A pre-existing conservation limit was adopted as the LRP, spawning escapements corresponding to egg deposition densities in fluvial habitat. Values are extrapolated from a subset of rivers and applied to a large number of rivers.	SRR-Empirical	Returns or Spawners	Other	2020: SR 2020/031 (2021: SR 2021/032)
Atlantic Salmon - NL	A pre-existing conservation limit was adopted as the LRP, spawning escapements corresponding to egg deposition densities in fluvial and lake habitat. Values are extrapolated from a subset of rivers and applied to a large number of rivers.	SRR-Empirical	Returns or Spawners	Index	2019: SAR 2020/038, RD 2020/029 (2020: SR 2020/045)
Bocaccio Rockfish	0.4 $B_{MSY}$ (median estimate, composite base case), to which the most recent estimated SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	MSE	2019: SAR 2020/025 (2021: SR 2022/001)
Canary Rockfish	0.4 $B_{MSY}$ (median estimate, model run 11-u), against which the most recent estimate is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2009: SAR (RPA) 2009/041, RD 2009/013 (2009: <a href="http://www.dfo-mpo.gc.ca/csas-sccs/publications/sr-rs/2009/2009_019-eng.htm">http://www.dfo-mpo.gc.ca/csas-sccs/publications/sr-rs/2009/2009_019-eng.htm</a> )
Cusk - NAFO 4VWX5Z	0.4 of the mean CPUE from the halibut survey during a period of higher catch rates (1986-1992), against which a three-year running average is compared	$B_{MSY}$ -Empirical	CPUE (biomass proxy)	Index	2014: SAR (RPA) 2014/048, RD 2018/002 (2020: SR 2021/027)
Gaspereau - Maritimes - alewife	10% of unfished biomass (SSB per square kilometer) based on a meta-analysis	$B_0$ - Theoretical	Biomass (density)	unknown	2007: SAR 2007/030, RD 2007/032

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Geoduck	Two LRP versions; 40% estimated original (estimated unfished) exploitable biomass ( $B'$ ) for each sub-bed; a value is also provided for the overall stock irrespective of the number of beds, from which the whole stock status is derived.	$B_0$ - Empirical	Survey index (biomass proxy)	Index	2017: unclear, RD 2011/121 (2021: SR 2021/035)
Giant Red Sea Cucumber	50% of the biomass on first survey following phase 1 closure for each sub-area (a proxy for $B_0$ )	$B_0$ - Empirical	Survey index (biomass proxy)	Index	2010: SAR 2010/080, RD 2010/105
Goose Barnacle - Clayoquot Sound	0.2 of potential habitat (bed areas) estimated from a 2001 study, a habitat proxy for 0.2 $B_0$ , against which the most recent estimated total potential habitat (closed to commercial fishing) is compared	$B_0$ - Empirical	Estimated total potential habitat	Index	2016: SAR 2016/048, RD 2016/096
Green Sea Urchin - PMA 12 (Northeast Vancouver Island)	Density of legalsize urchins (test diameter $\geq 55$ mm) per square meter that is half the density associated with ability for stock to increase without management intervention (1997 index)	Other-Empirical	Index density (abundance proxy)	Model	2009: SAR 2009/080, RD 2010/027 (2021: SR 2021/036)
Green Sea Urchin - PMA 19 (Southeast Vancouver Island)	Density of legal-size urchins (test diameter $\geq 55$ mm) per square meter that is half the density associated with ability for stock to increase without management intervention (1997 index)	Other-Empirical	Index density (abundance proxy)	Model	2009: SAR 2009/080, RD 2010/027 (2021: SR 2021/036)
Greenland Halibut - NAFO 4RST	A $B_{recover}$ proxy, the geometric mean of survey biomass index ( $>40$ cm) from 1990-1994 (stock at lowest level and from which a recovery was observed) against which the most recent index is compared.	$B_{rec}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/017, RD 2021/059 (2021: SR 2022/002)
Grey Seal - Gulf of St. Lawrence	$N_{30}$ (30% of maximum estimated or inferred population size, $N_{max}$ )	$B_0$ - Historical	Abundance	Model	2016: SAR 2017/045, RD 2017/052

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Grey Seal - Sable Island and Southwest Nova Scotia	$N_{30}$ (30% of maximum estimated or inferred population size, $N_{max}$ )	$B_0$ - Historical	Abundance	Model	2016: SAR 2017/045, RD 2017/052
Grey Seal - Scotian Shelf	$N_{30}$ (30% of maximum estimated or inferred population size, $N_{max}$ )	$B_0$ - Historical	Abundance	Model	2016: SAR 2017/045, RD 2017/052
Haddock - NAFO 3Ps	$B_{rec}$ (lowest SSB in the Campelen survey index where a large, 90th percentile recruitment event was observed; 1998), against which the most recent index is observed	$B_{rec}$ - Empirical	Biomass (SSB)	Index	2018: SAR 2019/007, RD 2020/024
Harp Seal - Northwest Atlantic Ocean	$N_{30}$ (30% of maximum estimated or inferred population size, $N_{max}$ )	$B_0$ - Historical	Abundance	Model	2019: SAR 2020/020, RD 2021/006
Intertidal Clams - Depuration	Clam density below which production of legal-size clams is at risk of impairment (economic collapse)	Other-Empirical	Index density (abundance proxy)	Index	2005: RD 2005/052
Longhorn Sculpin - St. Mary's Bay	0.4 of the CPUE time series median (1999-2019), a proxy for $B_{MSY}$ , against which a 3-year moving median CPUE is compared	$B_{MSY}$ - Empirical	CPUE (biomass proxy)	Index	2020: SAR 2020/041
Lumpfish - NAFO 3KLPs	0.4 of survey index biomass during a productive period (1996-2006), a proxy for $B_{MSY}$ . This may be a composite of two indices, one for 3KP and one for 3Ps, to which the most recent survey biomass index is compared	$B_{MSY}$ - Empirical	Composite index (biomass proxy)	Index	2019: SAR (RPA) 2021/019
Monkfish - NAFO 3LNOPs	0.4 of the geometric mean of survey index from 2007-2013, a proxy for $B_{MSY}$	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2017: SAR 2018/010, RD 2018/061

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Northern Shrimp - Eastern Assessment Zone	40% of the geometric mean of the female spawning stock biomass indices from the 2009–2019 surveys	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/014 (2020: SR 2020/014)
Northern Shrimp - SFA 4	30% of geometric mean female SSB index, 2005-2009	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/049 (2016: SR 2016/013)
Northern Shrimp - SFA 5	30% of geometric mean female SSB index, 1996-2001, against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/049 (2016: SR 2016/013)
Northern Shrimp - SFA 6	30% of geometric mean female SSB index, 1996-2003, against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/049 (2016: SR 2016/013)
Northern Shrimp - SFA 8 (Gulf, Esquiman)	Average survey composite index (four indices) between two lowest years 1980s-1990s (a $B_{recover}$ proxy), against which the most recent composite index is compared	$B_{rec}$ - Empirical	Composite index (abundance proxy)	Index	2020: SAR 2020/010, RD 2020/012 (2021: SR 2021/015)
Northern Shrimp - SFA 9 (Gulf, Anticosti)	Average survey composite index (four indices) between two lowest years 1980s-1990s (a $B_{recover}$ proxy), against which the most recent composite index is compared	$B_{rec}$ - Empirical	Composite index (abundance proxy)	Index	2020: SAR 2020/010, RD 2020/012 (2021: SR 2021/015)
Northern Shrimp - SFA 10 (Gulf, Sept-Îles)	Average survey composite index (four indices) between two lowest years 1980s-1990s (a $B_{recover}$ proxy), against which the most recent composite index is compared	$B_{rec}$ - Empirical	Composite index (abundance proxy)	Index	2020: SAR 2020/010, RD 2020/012 (2021: SR 2021/015)
Northern Shrimp - SFA 12 (Gulf, Estuary)	Average survey composite index (four indices) between two lowest years 1980s-1990s (a $B_{recover}$ proxy), against which the most recent composite index is compared	$B_{rec}$ - Empirical	Composite index (abundance proxy)	Index	2020: SAR 2020/010, RD 2020/012 (2021: SR 2021/015)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Northern Shrimp - SFA 13-15 (Scotian Shelf)	30% of average SSB index between 2000-2010, a high productivity period, and similar to a proxy for $B_{\text{recover}}$ from the low-productivity pre-1990 period and representative of biomasses able to fulfill ecosystem functions, against which the most recent index is compared	$B_{\text{MSY}}$ - Empirical	Survey index (biomass proxy)	Index	2018: SAR 2019/013, RD 2020/045 (2020: SR 2021/014)
Northern Shrimp - Western Assessment Zone	40% of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys, against which the most recent index is compared	$B_{\text{MSY}}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/014 (2020: SR 2020/014)
Orange-Footed Sea Cucumber - NAFO 4W Midshore Zone F	0.2 of an empirical proxy for $B_0$ , the highest CPUE of the time series, against which the most recent CPUE is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/007
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zone 1	0.2 of an empirical proxy for $B_0$ , the highest CPUE of the time series, against which the most recent CPUE is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/007
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zones 2	0.2 of an empirical proxy for $B_0$ , the highest CPUE of the time series, against which the most recent CPUE is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/007
Orange-Footed Sea Cucumber - NAFO 4Vs Area of Access 2	0.2 of an empirical proxy for $B_0$ , the highest CPUE of the time series, against which the most recent CPUE is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/007
Orange-Footed Sea Cucumber - Southwest New Brunswick Zone 1	0.3 of an empirical proxy for $B_0$ , the highest CPUE of the time series, against which the most recent CPUE is compared	$B_0$ - Empirical	CPUE (biomass proxy)	Index	2019: SAR 2021/007

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Pacific Cod - 3CD (West Coast Vancouver Island)	Biomass estimate from 1986, agreed to be a low level state to avoid ( $B_{min}$ ; historically low state from which stock recovered to above average, here considered similarly to $B_{rec}$ ), against which the most recent estimate (model-averaged over a reference case and six sensitivity cases) is compared	$B_{rec}$ - Historical	Biomass	Multiple Models	2018: SAR 2019/008, RD 2020/070 (2020: SR 2021/002)
Pacific Cod - PMFC 5ABCD (Queen Charlotte Sound and Hecate Strait)	Biomass estimate from 2000, agreed to be a low level state to avoid, against which the most recent estimate (model-averaged over a reference case and six sensitivity cases) is compared	Other-Historical	Biomass	Multiple Models	2018: SAR 2019/008, RD 2020/070 (2020: SR 2021/002)
Pacific Herring - Central Coast	0.3 $B_0$ (AM1 and AM2 model runs), against which the most recent estimates are compared. Status update used one model.	$B_0$ - Theoretical	Biomass (SSB)	MSE	2017: SAR 2018/002, RD 2018/028 (2021: SR 2021/039)
Pacific Herring - Haida Gwaii	0.3 $B_0$ (AM1 and AM2 model runs), against which the most recent estimates are compared. Status update used one model.	$B_0$ - Theoretical	Biomass (SSB)	MSE	2017: SAR 2018/002, RD 2018/028 (2021: SR 2021/039)
Pacific Herring - Prince Rupert District	0.3 $B_0$ (AM1 and AM2 model runs), against which the most recent estimates are compared. Status update used one model.	$B_0$ - Theoretical	Biomass (SSB)	MSE	2017: SAR 2018/002, RD 2018/028 (2021: SR 2021/039)
Pacific Herring - Strait of Georgia	0.3 $B_0$ (AM1 and AM2 model runs), against which the most recent estimates are compared. Status update used one model.	$B_0$ - Theoretical	Biomass (SSB)	MSE	2018: SAR 2019/001, - (2021: SR 2021/039)
Pacific Herring - West Coast Vancouver Island	0.3 $B_0$ (AM1 and AM2 model runs), against which the most recent estimates are compared. Status update used one model.	$B_0$ - Theoretical	Biomass (SSB)	MSE	2018: SAR 2019/001, - (2021: SR 2021/039)
Pacific Lingcod - PMFC 4B (Inside, Strait of Georgia)	0.4 $B_{MSY}$ (a single estimate and single status relative to the most recent SSB is derived by using model averaging across 9 scenarios)	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2014: SAR 2015/014, RD 2016/013

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Pacific Lingcod - PMFC 5CDE (Outside, Hecate Strait and west coast Haida Gwaii)	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/051, RD 2011/124
Pacific Lingcod - PMFC 3D (Outside Northwest Vancouver Island)	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/051, RD 2011/124
Pacific Lingcod - PMFC 5AB (Outside Queen Charlotte Sound)	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/051, RD 2011/124
Pacific Lingcod - PMFC 3C (Outside Southwest Vancouver Island)	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/051, RD 2011/124
Pacific Ocean Perch - PMFC 3CD (West Coast Vancouver Island)	0.4 $B_{MSY}$ , against which the most recent estimated SSB (mature females) is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2012: SAR 2013/038, RD 2013/093
Pacific Ocean Perch - PMFC 5ABC (Queen Charlotte Sound)	0.4 $B_{MSY}$ , against which the most recent estimated SSB (mature females) is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2017: SAR 2017/043, RD 2018/038
Pacific Ocean Perch - PMFC 5DE-HS/DE/WHG	0.4 $B_{MSY}$ , against which the most recent estimated SSB (mature females) is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2012: SAR 2013/038, RD 2013/092
Pollock - NAFO 4VWXmn (Eastern Component)	0.4 of geometric mean survey index from 1984-1993, a proxy for $B_{MSY}$ , against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2009: SAR 2009/025, RD 2009/001

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Pollock - NAFO 4X5 (Western Component)	Survey index ratio (Jy) of the three-year running geometric mean survey index relative to productive reference period (1984-1994), against which the most recent index ratio is compared	Other-Empirical	Survey index (biomass proxy)	MSE	2011: SAR 2011/054, RD 2011/090 (2020: SR 2021/025)
Quillback Rockfish - Inside	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/072, RD 2011/035
Quillback Rockfish - Outside	0.4 $B_{MSY}$ , against which the most recent biomass estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2011: SAR 2011/072, RD 2011/035
Red Sea Urchin	Density of mature urchins ( $\geq 50$ mm) suggesting persistence under high levels of sea otter predation, derived from another analysis, against which the most recent density is compared. Status is estimated for each of three sub-areas combined and individually.	Other-Empirical	Index density (abundance proxy)	Model	2019: SAR 2019/036, RD 2019/061
Redfish - Unit 1+2 (S. <i>fasciatus</i> )	A $B_{recover}$ proxy, the geometric mean of 2010-2012 SSB in the Unit 1 survey, against which the most recent SSB index is compared	$B_{rec}$ - Empirical	Survey index (biomass proxy)	Index	2020: SAR 2020/019, RD 2021/015 (2017: SR 2017/023)
Redfish - Unit 1+2 (S. <i>mentella</i> )	A $B_{recover}$ proxy, the geometric mean of 2010-2012 SSB in the Unit 1 survey, against which the most recent SSB index is compared	$B_{rec}$ - Empirical	Survey index (biomass proxy)	Index	2020: SAR 2020/019, RD 2021/015 (2017: SR 2017/023)
Redfish - Unit 3	40% of mean smoothed survey mature biomass index over 1970-2010, a $B_{MSY}$ proxy, against which a 5-year smoothed moving average is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2020: SR 2021/026
Redstripe Rockfish - PMFC 3CD5ABC (BC South)	0.4 $B_{MSY}$ , against which the most recent spawning biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2018: SAR 2018/049, RD 2021/014

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Redstripe Rockfish - PMFC 5DE (BC North)	0.4 $B_{MSY}$ , against which the most recent spawning biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2018: SAR 2018/049, RD 2021/014
Rock Sole - PMFC 5AB (Queen Charlotte Sound)	0.4 $B_{MSY}$ , against which the most recent female spawning biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2013: SAR 2014/039, RD 2016/009
Rock Sole - PMFC 5CD (Hecate Strait)	0.4 $B_{MSY}$ , against which the most recent female spawning biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2013: SAR 2014/039, RD 2016/009
Rougheye Rockfish - PMFC 3CD5AB (REBS south)	0.4 $B_{MSY}$ (composite base case from 6 models), against which the most recent estimated female SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2020: SAR 2020/047
Rougheye Rockfish - PMFC 5DE (REBS north)	0.4 $B_{MSY}$ (composite base case from 9 models), against which the most recent estimated female SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2020: SAR 2020/047
Sablefish	0.4 $B_{MSY}$ (from operating model), against which the most recent female SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	MSE	2017: SAR 2017/017, RD 2019/032 (2019: SR 2020/025)
Sea Scallop - SFA 20	CPUE that is one half SD below the 1992-2006 mean, against which either the last or the average of the last two CPUE values are compared	Other-Empirical	CPUE (biomass proxy)	Index	2020: SAR 2020/054 (2021: SR 2021/010)
Sea Scallop - SFA 28 - SPA 1a (Inshore Bay of Fundy)	Analog to $B_{recover}$ , lowest biomass from which a sustained recovery occurred (commercial biomass in meats), against which the most recent commercial biomass is compared	$B_{rec}$ - Historical	Biomass (commercial)	Model	2015: SAR 2016/004, RD 2016/021 (2020: SR 2021/005)
Sea Scallop - SFA 28 - SPA 1b (Inshore Bay of Fundy)	Analog to $B_{recover}$ , lowest biomass from which a sustained recovery occurred (commercial biomass in meats), against which the most recent commercial biomass is compared	$B_{rec}$ - Historical	Biomass (commercial)	Model	2015: SAR 2016/004, RD 2016/021 (2020: SR 2021/005)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Sea Scallop - SFA 28 - SPA 3 (Inshore Bay of Fundy)	Analog to $B_{\text{recover}}$ , lowest biomass from which a sustained recovery occurred (commercial biomass in meats), against which the most recent commercial biomass is compared	$B_{\text{rec}}$ - Historical	Biomass (commercial)	Model	2015: SAR 2016/004, RD 2016/021 (2020: SR 2021/005)
Sea Scallop -SFA 28 - SPA 4 + 5 (Inshore Bay of Fundy)	Analog to $B_{\text{recover}}$ , lowest biomass from which a sustained recovery occurred (commercial biomass in meats), against which the most recent commercial biomass is compared	$B_{\text{rec}}$ - Historical	Biomass (commercial)	Model	2015: SAR 2016/004, RD 2016/021 (2020: SR 2021/005)
Sea Scallop - SFA 28 - SPA 6 (Inshore Bay of Fundy)	CPUE, lowest observed since 1997, against which the most recent CPUE is compared	$B_{\text{rec}}$ - Empirical	CPUE (biomass proxy)	Model	2015: SAR 2016/004, RD 2016/021 (2020: SR 2021/005)
Sea Scallop - SFA 29W - Subarea B (Inshore)	30% of biomass density at MSY in high suitability areas, against which the most recent estimated density is compared	$B_{\text{MSY}}$ - Theoretical	Biomass (commercial)	Model	2015: SAR 2015/035, RD 2015/067 (2020: SR 2020/046)
Sea Scallop - SFA 29W - Subarea C (Inshore)	30% of biomass density at MSY in high suitability areas, against which the most recent estimated density is compared	$B_{\text{MSY}}$ - Theoretical	Biomass (commercial)	Model	2015: SAR 2015/035, RD 2015/067 (2020: SR 2020/046)
Sea Scallop - SFA 29W - Subarea D (Inshore)	30% of biomass density at MSY in high suitability areas, against which the most recent estimated density is compared	$B_{\text{MSY}}$ - Theoretical	Biomass (commercial)	Model	2015: SAR 2015/035, RD 2015/067 (2020: SR 2020/046)
Sea Scallop - SFA 27, Georges 'a' (Offshore)	30% of mean estimated commercial biomass (1986-2009), against which the most recent estimate is compared	$B_{\text{MSY}}$ - Historical	Biomass (commercial)	Model	2013: SAR 2013/058, RD 2013/079 (2020: SR 2020/043)
Shortspine Thornyhead	0.4 $B_{\text{MSY}}$ , against which the most recent model-averaged biomass is compared	$B_{\text{MSY}}$ - Theoretical	Biomass	Multiple Models	2015: SAR 2016/016, RD 2017/015
Shrimp Trawl	0.4 of the ln average biomass index over 1997 to 2007, a $B_{\text{MSY}}$ proxy, against which the most recent index is compared	$B_{\text{MSY}}$ - Empirical	Survey index (biomass proxy)	Index	2011: SAR 2011/085

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Silver Hake - NAFO 4VWX	0.4 $B_{MSY}$ , against which the most recent estimate is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2012: SAR 2013/018, RD 2013/009 (2019: SR 2020/023)
Silvergray Rockfish	0.4 $B_{MSY}$ , against which the most recent female spawning biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2013: SAR 2014/028, RD 2016/042
Smooth Skate - NAFO 2J3K (Northeastern Newfoundland and Labrador)	0.4 of the geometric mean of survey index from 1981-1988, a proxy for $B_{MSY}$ , against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2013: SAR (RPA) 2013/035, RD 2013/098 (2016: SR 2017/011)
Snow Crab - NAFO 2HJ	LRP is a composite of three thresholds of indices with multiple rationales supporting their choice (egg clutches, Fishery CPUE, Fishery Discards), any breach of one constitutes a breach of the LRP	Other-Empirical	Multiple	Index	2020: SAR 2021/009
Snow Crab - NAFO 3K	LRP is a composite of three thresholds of indices with multiple rationales supporting their choice (egg clutches, Fishery CPUE, Fishery Discards), any breach of one constitutes a breach of the LRP	Other-Empirical	Multiple	Index	2020: SAR 2021/009
Snow Crab - NAFO 3L (Inshore)	LRP is a composite of three thresholds of indices with multiple rationales supporting their choice (egg clutches, Fishery CPUE, Fishery Discards), any breach of one constitutes a breach of the LRP	Other-Empirical	Multiple	Index	2020: SAR 2021/009
Snow Crab - NAFO 3LNO (Offshore)	LRP is a composite of three thresholds of indices with multiple rationales supporting their choice (egg clutches, Fishery CPUE, Fishery Discards), any breach of one constitutes a breach of the LRP	Other-Empirical	Multiple	Index	2020: SAR 2021/009

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Snow Crab - NAFO 3Ps	LRP is a composite of three thresholds of indices with multiple rationales supporting their choice (egg clutches, Fishery CPUE, Fishery Discards), any breach of one constitutes a breach of the LRP	Other-Empirical	Multiple	Index	2020: SAR 2021/009
Snow Crab - CFA 12 (12, 18, 25, 26), 12E, 12F, 19	Lowest trawl survey biomass of hard-shelled commercial-sized males that produced good recruitment at Instar VIII (2000), against which the most recent index is compared	$B_{rec}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/021
Snow Crab - NAFO 4X (Scotian Shelf)	25% of estimated K (carrying capacity) in fishable biomass (mature male crab > 95 mm CW), against which the most recent estimate is compared	$B_0$ - Theoretical	Biomass	Model	2020: SAR 2020/042 (2021: SR 2021/033)
Snow Crab - CFA 20-22 (Northeastern Nova Scotia)	25% of estimated K (carrying capacity) in fishable biomass (mature male crab > 95 mm CW), against which the most recent estimate is compared	$B_0$ - Theoretical	Biomass	Model	2020: SAR 2020/042 (2021: SR 2021/033)
Snow Crab - CFA 23-24 (Southeastern Nova Scotia)	25% of estimated K (carrying capacity) in fishable biomass (mature male crab > 95 mm CW), against which the most recent estimate is compared	$B_0$ - Theoretical	Biomass	Model	2020: SAR 2020/042 (2021: SR 2021/033)
Spot Prawn	At the management unit level, 0.4 of a survey index proxy for $B_{MSY}$ (females per trap in March) derived from a Ricker SRR. Status for the entire stock is derived from the number of subunits closed (1 closed = Cautious; 20% closed = Critical).	$B_{MSY}$ /SRR- Empirical	Survey index (abundance proxy)	Index	2012: SR 2012/041
Striped Bass - Gulf	0.5 of eggs in spawners associated with maximum recruitment (Beverton-Holt), to which the most recent estimate is compared; status varies with model.	SRR- Theoretical	Estimated eggs in spawners	Multiple Models	2020: SAR 2021/018 (2020: SR 2020/009)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Striped Shrimp – Eastern Assessment Zone	40% of the geometric mean of the female spawning stock biomass indices from the 2009–2019 surveys, against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/014 (2020: SR 2020/014)
Striped Shrimp - Western Assessment Zone	40% of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys, against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2021: SAR 2021/014 (2020: SR 2020/014)
Walleye Pollock - PMFC 5CDE (BC North)	$B_{min}$ , analogous to $B_{rec}$ , lowest spawning biomass from which the stock subsequently recovered to $B_{avg}$ (average spawning biomass from 1967-2016), a proxy for $B_{MSY}$ , against which the most recent model-averaged biomass is compared	$B_{rec}$ - Historical	Biomass (SSB)	Multiple Models	2017: SAR 2018/020, RD 2021/004
Walleye Pollock - PMFC 3CD5AB (BC South)	$B_{min}$ , analogous to $B_{rec}$ , lowest spawning biomass from which the stock subsequently recovered to $B_{avg}$ (average spawning biomass from 1967-2016), a proxy for $B_{MSY}$ , against which the most recent model-averaged biomass is compared	$B_{rec}$ - Historical	Biomass (SSB)	Multiple Models	2017: SAR 2018/020, RD 2021/004
White Hake - NAFO 4RST* (Northern Gulf)	0.4 of survey index adult (> 45 cm) biomass from 1987-1990, before a large decline, a proxy for $B_{MSY}$ , against which the most recent survey index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2015: SAR (RPA) 2016/035, RD 2015/076
White Hake - NAFO 4T (Southern Gulf)	40% of SSB producing maximum surplus production as determined from Ricker curve fit to 1978-1994 time series, to which the most recent SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2021: SAR 2021/033, RD 2022/005 (2019: SR 2020/008)
White Hake - NAFO 4VW (Eastern Scotian Shelf)	0.4 of survey index adult (> 42 cm) biomass from 1970-1992, a productive period, a proxy for $B_{MSY}$ , against which the running three year geometric mean survey index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Other	2015: SAR (RPA) 2016/035, RD 2016/100

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
White Hake - NAFO 4X5Zc (Western Scotian Shelf, Bay of Fundy and northern Georges Bank)	0.4 of survey index adult (> 42 cm) biomass from 1970-1998, a productive period after which stock levels declined, a proxy for $B_{MSY}$ , against which the running three year geometric mean survey index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Other	2015: SAR (RPA) 2016/035, RD 2016/100
Widow Rockfish	0.4 $B_{MSY}$ , against which the most recent female spawning biomass is compared (composite base case)	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2019: SAR 2019/044, RD 2021/039
Winter Flounder - NAFO 4RST (Gulf of St. Lawrence)	40% of estimated SSB during a productive reference period of 1973-1994, considered a $B_{MSY}$ proxy, to which the most recent SSB is compared	$B_{MSY}$ - Historical	Biomass (SSB)	Model	2017: SAR 2017/022, RD 2019/026 (2019: SR 2020/008)
Winter Skate - NAFO 4VW	0.4 $B_{MSY}$ , against the most recent total biomass (>36 cm) is compared	$B_{MSY}$ - Theoretical	Biomass	Model	2016: SAR (RPA) 2017/014
Winter Skate - NAFO 4T (Southern Gulf of St. Lawrence)	0.4 of $B_{MSY}$ proxy (where estimates from a surplus production model are scaled against biomass in a reference year of 1971 and applied to an age structured model) against which the most recent biomass estimate is compared	$B_{MSY}$ - Historical	Biomass	Multiple Models	2016: SAR (RPA) 2016/059, RD 2016/119
Witch Flounder - NAFO 23KL	0.4 of mean survey biomass from 1983-1984, a proxy for $B_{MSY}$	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2018: SAR 2018/053, RD 2019/066
Witch Flounder - NAFO 3Ps	"Interim LRP" based on 40% of the geometric mean survey index from 1983-1993, considered a $B_{MSY}$ proxy, against which the most recent index is compared	$B_{MSY}$ - Empirical	Survey index (biomass proxy)	Index	2017: SAR 2018/011, RD 2018/064
Witch Flounder - NAFO 4RST	0.4 $B_{MSY}$ , against which the most recent estimated SSB is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2017: SAR 2017/036, RD 2018/023 (2019: SR 2020/008)

Assessment Unit	Description of LRP and Stock Status Metric	LRP Category	Indicator	Advice Framework	Last Assessment, Evaluation or RPA (Update), with Year
Yelloweye Rockfish - Inside	0.4 $B_{MSY}$ (six model scenarios), against which the most recent estimated SSB is compared. Single status is from a consensus between models.	$B_{MSY}$ - Theoretical	Biomass (SSB)	MSE	2020: SAR 2020/056
Yelloweye Rockfish - Outside	0.4 $B_{MSY}$ (five model scenarios), against which the most recent estimated SSB is compared. Single status is from a consensus between models.	$B_{MSY}$ - Theoretical	Biomass (SSB)	MSE	2019: SAR 2020/024, RD 2020/069
Yellowmouth Rockfish	0.4 $B_{MSY}$ (two model scenarios), against which the most recent estimated SSB is compared. Single status is from a consensus between models.	$B_{MSY}$ - Theoretical	Biomass (SSB)	Multiple Models	2021: SAR 2022/001
Yellowtail Flounder - NAFO 4T	0.4 of historical proxy for $B_{MSY}$ (average >25 cm biomass 1977-1997), against which the most recent estimated biomass is compared	$B_{MSY}$ - Historical	Biomass	Model	2021: SAR 2021/022 (2019: SR 2019/006)
Yellowtail Rockfish	0.4 $B_{MSY}$ , against which the most recent spawning female biomass is compared	$B_{MSY}$ - Theoretical	Biomass (SSB)	Model	2014: SAR 2015/010

Table A.3.4. Other details of LRPs, indicators and stock status metrics for 153 assessment units used in this study. CPUE = catch per unit effort. MSE = management strategy evaluation (inclusive of closed-loop simulation). RD = Research Document, RPA = Recovery Potential Assessment, SAR = Science Advisory Report, SR = Science Response. SRR = stock recruitment relationship. SSB = spawning stock biomass.

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
American Lobster - LFA 19-21 (Gaspé)	Lobster	SR 2013/027 (2013)	No/ unknown	No/ unknown	25: Productive period during which two generations of lobsters produced in large numbers	--	--
American Lobster - LFA 27 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 28 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 29 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 30 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
American Lobster - LFA 31A (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 31B (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 32 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 33 (Inshore)	Lobster	RD 2020/017 (2018)	No/ unknown	No/ unknown	25: Approximately two generations, covered both high and low productivity periods	2012	Framework changes
American Lobster - LFA 34 (Inshore)	Lobster	SAR 2021/015 (2019)	<10	No/ unknown	5: Lowest non-zero biomasses from which the stock has rebuilt	--	Framework changes
American Lobster - LFA 35 (Inshore)	Lobster	SAR 2021/020 (2019)	No/ unknown	No/ unknown	8: High productivity period	2012	Framework changes
American Lobster - LFA 36 (Inshore)	Lobster	SAR 2021/020 (2019)	No/ unknown	No/ unknown	8: High productivity period	2012	Framework changes
American Lobster - LFA 38 (Inshore)	Lobster	SAR 2021/020 (2019)	No/ unknown	No/ unknown	8: High productivity period	2012	Framework changes

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
American Lobster - LFA 41 (Offshore)	Lobster	RD 2017/065 (2016)	<10	Yes	5: Lowest non-zero biomasses	2012 ,2014	Framework changes
American Lobster - LFA 23, 24, 25, 26A, 26B (Southern Gulf)	Lobster	SR 2014/027 (2013)	<10	No/ unknown	36: Used a "reasonable timeframe" of 1.5 to 2 generations for landings-based indicators, based on Gendron and Savard 2012 and Tremblay et al. 2012	--	--
American Lobster - LFA 22 (Îles-de-la-Madeleine)	Lobster	SAR 2012/012, RD 2012/010 (2012)	<10	No/ unknown	25: Productive period during which two generations of lobsters produced in large numbers	--	--
American Plaice - NAFO 2+3K	Flatfish	SAR 2012/025, RD 2012/152 (2012)	>=10	Yes	--	--	--
American Plaice - NAFO 3Ps	Flatfish	SAR 2012/025, RD 2012/152 (2012)	>=10	No/ unknown	--	--	--
American Plaice - NAFO 4VWX (Scotian Shelf)	Flatfish	SAR 2012/035, RD 2012/030 (2012)	No/ unknown	No/ unknown	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
American Plaice - NAFO 4T (Southern Gulf of St. Lawrence)	Flatfish	SAR 2012/018, RD 2012/108 (2016)	>=10	Yes	--	2012	Model updates, new data
Arctic Char - Cambridge Bay	Salmon	SAR 2014/051, RD 2014/096 (2014)	No/ unknown	No/ unknown	--	--	--
Arctic Char - Ijaruvung Lake	Salmon	SAR 2018/021 (2017)	No/ unknown	No/ unknown	--	--	--
Arctic Char - Iqalujuaq Fiord	Salmon	SAR 2018/021 (2017)	No/ unknown	No/ unknown	--	--	--
Arctic Char - Irvine Inlet	Salmon	SAR 2018/021 (2017)	No/ unknown	No/ unknown	--	--	--
Arctic Surfclam - Banquereau	Sessile broadcast spawners	SAR 2012/035, RD 2013/007 (2017)	No/ unknown	No/ unknown	--	2012	Model/framework change
Arctic Surfclam - Grand Bank	Sessile broadcast spawners	SAR 2012/035, RD 2013/007	No/ unknown	No/ unknown	--	--	--
Arrowtooth Flounder	Flatfish	SAR 2015/055, RD 2017/025 (2015)	No/ unknown	Yes	--	--	--
Atlantic Cod - NAFO 2J3KL (Northern Cod)	Gadoid	SAR 2019/058, RD 2019/052 (2010)	>=10	Yes	7: "Medium" recruitment	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Atlantic Cod - NAFO 3Ps (St. Pierre Bank)	Gadoid	SAR 2020/018, -- (2019)	>=10	Yes	--	2004	New model
Atlantic Cod - NAFO 4RS3Pn (Northern Gulf)	Gadoid	Proc 2011/006, RD 2011/003 (2010)	>=10	Yes	--	--	--
Atlantic Cod - NAFO 4VsW (Eastern Scotian Shelf)	Gadoid	SAR (RPA) 2011/028, RD 2011/138 (2011)	>=10	Yes	--	--	--
Atlantic Cod - NAFO 4X5Y (Scotian Shelf and Bay of Fundy)	Gadoid	SAR 2019/015, (2018)	>=10	No/ unknown	--	2010	Unknown
Atlantic Cod - NAFO 4TVn (Southern Gulf)	Gadoid	SSR 2003/016, RD 2003/015 (2003)	<10	Yes	1: The lowest biomass from which the stock has recovered readily	--	--
Atlantic Halibut - NAFO 3NOPs4VWX+5	Flatfish	SAR 2015/012, RD 2016/001 (2014)	>=10	Yes	1: Lowest SSB in time series that produced 50% recruitment	2010	New model
Atlantic Herring - NAFO 4T (Fall Spawner)	Clupeid	SAR 2005/070, RD 2005/082 (2005*)	<10	Yes	4: Lowest SSB from which the stock was able to recover	--	New model and framework

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Atlantic Herring - NAFO 4T (Spring Spawner)	Clupeid	SAR 2005/070, RD 2005/082 (2005*)	<10	Yes	4: Lowest SSB from which the stock was able to recover	--	New model and framework
Atlantic Herring - NAFO 4VWX (Southwest Nova Scotia/Bay of Fundy)	Clupeid	SAR 2012/035, RD 2012/025 (2012*)	<10	Yes	6: Trends were stable and representative of serious harm	--	Estimation method changes
Atlantic Mackerel - NAFO 3+4	Scombrid	SAR 2017/034, RD 2014/066 (2014)	<10	Yes	--	--	--
Atlantic Salmon - Gulf	Salmon	SR 2018/015, SAR 2015/058 (RDs 2015/074 and /075) (2018)	No/ unknown	Yes	--	--	--
Atlantic Salmon - Maritimes	Salmon	SAR 2015/058 (RDs 2015/074 and /075), (1991*)	No/ unknown	No/ unknown	--	--	--
Atlantic Salmon - NL	Salmon	RD 2006/071, SAR 2017/035 (1991*)	No/ unknown	No/ unknown	--	--	--
Bocaccio Rockfish	Sebastid	SAR 2020/025 (2008)	>=10	Yes	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Canary Rockfish	Sebastid	SAR (RPA) 2009/041, RD 2009/013 (2008)	No/ unknown	No/ unknown	--	--	--
Cusk - NAFO 4VWX5Z	Gadoid	SAR 2012/035, RD 2012/026 (2012)	<10	No/ unknown	7: The period before CPUE begins to decline	--	--
Gaspereau - Maritimes - alewife	Clupeid	RD 2016/105 (2016)	No/ unknown	No/ unknown	--	--	--
Geoduck	Sessile broadcast spawners	RD 2007/064 (2005*)	No/ unknown	Yes	1: Tied to the timing of the first survey plus exploratory landings. Biomass from first survey plus landings before 1989.	--	A proxy was needed
Giant Red Sea Cucumber	Echinoderm	RD 2008/065 (2007)	No/ unknown	Yes	Unclear	--	--
Goose Barnacle - Clayoquot Sound	Sessile broadcast spawners	SAR 2016/048, RD 2016/096 (2016)	No/ unknown	Yes	n/a: Not historical but spatial - existing data from 2001 as to potential habitat	--	--
Green Sea Urchin - PMA 12 (Northeast Vancouver Island)	Echinoderm	SR 2018/054 (2018)	No/ unknown	No/ unknown	1: Half the lowest observed density from which the population increased with no intervention	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Green Sea Urchin - PMA 19 (Southeast Vancouver Island)	Echinoderm	SR 2018/054 (2018)	No/ unknown	No/ unknown	1: Half the lowest observed density from which the population increased with no intervention	--	--
Greenland Halibut - NAFO 4RST	Flatfish	SAR 2017/049, Proc 2017/037 (2017)	<10	Yes	5: Lowest level of population where a recovery was observed	--	--
Grey Seal - Gulf of St. Lawrence	Pinniped	SAR 2010/089, RD 2003/067 (2003)	No/ unknown	Yes	1: Will underestimate Bo	--	--
Grey Seal - Sable Island and Southwest Nova Scotia	Pinniped	SAR 2010/089, RD 2003/067 (2003)	No/ unknown	Yes	1: Will underestimate Bo	--	--
Grey Seal - Scotian Shelf	Pinniped	SAR 2010/089, RD 2003/067 (2003)	No/ unknown	Yes	1: Will underestimate Bo	--	--
Haddock - NAFO 3Ps	Gadoid	SAR 2019/007, RD 2020/024 (2018)	>=10	No/ unknown	1: Year for which survey data was available and which met the criteria of a 90th percentile rec deviation	--	--
Harp Seal - Northwest Atlantic Ocean	Pinniped	SAR 2012/067, RD 2003/067 (2003)	No/ unknown	Yes	1?: Will underestimate Bo	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Intertidal Clams - Depuration	Sessile broadcast spawners	RD 2000/122, -- (1999)	>=10	No/ unknown	--	--	--
Longhorn Sculpin - St. Mary's Bay	Scorpaeni-formes	SAR 2020/041, -- (2020)	No/ unknown	No/ unknown	21: Entire time series, both fishing up and down	--	--
Lumpfish - NAFO 3KLPs	Scorpaeni-formes	SAR (RPA) 2021/019, -- (2020)	No/ unknown	No/ unknown	11: A productive period	--	--
Monkfish - NAFO 3LNOPs	Lophiiformes	SAR 2018/010, RD 2018/061 (2017)	<10	Yes	7: A period of high productivity (successive years of high biomass)	--	--
Northern Shrimp - Eastern Assessment Zone	Shrimp	SAR 2020/053, RD 2020/072 (2020)	No/ unknown	Yes	11: entire time series	2010	PA Policy
Northern Shrimp - SFA 4	Shrimp	SAR 2011/003, RD 2011/004 (Unclear)	No/ unknown	No/ unknown	5: productive period	--	Minor changes in survey calculations
Northern Shrimp - SFA 5	Shrimp	SAR 2010/018, RD 2011/004 (2010)	No/ unknown	No/ unknown	6: productive period	--	Minor changes in survey calculations
Northern Shrimp - SFA 6	Shrimp	SAR 2010/018, RD 2011/004 (2010)	No/ unknown	No/ unknown	8: productive period	--	Minor changes in survey calculations

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Northern Shrimp - SFA 8 (Gulf, Esquiman)	Shrimp	SAR 2011/062, RD 2012/006 (2011)	<10	No/ unknown	2: Two separate times when stocks increased twice (at different levels of predation)	--	--
Northern Shrimp - SFA 9 (Gulf, Anticosti)	Shrimp	SAR 2011/062, RD 2012/006 (2011)	<10	No/ unknown	2: Two separate times when stocks increased twice (at different levels of predation)	--	--
Northern Shrimp - SFA 10 (Gulf, Sept-Iles)	Shrimp	SAR 2011/062, RD 2012/006 (2011)	No/unknown n	No/ unknown	2: Two separate times when stocks increased twice (at different levels of predation)	--	--
Northern Shrimp - SFA 12 (Gulf, Estuary)	Shrimp	SAR 2011/062, RD 2012/006 (2011)	<10	No/ unknown	2: Two separate times when stocks increased twice (at different levels of predation)	--	--
Northern Shrimp - SFA 13-15 (Scotian Shelf)	Shrimp	SAR 2011/029, RD 2011/102 (2010)	No/ unknown	Yes	11: High productivity period	--	No information on this inconsistency
Northern Shrimp - Western Assessment Zone	Shrimp	SAR 2020/053, RD 2020/072 (2020)	No/ unknown	Yes	6: entire time series	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Orange-Footed Sea Cucumber - NAFO 4W Midshore Zone F	Echinoderm	SAR 2021/007, -- (2019)	No/ unknown	No/ unknown	1?: Highest catch rates	--	--
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zone 1	Echinoderm	SAR 2021/007, -- (2019)	No/ unknown	No/ unknown	1?: Highest catch rates	--	--
Orange-Footed Sea Cucumber - NAFO 4W Offshore Zones 2	Echinoderm	SAR 2021/007 (2019)	No/ unknown	No/ unknown	1?: Highest catch rates	--	--
Orange-Footed Sea Cucumber - NAFO 4Vs Area of Access 2	Echinoderm	SAR 2021/007 (2019)	No/ unknown	No/ unknown	1?: Highest catch rates	--	--
Orange-Footed Sea Cucumber - Southwest New Brunswick Zone 1	Echinoderm	SAR 2021/007 (2019)	No/ unknown	No/ unknown	1?: Highest catch rates	--	--
Pacific Cod - 3CD (West Coast Vancouver Island)	Gadoid	SAR 2019/008, RD 2020/070 (2018)	No/ unknown	Yes	1: Historically low state from which stock recovered to above average	--	--
Pacific Cod - PMFC 5ABCD (Queen Charlotte Sound and Hecate Strait)	Gadoid	SAR 2019/008, RD 2020/070 (2018)	No/ unknown	Yes	1: Precipitated strong TAC decrease	2014	Re-review

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Pacific Herring - Central Coast	Clupeid	SAR 2017/030, RD 2018/009 (2017)	<10	Yes	--	--	--
Pacific Herring - Haida Gwaii	Clupeid	SAR 2017/030, RD 2018/009 (2017)	<10	Yes	--	--	--
Pacific Herring - Prince Rupert District	Clupeid	SAR 2017/030, RD 2018/009 (2017)	<10	Yes	--	--	--
Pacific Herring - Strait of Georgia	Clupeid	SAR 2017/030, RD 2018/009 (2017)	<10	Yes	--	--	--
Pacific Herring - West Coast Vancouver Island	Clupeid	SAR 2017/030, RD 2018/009 (2017)	<10	Yes	--	--	--
Pacific Lingcod - PMFC 4B (Inside, Strait of Georgia)	Scorpaeni-formes	SAR 2015/014, RD 2016/013 (2014)	No/ unknown	Yes	--	2005	PA Policy
Pacific Lingcod - PMFC 5CDE (Outside, Hecate Strait and west coast Haida Gwaii)	Scorpaeni-formes	SAR 2011/051, RD 2011/124 (2011)	No/ unknown	No/ unknown	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Pacific Lingcod - PMFC 3D (Outside Northwest Vancouver Island)	Scorpaeni-formes	SAR 2011/051, RD 2011/124 (2011)	No/ unknown	No/ unknown	--	--	--
Pacific Lingcod - PMFC 5AB (Outside Queen Charlotte Sound)	Scorpaeni-formes	SAR 2011/051, RD 2011/124 (2011)	No/ unknown	No/ unknown	--	--	--
Pacific Lingcod - PMFC 3C (Outside Southwest Vancouver Island)	Scorpaeni-formes	SAR 2011/051, RD 2011/124 (2011)	No/ unknown	No/ unknown	--	--	--
Pacific Ocean Perch - PMFC 3CD (West Coast Vancouver Island)	Sebastid	SAR 2013/038, RD 2013/093 (2012)	No/ unknown	No/ unknown	--	--	--
Pacific Ocean Perch - PMFC 5ABC (Queen Charlotte Sound)	Sebastid	SAR 2011/017, RD 2011/111 (2010)	No/ unknown	No/ unknown	--	--	--
Pacific Ocean Perch - PMFC 5DE-HS/DE/WHG	Sebastid	SAR 2013/038, RD 2013/092 (2012)	No/ unknown	No/ unknown	--	--	--
Pollock - NAFO 4VWXmn (Eastern Component)	Gadoid	SAR 2012/035, RD 2012/027 (2012)	>=10	No/ unknown	10: Sustained period of high productivity	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Pollock - NAFO 4X5 (Western Component)	Gadoid	SAR 2012/035, SAR 2011/054 (2012)	No/ unknown	No/ unknown	11: Period of highest productivity in time series	--	--
Quillback Rockfish - Inside	Sebastid	SAR 2011/072, RD 2011/035 (2011)	No/ unknown	No/ unknown	--	--	--
Quillback Rockfish - Outside	Sebastid	SAR 2011/072, RD 2011/035 (2011)	No/ unknown	No/ unknown	--	--	--
Red Sea Urchin	Echinoderm	SAR 2019/036, RD 2019/061 (2019)	No/ unknown	No/ unknown	--	--	--
Redfish - Unit 1+2 ( <i>S. fasciatus</i> )	Sebastid	SAR 2020/019, RD 2021/015 (2020)	>=10	Yes	3: Years that produced the big cohorts	2012, 2018	Framework changes
Redfish - Unit 1+2 ( <i>S. mentella</i> )	Sebastid	SAR 2020/019, RD 2021/015 (2020)	>=10	Yes	3: Years that produced the big cohorts	2012, 2018	Framework changes
Redfish - Unit 3	Sebastid	SAR 2012/004, RD 2012/015 (2011)	No/ unknown	Yes	42: No trend over entire time series	2010	Loss of model

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Redstripe Rockfish - PMFC 3CD5ABC (BC South)	Sebastid	SAR 2018/049, RD 2021/014 (2018)	No/ unknown	Yes	--	--	--
Redstripe Rockfish - PMFC 5DE (BC North)	Sebastid	SAR 2018/049, RD 2021/014 (2018)	No/ unknown	Yes	--	--	--
Rock Sole - PMFC 5AB (Queen Charlotte Sound)	Flatfish	SAR 2014/039, RD 2016/009 (2013)	No/ unknown	Yes	--	2006	PA Policy
Rock Sole - PMFC 5CD (Hecate Strait)	Flatfish	SAR 2014/039, RD 2016/009 (2013)	No/ unknown	Yes	--	2006	PA Policy
Rougheye Rockfish - PMFC 3CD5AB (REBS south)	Sebastid	SAR 2020/047, -- (2020)	No/ unknown	Yes	--	--	--
Rougheye Rockfish - PMFC 5DE (REBS north)	Sebastid	SAR 2020/047, -- (2020)	No/ unknown	Yes	--	--	--
Sablefish	Scorpaeni-formes	SAR 2011/025, RD 2011/063 (2011)	No/ unknown	No/ unknown	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Sea Scallop - SFA 20	Scallop	SAR 2010/044, RD 2010/068 (2010)	<10	No/ unknown	15: Unclear	--	--
Sea Scallop - SFA 28 - SPA 1a (Inshore Bay of Fundy)	Scallop	SAR 2014/018, RD 2014/016 (2013)	<10	No/ unknown	1: lowest biomass in the time series from which a sustained recovery occurred	--	--
Sea Scallop - SFA 28 - SPA 1b (Inshore Bay of Fundy)	Scallop	SAR 2014/018, RD 2014/016 (2013)	<10	No/ unknown	1: lowest biomass in the time series from which a sustained recovery occurred	--	--
Sea Scallop - SFA 28 - SPA 3 (Inshore Bay of Fundy)	Scallop	SAR 2014/018, RD 2014/016 (2013)	<10	No/ unknown	1: lowest biomass in the time series from which a sustained recovery occurred	--	--
Sea Scallop -SFA 28 - SPA 4 + 5 (Inshore Bay of Fundy)	Scallop	SAR 2014/018, RD 2014/016 (2013)	No/ unknown	No/ unknown	1: lowest biomass in the time series from which a sustained recovery occurred	--	--
Sea Scallop - SFA 28 - SPA 6 (Inshore Bay of Fundy)	Scallop	SAR 2016/004, SAR 2014/018 (2015)	No/ unknown	No/ unknown	1: Lowest in series	--	--
Sea Scallop - SFA 29W - Subarea B (Inshore)	Scallop	SR 2016/058, RD 2016/107 (2015)	<10	No/ unknown	--	--	--
Sea Scallop - SFA 29W - Subarea C (Inshore)	Scallop	SR 2016/058, RD 2016/107 (2015)	<10	No/ unknown	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Sea Scallop - SFA 29W - Subarea D (Inshore)	Scallop	SR 2016/058, RD 2016/107 (2015)	<10	No/ unknown	--	--	--
Sea Scallop - SFA 27, Georges 'a' (Offshore)	Scallop	SAR 2013/058, RD 2013/079 (2013)	No/ unknown	No/ unknown	29: entire time series?	2012	Narrowing of historical time period used
Shortspine Thornyhead	Sebastid	SAR 2016/016, RD 2017/015 (2015)	No/ unknown	Yes	--	--	--
Shrimp Trawl	Shrimp	Proc 2008/031, SAR 2011/085 (2008)	<10	No/ unknown	11: stable productive period	--	--
Silver Hake - NAFO 4VWX	Gadoid	SAR 2013/018, RD 2013/009 (2012)	No/ unknown	No/ unknown	--	--	--
Silvergray Rockfish	Sebastid	SAR 2014/028, RD 2016/042 (2013)	No/ unknown	Yes	--	--	--
Smooth Skate - NAFO 2J3K (Northeastern Newfoundland and Labrador)	Elasmo-branch	SAR (RPA) 2013/035, RD 2013/098 (2013)	>=10	No/ unknown	8: period of higher productivity	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Snow Crab - NAFO 2HJ	Crab	SAR 2019/041, RD 2018/054 (2018)	<10	Yes	--	--	--
Snow Crab - NAFO 3K	Crab	SAR 2019/041, RD 2018/054 (2018)	<10	Yes	--	--	--
Snow Crab - NAFO 3L (Inshore)	Crab	SAR 2019/041, RD 2018/054 (2018)	<10	Yes	--	--	--
Snow Crab - NAFO 3LNO (Offshore)	Crab	SAR 2019/041, RD 2018/054 (2018)	No/ unknown	Yes	--	--	--
Snow Crab - NAFO 3Ps	Crab	SAR 2019/041, RD 2018/054 (2018)	<10	Yes	--	--	--
Snow Crab - CFA 12 (12, 18, 25, 26), 12E, 12F, 19	Crab	SAR 2010/014, RD 2010/091 (2010*)	No/ unknown	Yes	1: lowest biomass of hard shelled commercial-sized adult male crab (post-fishery as estimated from the trawl survey) which produced good recruitment rates of juvenile crab at Instar VIII	Re-estimated	Minor changes in survey calculations

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Snow Crab - NAFO 4X (Scotian Shelf)	Crab	SAR 2012/050, RD 2012/024 (2012)	No/ unknown	No/ unknown	--	--	--
Snow Crab - CFA 20-22 (Northeastern Nova Scotia)	Crab	SAR 2012/050, RD 2012/024 (2012)	No/ unknown	No/ unknown	--	--	--
Snow Crab - CFA 23-24 (Southeastern Nova Scotia)	Crab	SAR 2012/050, RD 2012/024 (2012)	No/ unknown	No/ unknown	--	--	--
Spot Prawn	Shrimp	None (2008)	No/ unknown	No/ unknown	--	--	--
Striped Bass - Gulf	Moronid	SAR 2021/018 (2020)	>=10	Yes	--	--	--
Striped Shrimp – Eastern Assessment Zone	Shrimp	SAR 2020/053, RD 2020/072 (2020)	No/ unknown	Yes	11: entire time series	--	Better alignment with policy
Striped Shrimp - Western Assessment Zone	Shrimp	SAR 2020/053, RD 2020/072 (2020)	No/ unknown	Yes	6: entire time series	--	--
Walleye Pollock - PMFC 5CDE (BC North)	Gadoid	SAR 2018/020, RD 2021/004 (2017)	No/ unknown	Yes	1: lowest spawning biomass from which the stock subsequently recovered to $B_{avg}$	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Walleye Pollock - PMFC 3CD5AB (BC South)	Gadoid	SAR 2018/020, RD 2021/004 (2017)	No/ unknown	Yes	1: lowest spawning biomass from which the stock subsequently recovered to $B_{avg}$	--	--
White Hake - NAFO 4RST* (Northern Gulf)	Gadoid	SAR (RPA) 2016/035, RD 2015/076 (2015)	>=10	No/ unknown	4: productive period, high mature biomass, years when size data were collected and before a large decline after 1990	--	--
White Hake - NAFO 4T (Southern Gulf)	Gadoid	SAR (RPA) 2016/034, RD 2016/045 (2015)	>=10	No/ unknown	--	--	--
White Hake - NAFO 4VW (Eastern Scotian Shelf)	Gadoid	SAR (RPA) 2016/035, RD 2016/100 (2015)	>=10	No/ unknown	23: productive period	--	--
White Hake - NAFO 4X5Zc (Western Scotian Shelf, Bay of Fundy and northern Georges Bank)	Gadoid	SAR (RPA) 2016/035, RD 2016/100 (2015)	<10	No/ unknown	29: productive period	--	--
Widow Rockfish	Sebastid	SAR 2019/044, RD 2021/039 (2019)	No/ unknown	Yes	--	--	--

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Winter Flounder - NAFO 4RST (Gulf of St. Lawrence)	Flatfish	SAR 2017/022, RD 2019/026 (2017)	>=10	No/ unknown	22: productive period	--	--
Winter Skate - NAFO 4VW	Elasmo-branch	SAR (RPA) 2017/014, -- (2016)	>=10	No/ unknown	--	--	--
Winter Skate - NAFO 4T (Southern Gulf of St. Lawrence)	Elasmo-branch	SAR (RPA) 2016/059, RD 2016/119 (2016)	>=10	No/ unknown	--	--	--
Witch Flounder - NAFO 23KL	Flatfish	SAR 2018/053, RD 2019/066 (2018)	>=10	No/ unknown	2: Early part of time series, from a period where stock and landings were stable and varied without trend	--	--
Witch Flounder - NAFO 3Ps	Flatfish	SAR 2018/011, RD 2018/064 (2017)	No/ unknown	Yes	11: stable trend under a range of harvest levels	--	--
Witch Flounder - NAFO 4RST	Flatfish	SAR 2012/17, RD 2012/122 (2012)	>=10	No/ unknown	--	--	Re-estimated
Yelloweye Rockfish - Inside	Sebastid	SAR 2020/056 (2020)	No/ unknown	Yes	--	2011	Model change
Yelloweye Rockfish - Outside	Sebastid	SAR 2020/024, RD 2020/069 (2019)	No/ unknown	No/ unknown	--	2015	Model change

Assessment Unit	Type	Advice for Current Choice (Year of Meeting)	Depletion History (Years below LRP)	Multiple Options Considered?	Historical Period (Years, qualities) if applicable	Past LRPs (Year of Meeting)	Reasons for Any Past Changes to Rationales (or Re-estimation)
Yellowmouth Rockfish	Sebastid	SAR (RPA) 2011/060, RD 2012/095 (2011)	No/ unknown	Yes	--	--	--
Yellowtail Flounder - NAFO 4T	Flatfish	SAR 2021/022 (2021)	>=10	No/ unknown	21: Unclear	2015	Framework changes
Yellowtail Rockfish	Sebastid	SAR 2015/010 (2014)	No/ unknown	No/ unknown	--	--	--

Table A.3.5. List of assessment units and associated Science Advisory Reports or Research Documents where various reasons were provided for or against different choices of LRP at the time an LRP was selected.

LRP Category	Statements in Support of Choices	Reasons Against Choices
Fractions of $B_{MSY}$	<p>Consistent with PA Policy (68)</p> <p>Estimates consistent with past evidence of ability to recover (5)</p> <p>Suitable for data poverty (4)</p> <p>Uses the most information on stock production (2)</p> <p>Facilitates selection of policy provisional default USR (1)</p> <p>Supported by fishery interests (1)</p>	<p>Estimates sensitive to or are implausible due to assumptions regarding life history parameters (10)</p> <p>Concerns with stationarity (5)</p> <p>Poor stock-recruitment relationship (5)</p> <p>Estimates differed from other options or other concerns about appropriateness given data poverty (3)</p> <p>Associated with past declines (2)</p> <p>Cannot be estimated or poor model fit (2)</p> <p>Data issues or requirements (2)</p>
Fractions of $B_0$ or $K$	<p>Consideration of or based on best practices from other jurisdictions (11)</p> <p>May be more robust to model assumptions than <math>B_{MSY}</math> (9)</p> <p>Estimates consistent with past evidence of low surplus production (8) or where recovery was observed (1)</p> <p>Supported by analogies to similar stocks or meta-analysis (6)</p> <p>Feasible to estimate (5)</p> <p>Suitably equivalent to 0.4 <math>B_{MSY}</math> or PA Policy (4)</p> <p>Relative depletion more suitable for management and/or COSEWIC (4)</p>	<p>Sensitive to model assumptions (3)</p> <p>Other data challenges (1)</p>
$B_{recover}$	<p>Only viable method and/or <math>B_{MSY}</math> or <math>B_0</math> were not feasible to estimate (6)</p> <p>Supported by fishery interests (4)</p> <p>Suitable for spasmodic stocks (3)</p> <p>Historical reference points scale with biomass and fishing mortality (1)</p> <p>Acceptable performance in simulation (1)</p>	<p>Change in productivity regime (3)</p> <p>Implausibly high or low estimates compared to other options (2)</p> <p>Used primarily to validate other options (2)</p> <p>Data problems or high variability (2)</p> <p>Doesn't use all information available (2)</p> <p>Subsequently information improved around undesirable states (1)</p> <p>Could not be identified (1)</p> <p>Represents chance event (1)</p>

<b>LRP Category</b>	<b>Statements in Support of Choices</b>	<b>Reasons Against Choices</b>
Stock-Recruitment Relationship	Acceptable fit of stock-recruitment method (4) Acceptable performance in simulation (3) Supported by analogies to similar stocks or meta-analysis (3) Data requirements considered (4) Eggs considered best indicator of productivity (1)	Poor stock-recruitment relationship and/or extrapolation required (7) Implausibly low due to high natural mortality (5)
Other	Estimates consistent among several options and/or multiple lines of evidence of serious harm (7) Consistent with meta-analysis (3) Acceptable performance in simulation or modelling (2) Supported by analogies to similar stocks or meta-analysis (1) Represents an agreed-upon undesirable state (1)	Stationarity concerns (5) Highly variable indices (1) Higher data requirements (1)