NORTH PACIFIC FISHERY MANAGEMENT COUNCIL

Bill Tweit, Interim Chair | David Witherell, Executive Director
1007 W. 3rd Avenue, Suite 400, Anchorage AK 99501
Phone 907-271-2809 | www.npfmc.org

August 30, 2023

Dr. Richard Methot, Senior Scientist for Stock Assessments
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Science and Technology
Via email: richard.methot@noaa.gov

Dear Dr. Methot,

At the June 2023 meeting, the North Pacific Fishery Management Council (Council)'s Scientific and Statistical Committee (SSC) received a presentation from you on the agency's draft "Technical Guidance for Estimating Status Determination Reference Points and their Proxies in Accordance with the National Standard 1 Guidelines." The SSC formed a subgroup of seven members to review the document by your requested August 31, 2023 deadline. Because the deadline did not overlap an SSC meeting, there has not been an opportunity for the subgroup's comments to be reviewed and approved by the SSC as a whole. Nonetheless, the attached written comments submitted by the SSC co-Chairs highlight the subgroup's review of the technical guidance with respect to its applicability and consistency with the Council's specification processes. Overall, the SSC subgroup found that the draft technical memorandum provided a helpful review of approaches for calculating and evaluating reference points for status determinations, and identified some specific areas in the document for improvement. The Council's interim Chair has endorsed the attached comments and recommendations.

The Council and the SSC appreciate the opportunity to review and provide comment on the draft technical guidance. The update is timely, given changes to National Standard 1 guidelines and changes in the scientific approaches to estimating reference points since the last update on technical guidance in 1998. In future, we would be grateful if the timeline for providing input on such guidance documents could span two Council meetings, so that the SSC and the Council have an opportunity to collectively review and approve comments provided.

Sincerely,

David Witherell
Executive Director

Enclosure: NPFMC SSC Subgroup report

Subject: Request for Input on: NMFS Technical Guidance for Estimating Status Determination Reference Points and their Proxies in Accordance with the National Standard 1 Guidelines

Date: August 2023

From: NPFMC SSC co-Chairs, Dr. Sherri Dressel and Dr. Franz Mueter

To: Dr. Rick Methot, Senior Scientist for Stock Assessments
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

A subgroup of the North Pacific Fishery Management Council's (NPFMC) Scientific and Statistical Committee (SSC) reviewed the draft NMFS technical memorandum "Technical Guidance for Estimating Status Determination Reference Points and their Proxies in Accordance with the National Standard 1 Guidelines".

This technical memorandum summarizes research and development into updated technical guidance with regard to calculating and evaluating reference points for status determinations. National Standard 1 (NS1) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires preventing overfishing while achieving, on a continuing basis, optimum yield (OY), from managed U.S. fisheries. OY is limited by the biologically feasible maximum sustainable yield (MSY) which in turn serves as the basis for status determination criteria (SDC) by which NOAA determines when a stock is experiencing overfishing or is overfished. The Maximum Fishing Mortality Threshold (MFMT) is the level of fishing mortality above which overfishing is occurring, and the Minimum Stock Size Threshold (MSST) is the biomass limit below which a stock is considered to be overfished and in need of rebuilding. Varied approaches for establishing these reference points have evolved regionally and internationally. This document describes recommended approaches where feasible to do so, and the advantages and disadvantages of alternatives where definitive advice is not feasible.

Here we review these situations and recommendations for their applicability and consistency with NPFMC specification processes. Overall, the SSC found that the draft technical memorandum provided a helpful review of approaches for calculating and evaluating reference points for status determinations. This document provides a much needed technical update given changes in NS1 guidelines and changes in the scientific approaches to estimating reference points since the last update on technical guidance in 1998 (Restrepo et al. 1998). This update is especially timely as the NPFMC and SSC consider approaches for adapting to a changing environment driven by climate change. Along these lines, we were pleased to see technical guidance pertaining to non-stationarity and associated considerations for assessments, evaluating productivity and reference periods for B_{MSY}, management strategy evaluation, and multi-species and ecosystem management considerations. There are areas in the document we feel could be improved, and we offer the following comments for consideration by the authors.

Gaps

While the document covers the major elements, we believe there are gaps that could be addressed through the inclusion of additional information or future guidance, as appropriate:

- *Uncertainty and Buffers:* The document would greatly benefit from the addition of a discussion about approaches for addressing uncertainty in setting Allowable Biological Catch limits. We note that the P* approach is used by the Pacific Council for harvest specification and is included in the NPFMC's Fisheries Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs. A useful addition to the document would be to include work done by Privitera-Johnson and Punt (2010) and Shertzer et al (2008) on the P* approach, and to provide examples of P* implemented in domestic fisheries. Additionally, the NPFMC uses a risk table approach for groundfish stocks to evaluate and document unanticipated uncertainty in assessments caused by environmental and

ecosystem dynamics, structural uncertainty and modeling challenges such as retrospective patterns as well as unexpected changes in fishery dynamics.

The risk table is a standardized scoring framework designed to evaluate unanticipated ecosystem and environmental impacts on marine resources that may require a reduction below maxABC in order to avoid exceeding the true (and unknown) OFL, while also improving transparency in SSC decisions (Dorn and Zador 2020). The table contains three risk categories: assessment-related, population dynamics, environmental and ecosystem, and fishery performance. These categories are evaluated and scored based on levels of concern ranging from a normal level (score of 1) to an extreme concern (score of 4). A similar, though less formal approach, is used for Bering Sea crab, where a reduction from OFL to obtain the ABC is given by the larger of either the P* approach (with P* fixed at 0.49) or a buffer that takes into account the tier level, stock assessment uncertainties, and unanticipated environmental impacts.

- *Optimal Yield (OY):* The document contains little discussion on methods used to establish Optimum Yield and its application among U.S. fisheries, particularly in the context of environmental and multi-species management, and updating OY to adapt to changes in the human environment related to climate. This type of in-depth discussion could be outside the scope of this document and, if so, NMFS should consider future technical guidance on best practices for setting and updating OY, with examples. (See also comments made below regarding guidance provided by The National Academy of Sciences Report (2013) Evaluating the Effectiveness of Fish Stock Rebuilding Plans in the United States, which also comments on OY and how it is defined.)

- *F_{MSY} Proxies*: Include advice on approaches for establishing F_{MSY} proxies for stocks where fishery selectivity occurs to the right of the maturity curve, resulting in unrealistically high values of F_{MSY}. The Bering Sea snow crab (***Chionoecetes opilio)*** is one such example where fishing occurs on the mature proportion of the population. Empirical measures of surplus production have been explored to estimate the exploitation rate and biomass corresponding to MSY for Alaska crab stocks (Punt and Szuwalski 2012).

- *Rebuilding:* The National Research Council's (NRC) Report, Evaluating the Effectiveness of Fish Stock Rebuilding Plans in the United States, comments on the need for inclusion of socioeconomic concerns (NRC 2014). Report findings note that compliance with the MSFCMA requires that economic and social considerations for rebuilding plans are contingent on biological mandates being met. However, rebuilding plans that do not meet the biological mandates cannot be adopted, even if doing so would improve projected socioeconomic outcomes. The requirement to rebuild within 10 years, whenever possible according to the biology of the stock, reduces the flexibility to adapt rebuilding plans according to economic and social considerations. Alternative example rebuilding plans using net present value are presented for consideration in the report (see figure below).

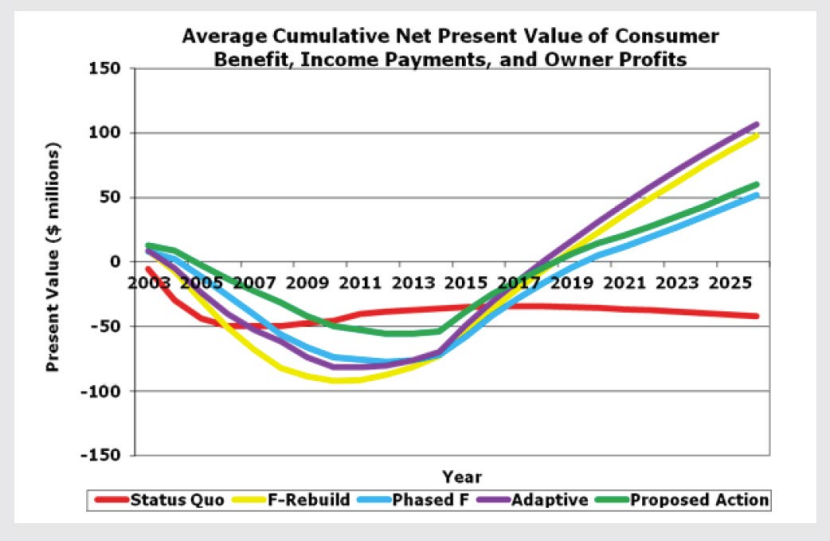

Figure 6.1 (from NRC 2014): Economic net benefits for different rebuilding strategies.

- The NRC (2014) identified seven topics that directly or indirectly relate to the overarching issue of what should be the appropriate degree of flexibility in stock rebuilding. These topics include: 1) the balance between prescriptiveness and flexibility; 2) defining the success of rebuilding fisheries; 3) rebuilding under ecosystem-based fisheries management; 4) rebuilding time frames; 5) model predictions, projections and data limitations; 6) mixed-stock fisheries; and 7) the role of biological science and socioeconomic factors. The findings and recommendations of this report should be considered in this technical guidance and future updates to the National Standard Guidelines (please see our comments in the section on the revision of National Standard 1 guidelines).

Document Structure

Overall we found the data quality structure of the document (i.e., Tiers) and the overall document sections to follow a logical progression. We think the document in general could be made more accessible to readers by improving several key aspects:

- We are concerned that the document presents many ambiguities in regard to using methods that are untested or still in the development and research phase. As presented, the details in the document make it difficult to delineate guidance that represents recommended methods and approaches based on solid technical information for status determination versus discussions that are ideas warranting further investigation and future research, but should not yet be applied for status determination. A lack of clarity on these issues may create confusion and we suggest the authors consider removing speculative methods from the document or to a separate section and that the main recommendations for each major section of the report are summarized and highlighted at the end of the section.

- The document is generally difficult to navigate due to the large number of subsections. Numbering the subsections would help readers navigate the document.

Section-Specific Comments

Executive Summary

- *Page v (direct estimation):* The following two bullets in the description seem contradictory and differ from common practice in the North Pacific where we often recommend fixing a parameter based on expert judgment or meta-analyses:
    - "Expert judgment and information from other stocks can be used in parameter estimation through the use of priors for key parameters such as natural mortality rate and spawner recruitment. Priors help achieve a balance among estimability, bias and variance.
    - Seek alignment between the priors used in the assessment and the equivalent SPR proxies used when direct estimation is not attempted."

- It was surprising to see $F_{0.1}$ and F_{max}, commonly used in the 1980s and 1990s, granted a full bullet in the executive summary. Neither of these yield-per-recruit calculations give consideration to the productive capacity of the stock, and therefore, strictly speaking, are not F_{MSY} proxies. We recommend that all discussion of F_{max} and $F_{0.1}$ be removed from the technical guidance. Better proxies are now available.

- The guidelines recommend setting MSST and control rule inflection biomass based on a long-term perspective; and setting F_{MSY}, B_{MSY}, MSY, and rebuilding targets on the basis of recent prevailing conditions. The guidelines note such an approach is untried in practice and thus needs testing before being used. We believe this research idea does not rise to the level of a technical guideline and seems out of place in the executive summary. Perhaps these types of research questions could be extracted from the text and collated in a separate section.

- There is a good description of the dynamic B_0 approach in the document and a discussion of the strengths and weaknesses of the approach. We recommend the authors provide clarity in the document as to whether NMFS intends to recommend dynamic B_0 as a preferred approach for status determination. The NPFMC currently recognizes the large effect of previous regime shifts in the North Pacific in its choice of baseline periods for calculating reference points. The trade-off between the increased flexibility of shorter periods vs. the greater stability of longer periods occurs on a continuum that may better be described without artificially separating dynamic reference points from other similar approaches.

Approaches to calculating MSY-related quantities

- *Which parameterization of the SRR form to use? (Page 8):* The discussion of the steepness/R_0 parameterization of the Beverton Holt SRR seems very one-sided against use of this parameterization. We agree with the main point in Miller and Brooks (2021) that estimates of steepness and equilibrium points of the stock recruit curve depend on the biological parameters used to calculate SPR@F=0. However, we believe the guidance should be that there needs to be more careful consideration of how those parameters are selected, rather than to revert to the original non-intuitive parameterization of the Beverton Holt SRR. This seems a big step backwards. It is simply not true that steepness formulations require the assumption that growth, natural mortality, and fecundity are constant over time. The vast majority of assessments on the West Coast and North Pacific do not incorporate time-variation in biological parameters (either because of lack of data or because this variation is not considered important), so the concerns raised by Miller and Brooks (2021) are not germane across all systems. Use of the steepness/R_0 parameterization allows use of priors based on meta-analyses of steepness to inform the

assessment, and allows sensitivity analyses to be done, such as likelihood profiles on steepness and R_0, which are extremely valuable for understanding how different data sources inform the assessment. When there is time variation in biological parameters, as is likely to be more often the case under a changing climate, there is no easy way to avoid making a choice of which biological parameters to use for calculating reference points and status determination, regardless of which method is used.

- The second paragraph on page 10 concludes that fixing steepness is not recommended. However, we note this is a practice used in several assessments in the North Pacific and there is a tradeoff between assessment performance and fixing steepness. In some situations, sensitivity to steepness has been evaluated and the parameter value based on studies. Alternatively we suggest an emphasis be placed on caution and evaluating assumptions, but not provide a full recommendation against the practice.

- Figures 1 and 3 show the steepness = 0.95 curve to be truncated, whereas it should go through the origin.

- On page 9 the following statement is incorrect and inconsistent with the discussion of priors representing life history information and/or meta-analyses: “Ideally, estimation of the SRR parameters, in either a frequentist or Bayesian framework, would proceed without penalizing the values the parameters may take beyond the imposition of reasonable bounds.” Should there be indications that this information contradicts stock dynamics and biology, further refinement of the priors and bounds should be considered.

- *Freely estimated SRR parameters* (page 9): The authors should consider noting that the circumstances where it is possible to obtain reliable estimates when freely estimating SRR parameters in a stock assessment model are extremely rare. On the other hand, overly weighting the estimation of SRR parameters within a stock assessment model can bias estimates of other parameters in the model, so care should be taken in appropriately weighting this element of the likelihood when estimation of the SRR is done internally to the assessment model.

Proxies for B_{MSY}

- The statement (page 13) “It is uncommon, however, for B_0 to be better estimated than B_{MSY}”, needs to be supported by a citation. This general statement is unsupported and likely to be highly dependent on the exploitation history of a stock.

Deferred B_{MSY} Estimate

- This section would greatly benefit from the addition of references and examples. It is unclear to the reader whether this discussion is hypothetical or based on real world examples and/or literature.

Spawning Potential Ratio (%SPR)

- The second paragraph on page 11: While the assertion that “it is irrefutable that spawners are necessary to the production of recruits” holds true in many contexts, this statement requires adjustment in cases for meta-populations, such as the presence of source-sink dynamics; or when political boundaries do not align with a population's range

- Page 12 and page 59: The range of values provided in the following statement contradicts those found in the appendix: "'Later studies considered a wider range of steepness and stock-recruitment relationships, representing a more realistic resilience and productivity for certain stocks such as rockfish, and found a much higher, more conservative SPR level in the range of 40-70% was needed." However, upon reviewing the studies presented in appendix table 1, it is evident that none of them have SPR values exceeding 60%. Notably, a study by Thorson et al (2018) demonstrated that the Dorn (2002) estimates of steepness were considerably lower than those updated with over a decade of additional data.

Tier 2: Surplus Production / Biomass Dynamics Models

- To improve consistency with the spawner recruitment relationship discussion under Tier 1 methods, we recommend to avoid using the simple Shaefer/Fox approaches in favor of the more general Pella-Tomlinson function or, at least, illustrate how the choice affects MSY calculations.

- We note the document indicates the ratio of biomass B_{MSY}/B_0 is fixed at 0.5; however, the ratio of B_{MSY}/B_0 for the Fox model is 1/e ~ 0.37.

Tier 3: Data-limited Approaches

- Assessments using absolute survey biomass estimates are regarded as a data-moderate approach, not data limited, in both the North Pacific and the Pacific Councils.

Overfished SDC from Trends in CPUE or Relative Abundance

- We support development of more flexible approaches to determining MSST based on indices of abundance. However, care needs to be taken to avoid unnecessarily declaring a stock overfished when annual abundance indices fall below a threshold due to uncertainty in estimation. Therefore, it should be clarified that it would be prudent and sensible to use a reasonable smoothing approach to fit to abundance trends and compare smoothed index values to the MSST.

- Discussion on forecasting with case examples using these methods, particularly in regard to rebuilding guidelines, would improve practical-use guidance offered in this section.

Overfishing SDC from Absolute Abundance

- This section contains a reference to "lower tiered assessments in the North Pacific" when discussing absolute abundance and overfishing. The discussion also indicates that "generally the absolute abundance method has only been used for defining an overfishing SDC rather than comparing it to an overfished SDC", but then seems to suggest it is possible to determine an overfished stock status. We recommend not mixing the overfishing and overfished discussion in this section and also note our recommendation under the heading "Document Structure" about clarifying theoretical and untested methods versus those that are recommendations for the guidance.

Units of Reproductive potential

- The Barneche reference is incorrect ("Barnache"). Further, a more recent meta-analysis by Marshall et al (2021) provided a somewhat smaller exponent of 1.18 and is worth referencing.

Fishery Technological Characteristics

- Stewart I., Hicks A., and Carpi (2021) discuss issues associated with estimating mortality among fisheries that differ appreciably and the consequences on SPR and yield. The authors should consider adding this reference to the section.

- We found the discussion on F_{MSST} in the multispecies context confusing (page 39). One point of confusion is whether, in a multispecies fishery, fishing mortality above the OFL ($F>F_{MSY}$) is allowed if F_{MSST} is being used? This interpretation seems to open the OFL approach up for reinterpretation and evaluation of what "small amounts" means: "With this additional metric (reference point) it may be possible to allow small amounts of overfishing to occur on some stocks (i.e., fish certain stocks above their F_{MSY}), while ensuring that they are not fished above their F_{MSST}, and thus still meeting the NS1 requirements that limits F on all stocks to a level that will not lead to the stock becoming overfished in the long term." We request clarification on these issues. (See also comments above regarding guidance provided by NRC (2014), which also comments on F_{MSST} in the multispecies context of "mixed-stock fisheries".)

Spatial Complexity

- This section notes that stock delineation should correspond to biological boundaries, but unfortunately lacks guidance or acknowledgment of issues associated with transboundary stocks and associated complications with reference point calculations. This is an increasingly important issue as distributional shifts occur due to climate change and the authors should consider whether additional technical guidance is warranted.

Age Truncation

- Age truncation is just one of several issues of concern in this section that are not easily taken into account but should be considered in setting catch limits. Some additional guidance on how this could be accomplished through a precautionary approach, for example in a risk assessment framework (e.g., risk tables and additional buffers between maxABC and ABC are used in the NPFMC process to account for uncertainty that is not otherwise accounted for in the assessment or harvest control rule) would be useful in this section. The section is lacking general recommendations of how to address these additional complexities and uncertainties

Overfishing Determinations

- Page 28: The NPFMC's strategy for reducing the ABC below maxABC based on the risk table serves as an exemplary approach that addresses both inherent within-model uncertainty and uncertainties stemming from model-misspecification and retrospective patterns. An objective of this process is to avoid having the ABC exceed the true OFL (which is unknown at the time). What is described as an "awkward situation" in this section is actually an inadequate buffer that does not fully account for the risk of F exceeding the MFMT.

  We recommend including discussion about the NPFMC risk table approach (see Dorn et al 2020) and, specifically, that temporal changes in model results should be included when determining whether a reduction from maxABC is needed. The Pacific Council similarly included consideration of retrospective variance in their P* approach and this warrants consideration in this section.

Multi-Year Approaches to Overfishing Stock Status Determinations

- We request the authors clarify two statements that appear to be contradictory with regard to FMP language: "The specific circumstances in which the multi-year approach is appropriate and will be

used for a particular stock needs to be described in an FMP or FMP amendment." and "A multi-year approach is used to determine overfishing status (3-year average of F compared to MFMT) for some South Atlantic and Gulf of Mexico stocks. The 3-year average approach is not explicitly specified in their FMPs, but is used when endorsed by the respective Council SSCs."

Approaching an Overfished Condition

- This section could be enhanced by incorporating guidance regarding projections and forecasting uncertainty. Specifically, the authors could provide insight into specific sources of uncertainty that should be taken into account in projections. This consideration is vital in determining whether a stock is nearing an overfished state. These sources may encompass aspects such as recruitment, growth, fishery selectivity/allocation, and the interplay between F (fishing mortality) and catch. It is of importance to establish a clear methodology for quantifying uncertainty, given that the cutoff point is a "50% chance of falling below MSST" threshold. This underscores the crucial role that incorporating uncertainty plays in this context. Furthermore, we note in subsection b. iii that the outcomes are contingent upon not only the accuracy, but also the precision of projections.

Regime Specific Averages

- This section would benefit from a clear example of a regime shift that was identified and used to adjust/update reference points.

Dynamic/Responsive Harvest Control Rules

- On page 36, the authors acknowledge: "It would be inappropriate for this hybrid approach to be designed and recommended in the technical guidance document". However, the authors then go on to outline the new approach. If this approach is speculative, then we recommend removing the approach from the document (please see our comment under the first bullet in "Document Structure").

Multispecies interactions

- This section would be strengthened with specific recommendations for how to move forward, such as those recommendations arising from the workshop on "Multispecies Modeling Applications in Fisheries Management" (Karp et al. 2023, either by reference or by including high-level recommendations in the technical guidance).

Technical Interactions: Mixed Stock Fishery

- This section would benefit from the addition of background references to NS1 guidelines at 50 CFR 600.310(l) that discuss exceptions to the requirements to prevent overfishing. The criteria in that section allows overfishing in specific circumstances and examples and/or recommendations related to how this criteria has been applied nationally would be beneficial, particularly in context with data limited stocks and salmon management.

Glossary

- Include a definition for both $F_{0.1}$ and F_{max} because they are used in the text (unless they are removed entirely, as suggested above).
- MSST is defined as the "level of biomass", but reproductive output is also used in this document.
- Include stock complex definition (even if only a reference to NS1 Guidelines)
- Define time series jargon used in the document such as "moving window" and "trailing average"

Other Comments

- The document recommends the use of software (such as ASPM and JABBA) for its analytical benefits. While this recommendation is valuable, it is important to acknowledge that various software packages are available for similar purposes. The authors should consider whether technical guidance should explicitly endorse specific software packages. If such endorsements are appropriate, this should be considered throughout the document, and the software described and referenced appropriately in an appendix.

Future NS1 Revisions

The NRC (2014) found that National 1 Standard Guidelines operationalize the MSA with respect to overfishing and other aspects of the MSA. These guidelines are by necessity a blend of legal, policy, and scientific interpretations of the MSA. In some cases, however, alternative interpretations to those chosen would have been more reasonable from a scientific point of view. For example, there is a discontinuity in rebuilding times at 10 years (see Figure 2.3 below). This results from the specification that the rebuilding time "shall… not exceed 10 years, except in cases there the biology of the stock… dictate otherwise". The alternative when 10 years cannot be achieved is apparently 2 generation times. On scientific grounds alone, it is difficult to justify 10 years, or any other specific value, as a standard for rebuilding time, although 10 years is probably a reasonable time for many stocks. The NRC (2014) suggests alternatives to addressing this discontinuity as well as other issues to be considered for future revisions of the National Standard Guidelines.

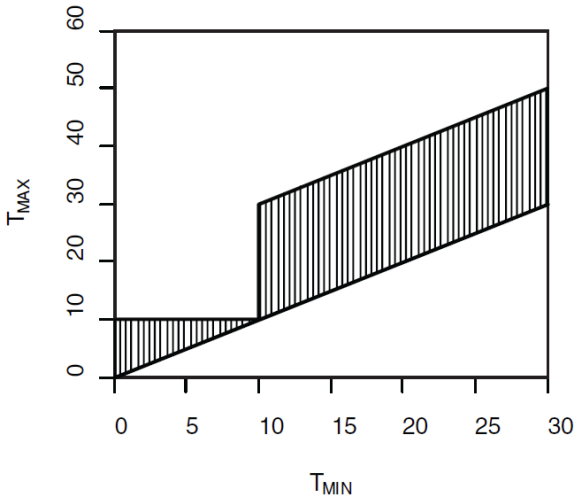

Figure 2.3 (From NRC 2014) shows the relationship between Tmin and Tmax, where T = time in years, for a stock with a generation time of 20 years. Ttarget must be selected from within the shaded region. The vertical line at Tmin = 10 years indicates the discontinuity in the specification of the time horizon available for rebuilding resulting from the addition of one generation time, once it is determined that the stock cannot rebuild within 10 years (i.e., Tmin>10).

Suggested References

Dorn, M. W., & Zador, S. G. (2020). A risk table to address concerns external to stock assessments when developing fisheries harvest recommendations. *Ecosystem Health and Sustainability, 6*(1), 1813634. doi:10.1080/20964129.2020.1813634

Karp, M. A., J. S. Link, M. Grezlik, S. Cadrin, G. Fay, P. Lynch, H. Townsend, R. D. Methot, et al. 2023. Increasing the uptake of multispecies models in fisheries management. ICES Journal of Marine Science, fsad001, https://doi.org/10.1093/icesjms/fsad001.

National Research Council. 2014. *Evaluating the Effectiveness of Fish Stock Rebuilding Plans in the United States*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18488.

Marshall, D.J., Bode, M., Mangel, M., Arlinghaus, R., and Dick, E.J. 2021. Reproductive hyperallometry and managing the world's fisheries. Proceedings of the National Academy of Sciences of the United States of America 118(34). doi:10.1073/pnas.2100695118

Privitera-Johnson, K. M., and Punt, A. É. (2020). Leveraging scientific uncertainty in fisheries management for estimating among-assessment variation in overfishing limits. *ICES Journal of Marine Science, 77*(2), 515–526. doi:10.1093/icesjms/fsz237.

Punt, A. E., and Szuwalski, C. (2012). How well can FMSY and BMSY be estimated using empirical measures of surplus production? Fisheries Research, 134–136:113–124, https://doi.org/https://doi.org/10.1016/j.fishres.2012.08.014.

Stewart, I. J., Hicks, A. C., & Carpi, P. (2021). Fully subscribed: Evaluating yield trade-offs among fishery sectors utilizing the Pacific halibut resource. Fisheries Research, 234(12), 10.1016/j.fishres.2020.105800.

Shertzer, K. W., M. H. Prager, and E. H. Williams. 2010. Probabilistic Approaches to Setting Acceptable Biological Catch and Annual Catch Targets for Multiple Years: Reconciling Methodology with National Standards Guidelines. *Marine and Coastal Fisheries*, 2(1): 451–458. doi:10.1577/C10-014.1.

Thorson, J.T., Dorn, M.W., and Hamel, O.S. 2018. Steepness for West Coast rockfishes: Results from a twelve-year experiment in iterative regional meta-analysis. Fisheries Research. doi:10.1016/j.fishres.2018.03.014.