Center for the Advancement of Population Assessment Methodology (CAPAM)

Biannual Report
July – December 2014

NOAA/IATTC/SIO
8901 La Jolla Shores Dr.
La Jolla, CA 92037, USA
www.CAPAMresearch.org

Background

The Center for the Advancement of Population Assessment Methodology (CAPAM) was formally established and began project work in February 2013. The CAPAM's mission involves research, education, and outreach that addresses animal population dynamics, models, and assessments associated with marine fishery resources. Presently, primary CAPAM staff includes: three principal investigators representing the three founding institutions, Mark Maunder (IATTC), Paul Crone (NOAA), and Brice Semmens (SIO); and one post-doctoral research scientist, Juan Valero (CAPAM). Graduate students at SIO are also involved with CAPAM in various capacities. Only Juan Valero's research position and some graduate research work are supported directly through CAPAM funds, with all other appointments, support, and services provided by the main institutions. Presently, one of the highest priorities for CAPAM is to establish a more formal infrastructure that allows administrative operations and research activities to be carried out as efficient as possible. Much work remains for solidifying and streamlining this effort, which will greatly assist identifying and processing funds for supporting project work conducted by staff and collaborators, preparing office and accommodation arrangements for visiting scientists, hosting and coordinating technical workshops/working groups/short courses, obtaining computer hardware and software necessary for conducting research projects, and ongoing website development. Deliverables associated with CAPAM projects are summarized in Appendix A. Finally, visit the CAPAM website for further information regarding the past, current, and future research activities and products (www.CAPAMresearch.org).

Programs and projects

Good practices in stock assessments modeling program

Presently, a major program for CAPAM is modeling research addressing the theories, estimators, and assumptions used in contemporary integrated stock assessment models, whereby 2-3 year research projects are conducted on important topics/parameterizations associated with developing stock assessments used to provide management advice on exploited marine populations.

Selectivity project
The first project focused on modeling selectivity in stock assessments. Selectivity research by CAPAM staff and collaborators included modeling work on functional forms (splines), alternative composition/selectivity choices and management, spatial structure, time-varying vs. -invariant selectivity, and diagnostics. A workshop (*Selectivity: theory, estimation, and application in fishery stock assessment models*) was held in March 2013 that was attended by over 70 fishery researchers from around the world (25 individuals also participated remotely via online access using WebEx meeting software). The 4-day workshop included 4 keynote and 26

research presentations, interactive technical sessions, and group discussions. Ultimately, the workshop represented an initial step involved in producing a timely, well summarized, and broadly available special issue in the professional literature on the topic of modeling selectivity in stock assessments.

- Workshop report and special issue publication: *Workshop Series Report 1* (selectivity) was published in fall 2013. A special issue in the journal *Fisheries Research* resulting from the March 2013 workshop on selectivity was published in fall 2014. The special issue contains 20 papers and a preface. Four papers were recently noted by the journal as being among the top 25 downloaded manuscripts. CAPAM staff and visiting scientists were involved in six of the publications.
- Good practices guide: Past and current selectivity research needs to be synthesized and included in the *Good Practices Guide* (GPG-selectivity). This will be accomplished by a formal working group that includes USA and international participation. The working group (WG) members have been selected and the first meeting was held via the internet in July 2014 using the online forum WebEx. The primary goal of the meeting was to discuss the approach for creating the selectivity section. The meeting resulted in the following recommendations: (1) the CAPAM staff will produce a preliminary draft of the GPG-selectivity that will be distributed to the WG for comments and suggested revisions; (2) based on the initial WG review, the CAPAM staff will produce a second draft of the GPG-selectivity (this version will also be made available for public review and comments); (3) a second (WebEx) meeting will be held to discuss completion and documentation of the final version of the GPG-selectivity; (4) the CAPAM staff will then prepare a final version that will be distributed broadly.
- Visiting scientists: Chris Francis, recently retired from New Zealand's National Institute of Water and Atmospheric Research, spent six-weeks from February to March, 2014 at the SWFSC and conducted research on data weighting in stock assessments. David Sampson from Oregon State University spent three-weeks from April to May 2014 at the SWFSC and conducted research on time-varying selectivity (see http://www.capamresearch.org/sites/default/files/Sampson-Report_for_CAPAM_Visiting_Scientist-2014.pdf).

Growth project
The second project under the Good practices in stock assessment modeling program has addressed *Growth: theory, estimation, and application in fishery stock assessment models*. A workshop was held in November 2014 that attracted over 100 scientists from around the world, as well as 20 scientists who participated through online arrangements. The 5-day workshop included 5 keynote and 30 research presentations, interactive technical sessions, and group discussions. Ultimately, the workshop represented an initial step involved in producing a timely, well summarized, and broadly available special issue in the professional literature on the topic of modeling growth in stock assessments.

- Workshop report and special issue publication: *Workshop Series Report 2* (growth) was published in spring 2015. A special issue in the journal *Fisheries Research* resulting from the workshop on growth is nearing completion and scheduled for publication in December 2015. The special issue is expected to include over 15 papers and a preface. CAPAM staff and visiting scientists are involved in five of the publications.

Data weighting project

The third project under the Good practices in stock assessment modeling program will address *Data conflict and weighting, likelihood functions, and process error*. A 5-day workshop will be held in October 2015 at the Southwest Fisheries Science Center in La Jolla, CA, which will include applied modeling sessions, keynote and research presentations, and focused discussions. Major topics will include data conflict and weighting, likelihood functions, temporal variation, and model misspecification. A workshop report (*Workshop Series Report 3* – data weighting) will be distributed in December 2015, followed by a special issue in *Fisheries Research* that is tentatively scheduled for publication in spring 2016. Finally, Dr. Felipe Carvalho (PIFSC) will be serving as a visiting scientist with CAPAM during September 2015 and working on research that will be presented at the workshop in October 2015.

Education and outreach

The CAPAM staff is involved with various projects supporting stock assessment and population dynamics education and mentoring. Notably, CAPAM principal investigators, researchers, and advisory panel members have served as instructors for undergraduate and graduate level coursework. These efforts have encouraged students to produce formal publications from their academic research and participate in professional workshops and related technical forums (e.g., CAPAM, WCSAM, AFS, etc.), as well as provided important hands-on training opportunities in assessment tools and techniques. The CAPAM education programs address goals highlighted in the newly established Quantitative Ecology and Socioeconomics Training (QUEST) program coordinated through NOAA/NMFS. A major goal of the QUEST program is to enhance education and training for the next generation of stock assessment researchers, ecosystem scientists, and marine resource economists.

Introduction to fisheries stock assessment short courses

CAPAM staff in collaboration with scientists from NOAA and other institutions have organized and conducted short courses on stock assessment in the USA and other countries. Short courses have been held in: Miami, January 27-29, 2014 at the University of Miami; Argentina, February 17-21, 2014, at the Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP); and Chile, March 3-7, 2014 at Universidad de Concepcion. Juan Valero's travel costs to teach the courses in Chile and Argentina were supported by NOAA Fisheries International Science Strategy. Dr Maunder's travel costs to teach the courses in Miami were supported by the

University of Miami. The materials developed for the courses in Argentina and Chile served as the basis for a stock assessment class conducted by Steve Teo (SWFSC) in La Jolla from June 24 to July 1, 2014.

Undergraduate and graduate level formal course instruction
Brice Semmens (SIO) taught two quantitative/modeling courses as part of the regular UCSD curriculum: Statistical Methods in Marine Biology (SIO 187, undergraduate), and Introduction to Bayesian Population Analysis (SIO 296, graduate). The undergraduate statistics course is a core class requirement for those students majoring in Marine Biology at SIO. The graduate level course addressed topics in mark-recapture analysis, hierarchical models, and state-space time-series analysis.

PhD Students Brian Stock and Lynn Waterhouse attended a short course in Newport, Oregon in September 2014 to learn ADMB as part of Andre Punt's (University of Washington) Fish559 course, Numerical Computing for the Natural Resources. Brian and Lynn remotely attended the remainder of the Fish559 course while at SIO through WebEx.

PhD Student Lynn Waterhouse remotely participated in University of Washington's Fish600 course taught by Melissa Haltuch and Owen Hamel of the Northwest Fisheries Science Center (NMFS). The intent of the course is to expose students to fishery stock assessment. The course helped provide a foundation for other work Lynn is doing with CAPAM research scientist, Juan Valero.

Graduate student and postdoctoral research mentoring
Graduate student and post-doctoral research associated with CAPAM programs has progressed substantially, in large part due to the active support, guidance, and mentoring from CAPAM personnel. Recent research activities follow.

White seabass assessment project
A collaborative project is underway with the Pfleger Institute of Environmental Research (PIER) and California Department of Fish and Wildlife (CDFW) on a white seabass (*Atractoscion nobilis*) stock assessment that will be formally reviewed and ultimately, used to assist management of the coastal population off southern California. Motivation for CAPAM's involvement with this project was to assist SIO's education-related goals to prepare students for stock assessment employment, and to develop joint projects that address marine resources actively managed by CDFW. The CAPAM research scientist, Juan Valero is currently working with SIO graduate student Lynn Waterhouse on this stock assessment. The assessment is expected to be completed and reviewed by Fall 2015.

Data-poor assessment methodologies for aggregating species
Graduate student Brian Stock is applying data-poor assessment methodologies for aggregating species where catch data are absent, as is often the case when conservation is the primary management concern. As part of his PhD research, Brian is extending a recently published method of estimating spawning potential ratio (SPR) for use on non-catch length-composition data. He plans to test the improved method using previously collected data from a Nassau grouper spawning aggregation.

Testing species distribution models' ability to predict spatiotemporal fisheries bycatch
Brian Stock is working with NMFS scientists at the NWFSC (Eric Ward) and SWFSC (Tomo Eguchi) to test the ability of recently developed spatial models to predict bycatch in two large fisheries observer datasets. Brian is comparing the new INLA-SPDE approach with other spatial modeling frameworks (GAMs, MaxEnt, and random forests), and will show how the models' performance differs across a broad range of bycatch rates. This work was funded by the NMFS Protected Species Toolbox from August 2014-July 2015.

Meta-analysis of US-wide fisheries using delay difference models
Lynn Waterhouse is conducting a meta-analysis of US-wide fisheries to assess the effectiveness of using delay difference models, possibly as an alternative for data-limited fisheries where state of the art stock assessments may not be possible. As part of her PhD research, Lynn is working with James Thorson (NWFSC) to use delay difference models applied to the NOAA trawl survey data (available through the OceanAdapt online portal) and regional level catch data to estimate biomass indices through time and to predict future indices.

Coastal angler tagging cooperative
SIO graduate student Lyall Bellquist is working with the recreational fishing community, the California Department of Fish and Game, and the San Diego Oceans Foundation to implement an assessment of *Paralabrax* spp. populations, vital rates, and movement patterns. The project aims to generate important demographic rate parameters used in stock assessments (e.g., mortality and growth). This information will help clarify *Paralabrax* spp. status and trends for the purpose of identifying appropriate population monitoring metrics for adaptive management.

Agent-based model for Southern Resident Killer Whales
In collaboration with colleagues at SWFSC and NWFSC, SIO/CAPAM postdoc Charlotte Boyd is developing a spatially-explicit individual based model (IBM) to explore the effects of changes in prey availability at various locations on the energy balances of endangered Southern Resident Killer Whales (*Orcinus orca*). This past year, Dr. Boyd focused primarily on developing the IBM framework in R. In the coming year, Dr. Boyd will develop a second-generation model designed to investigate one or more specific hypotheses on the relationship between habitat/prey attributes and killer whale survival and fecundity.

Research mentoring and collaborative work for data weighting workshop
The CAPAM staff is working collaboratively with graduate students from the University of Washington (UW) and scientists with the NWFSC on joint research projects that will be presented at the upcoming data weighting workshop in October 2015 (see above). It is expected that two to three papers from this collaborative work between CAPAM, UW, and the NWFSC will be submitted for publication in the special issue (data weighting, *Fisheries Research*).

APPENDIX A

Visiting scientists

- Dr. Sheng-Ping Wang. Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung, Taiwan. February 24 to March 24, 2013. Funded by the International Seafood Sustainability Foundation (ISSF).
- Dr. Chris Francis. Recently retired from New Zealand's National Institute of Water and Atmospheric Research. Six weeks (February-March 2014).
- Prof. David Sampson. Oregon State University. Three weeks (April-May 2014). See CAPAM website (http://www.capamresearch.org/sites/default/files/Sampson-Report_for_CAPAM_Visiting_Scientist-2014.pdf).

Presentations, short courses, collaborative work

- SIO PhD students Brian Stock and Lynn Waterhouse attended a 3-week Open Science for Synthesis workshop, July 21-August 8, 2014 at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, CA. The intensive training workshop focused on scientific computing and software, integrating statistical analysis with the use of open-source, community-supported programming languages.
- SIO PhD student Brian Stock attended the 99th Annual Meeting of the Ecological Society of America (ESA) from August 10-15, 2014 and gave a presentation entitled, "MixSIAR: Advanced stable isotope mixing models in R".
- SIO PhD student Lynn Waterhouse attended the Annual meeting of the American Fisheries Society (AFS) from August 17-22, 2014 and gave a presentation entitled, "One Fish, Two Fish: Evaluating an in Situ Visual Mark-Resighting Method to Assess the Abundance of Spawners at Fish Spawning Aggregation."
- SIO PhD student Lynn Waterhouse attended the Graybill/ENVR Conference, Modern Statistical Methods for Ecology, September 7-10, 2014, at Colorado State University in Fort Collins, Colorado and gave a speed presentation entitled, "Reconstructing population trends using a state space model based on an in situ mark-resighting method to assess the abundance of spawners at fish spawning aggregation."
- CAPAM Research Scientist Juan Valero taught a stock assessment course using the stock assessment platform Stock Synthesis in Chile, March 3-7, 2014 at the Universidad de Concepcion.
- CAPAM Research Scientist Juan Valero taught a stock assessment course using the stock assessment platform Stock Synthesis in Argentina, February 17-21, 2014 at the Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP).
- CAPAM PI Mark Maunder taught the course *Integrated Analysis Using Stock Synthesis: appropriate use of multiple data sets*, Miami, January 27-29, 2014 at the University of Miami.

- CAPAM Research Scientist Juan Valero taught the course Introduction to Fisheries Stock Assessment on December 9-13, 2013 at Scripps Institution of Oceanography, La Jolla CA, USA.
- CAPAM PI Mark Maunder attended the Workshop on Stock Assessment of Peruvian Small Pelagics as an invited expert, September 2-6, 2013, at the Instituto del Mar del Perú in Lima, Peru. He gave a presentation titled, "The current status of fisheries stock assessment."
- Presentations at the World Conference on Stock Assessment Methods (WCSAM) held in Boston July 15-19, 2013.
  - **Maunder, M. N.** *Challenges for fisheries stock assessment* (Keynote presentation).
  - **Crone, P.R.**, **J.L. Valero, M.N. Maunder, B.X. Semmens**. *Selectivity: theory, estimation, and application in fishery stock assessment models - Workshop overview.*
  - Hurtado-Ferro, F., **J.L. Valero**, C. Szuwalski, K. Johnson, C. McGilliard, C. Monahan, R. Licandeo, M. Muradian, A. Whitten, K. Ono, K. Vert-Pre, S. Anderson, C. Cunningham. *What generates retrospective patterns in statistical catch-at-age assessment models?*
  - Johnson, K., C. Monnahan, C. McGilliard, K. Vertpre, **J.L. Valero**, C. Szuwalski, R. Licandeo, M. Muradian, A. Whitten, K. Ono, S. Anderson, F. Hurtado Ferro, C. Cunningham. *Time-varying natural mortality in fisheries stock assessment models: identifying a default approach.*
  - Ono, K., K. Vert-Pre, S. Anderson, C. Cunningham, **J.L. Valero**, C. Szuwalski, K. Johnson, C. McGilliard, C. Monahan, F. Hurtado Ferro, R. Licandeo, M. Muradian, A. Whitten. *Better data yields better yields?: why the type, quantit,y and quality of data matters in fisheries stock assessments.*
  - **Valero, J.L.,** I. G. Taylor, **M.N. Maunder, P.R. Crone**. *Using simulation analysis to evaluate the use of cubic spline selectivity in integrated stock assessments.*
  - Whitten, A., C. McGilliard, **J.L. Valero**, S. Anderson, C. Cunningham, F. Hurtado Ferro, K. Johnson, R. Licandeo, C. Monnahan, M. Muradian, K. Ono, C. Szuwalksi, K. Vertpre. *Lessons Learned from a Stock Assessment Simulation Study.*

Publications (CAPAM staff in bold)

2015 (Listed here, given many papers were *in press* in 2014)

Aires-da-Silva, A., **M.N. Maunder**, K.M. Schaefer, D.W. Fuller. 2015. Improved growth estimates from integrated analysis of direct aging and tag-recapture data: an illustration with bigeye tuna (*Thunnus obesus*) of the eastern Pacific Ocean with implications for management. Fisheries Research 163:119-126.

Archer, S.K., J.E. Allgeier, **B.X. Semmens**, S.A. Heppell, C.V. Pattengill-Semmens, A.D. Rosemond, P.G. Bush, C.M. McCoy, B.C. Johnson, C.A. Layman. 2015. Hot moments in spawning aggregations: implications for ecosystem-scale nutrient cycling. Coral Reefs 34: 19-23.

Deroba, J.J., D.S. Butterworth, R.D. Methot, J.A.A. De Oliveira, C. Fernandez, A. Nielsen, S. X. Cardin, M. Dickey-Collas, C.M. Legault, J. Ianelli, **J.L. Valero**, C.L. Needle, J.M. O'Malley, Y.J. Chang, G.G. Thompson, C. Canales, D.P. Swain, D.C.M. Miller, N.T. Hintzen, M. Bertignac, L. Ibaibarriaga, A. Silva, A. Murta, L.T. Kell, C.L. de Moor, A.M. Parma, C.M. Dichmont, V.R. Restrepo, Y. Ye, E. Jardim, P.D. Spencer, D.H. Hanselman, J. Blaylock, M. Mood, P.J.F. Hulson. 2015. Simulation testing the robustness of stock assessment models to error: some results from the ICES Strategic Initiative on Stock Assessment Methods. ICES Journal of Marine Science 72:19-30.

Hurtado-Ferro, F., C. Szuwalski, J.L. **Valero**, S. Anderson, C. Cunningham, K. Johnson, R. Licandeo, C. McGilliard, C. Monnahan, M. Muradian, K. Ono, K. Vert-pre, A.R. Whitten. 2015. What generates retrospective patterns in statistical catch-at-age stock assessment models?. ICES Journal of Marine Science 72:99-110.

Hyun, S.Y., **M.N. Maunder**, B.J. Rothschild. 2015. Importance of modeling hetero-scedasticity of survey index data in fishery stock assessments. ICES Journal of Marine Science 72:130-136.

Johnson, K.F., C.C. Monnahan, C.R. McGilliard, K.A. Vert-pre, S.C. Anderson, C.J. Cunningham, F. Hurtado-Ferro, R. Licandeo, M. Muradian, K. Ono, C.S. Szuwalski, **J.L. Valero**, A.R. Whitten, A.E. Punt. 2015. Time-varying natural mortality in fisheries stock assessment models: identifying a default approach. ICES Journal of Marine Science 72:137-150.

Maunder, M.N., P.R. Crone, J.L. Valero, B.X. Semmens (Editors). 2015. Growth: theory, estimation, and application in fishery stock assessment models. Workshop Series Report 2. Center for the Advancement of Population Assessment Methodology (CAPAM). NOAA/IATTC/SIO, 8901 La Jolla Shores Dr., La Jolla, CA 92037. 55 p.

Maunder, M.N., R.B. Deriso, C.H. Hanson. 2015. Use of state-space population dynamics models in hypothesis testing: advantages over simple log-linear regressions for modeling survival, illustrated with application to longfin smelt (Spirinchus thaleichthys). Fisheries Research 164:102–111.

Maunder, M.N., K.R. Piner. 2015. Contemporary fisheries stock assessment: many issues still remain. ICES Journal of Marine Science 72:7-18.

Ono, K., R. Licandeo, M.L. Muradian, C.R. Cunningham, S.C. Anderson, F. Hurtado-Ferro, K.F. Johnson, C.F. McGilliard, C.F. Monnahan, C.S. Szuwalski, **J.L. Valero**, K.A. Vert-pre, A.R. Whitten, A.E. Punt. 2015. The importance of length and age composition data in statistical age-structured models for marine species. ICES Journal of Marine Science 72:31-43.

Scheuerell, M.D., E.R. Buhle, **B.X. Semmens**, M.J. Ford, T. Cooney, R.W. Carmichael. 2015. Analyzing large-scale conservation interventions with Bayesian hierarchical models: a case study of supplementing threatened Pacific salmon. Ecology and Evolution 5: 2115-2125.

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Carvalho, F., R. Ahrens, D. Murie, J.M. Ponciano, A. Aires-da-Silva, **M.N. Maunder,** F. Hazin. 2014. Incorporating specific change points in catchability in fisheries stock assessment models: An alternative approach applied to the blue shark (*Prionace glauca*) stock in the south Atlantic Ocean. Fisheries Research 154:135-146.

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Jackson, A. M., **B.X. Semmens**, Y.S. de Mitcheson, R.S. Nemeth, S.A. Heppell, P.G. Bush, Alfonso Aguilar-Perera, J.A. Claydon, M.C. Calosso, K.S. Sealey, M.T. Schärer, G. Bernardi. 2014. Population Structure and Phylogeography in Nassau Grouper (Epinephelus striatus), a Mass-Aggregating Marine Fish. PLOS ONE, 9: e97508.

Johnson, D.W.K. Grorud-Colvert, S. Sponaugle, **B.X. Semmens.** 2014. Phenotypic variation and selective mortality as major drivers of recruitment variability in fishes. Ecol. Lett. 17:743-755.

Thorson, J. T., M.D. Scheuerell, **B.X. Semmens**, C.V. Pattengill-Semmens. 2014. Demographic modeling of citizen science data informs habitat preferences and population dynamics of recovering fishes. Ecology 95(12): 3251-3258.

Wang, S.P., **M.N. Maunder**, T. Nishida, T., Y. R. Chen. 2014. Influence of model misspecification, temporal changes, and data weighting in stock assessment models: Application to swordfish (*Xiphias gladius*) in the Indian Ocean. Fisheries Research. DOI: 10.1016/j.fishres.2014.08.004

Special issue – Selectivity (*Fisheries Research, Vol. 158, 2014*)

Butterworth, D.S., R.A. Rademeyer, A. Brandão, H.F. Geromont, S.J. Johnston. 2014. Does selectivity matter? A fisheries management perspective. Fisheries Research, 158: 194-204.

Clark, W.G. 2014. Direct calculation of relative fishery and survey selectivities. Fisheries Research, 158: 135-137.

Crone, P.R., J.L. Valero. 2014. Evaluation of length- vs. age- composition data and associated selectivity assumptions used in stock assessments based on robustness of derived management quantities. Fisheries Research, 158: 165-171.

Hulson, P.J.F, D.H. Hanselman. 2014. Tradeoffs between bias, robustness, and common sense when choosing selectivity forms. Fisheries Research, 158: 63-73.

Hurtado-Ferro, F., A.E. Punt, K.T. Hill. 2014. Use of multiple selectivity patterns as a proxy for spatial structure. Fisheries Research, 158: 102-115.

Ichinokawa, M., H. Okamura, Y. Takeuchi. 2014. Data conflict caused by model mis-specification of selectivity in an integrated stock assessment model and its potential effects on stock status estimation. Fisheries Research, 158: 147-157.

Lee, H.H., K.R. Piner, R.D. Methot, **M.N. Maunder**. 2014. Use of likelihood profiling over a global scaling parameter to structure the population dynamics model: An example using blue marlin in the Pacific Ocean. Fisheries Research, 158: 138-146.

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Schueller, A.M., E.H. Williams, R.T. Cheshire. 2014. A proposed, tested, and applied adjustment to account for bias in growth parameter estimates due to selectivity. Fisheries Research, 158: 26-39.

Sharma, R., A. Langley, M. Herrera, J. Geehan, S.Y. Hyun. 2014. Investigating the influence of length–frequency data on the stock assessment of Indian Ocean bigeye tuna. Fisheries Research, 158: 50-62.

Stewart, I.J., S.J.D. Martell. 2014. A historical review of selectivity approaches and retrospective patterns in the Pacific halibut stock assessment. Fisheries Research, 158: 40-49.

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Waterhouse, L., D.B. Sampson, **M.N. Maunder, B.X. Semmens**. 2014. Using areas-as-fleets selectivity to model spatial fishing: Asymptotic curves are unlikely under equilibrium conditions. Fisheries Research, 158: 15-25.

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Crone, P.R., M.N. Maunder, J.L. Valero, J.D. McDaniel, B.X. Semmens (Editors). 2013. Selectivity: theory, estimation, and application in fishery stock assessment models. Workshop Series Report 1. Center for the Advancement of Population Assessment Methodology (CAPAM). NOAA/IATTC/SIO, 8901 La Jolla Shores Dr., La Jolla, CA 92037. 46 p.

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