

# **Fisheries Science**

AFS 415 - 3 credits

Fall 2016

## **Instructor**

Dr. Austin Humphries, Woodward Hall room 132, 401.874.9839, humphries@uri.edu, office hours MW 1-2pm or by appointment.

## **Meeting Time and Location**

Monday, Wednesday, and Friday, 11:00 - 11:50am in Davis Hall room 107.

## **Catalog Description**

Biology of aquatic resource animals, fisheries mensuration and assessment, fisheries ecology, fishing methods, aquatic resource management and conservation, fish and shellfish farming.

## **Course Narrative**

Fisheries science is a multidisciplinary field that uses principles in genetics, biology, ecology, oceanography, engineering, economics, human health, political science, anthropology, and sociology. Human needs shape the science that informs management of fisheries, which range in scale from artisanal to recreational to commercial. New fisheries continue to develop and many existing fisheries have supported sustainable harvest, human nutrition, and commerce for decades. The challenge for fisheries scientists is determining the largest yield (or catch) that can be taken from a species' stock over an indefinite period while minimizing negative ecosystem effects and satisfying a range of stakeholders.

## **Course Objective**

The objective of this course is to provide you with the background you need to solve problems in fisheries biology and management as it pertains to professional career opportunities. We will review the traditional range of concepts and approaches of fisheries science, but complement these with new avenues of science directed towards ecosystem-based management. You will learn about methods routinely used by fisheries professionals in the areas of individual fish growth, population growth, estimation of population numbers and biomass, and a few modeling techniques to determine the portion of the biomass that can be sustainably harvested.

Importantly, we will consider fisheries in an ecosystem context, thinking about the entire system including indirect interactions, biogeophysical forcings, and socioeconomic drivers and histories. The course objective is met through a combination of lectures, readings, discussions, homework, and individual or group problem-solving.

## **Student Learning Outcomes:**

By the end of the course, you will be able to:

- (1) identify important biological factors dictating fish populations,
- (2) recognize the role of environmental processes in fisheries science,
- (3) understand basic calculations that fisheries scientists use for management,
- (4) explain the need for ecosystem-based fisheries science, and
- (5) communicate controversial fisheries issues effectively.

## **Expectations and Requirements:**

This course is composed of *six elements*: homework, student-led class discussion (Pinocchio Test), two exams, a final comprehensive exam, and a seafood certification project. Two exams will be administered during the semester (15% each) and one final comprehensive exam (25%), and grading will be based on these, homework readings/assignments (15%), discussion on controversial fisheries papers (Pinocchio test; 15%), and a group project on seafood certification (15%).

*Homework assignments* will consist of four take-home quantitative exercises that will focus on estimating and modeling growth curves, stock recruitment, mark-recapture, and stock enhancement. You can work with classmates on these assignments and they are due two class periods after they are assigned, as indicated in the course schedule below. Each person (not one copy for the group) must turn in the assignment by hand, in class. I will also assign readings throughout the course that have 2-3 short-answer questions associated with them. I will collect responses to the short-answer questions randomly throughout the semester to make sure you are keeping up with readings. These questions are meant to guide your reading and inform discussion.

*Exams* are scheduled for **Oct 14 and Nov 18** and will be held outside of class to allow sufficient time so that you are not rushed. They will be a combination of short- and long-answer questions as well as some calculations. Please purchase and bring a simple calculator. If you are unable to take an exam due to illness, go to the infirmary (or other medical professional) and obtain a valid medical excuse in order to take a make-up exam (this rule also applies to the final exam). The final exam will be comprehensive over the whole semester. According to the University's final exam schedule, the final exam for this course will be given **Wednesday, Dec 14, from 8:00 am – 11:00 am**. Please incorporate this into your travel plans for end-of-the-semester travel. I do not intend to give this final or any alternate final exam at any other date or time.

*Student-led discussion* - Some fisheries scientists argue that a poorly reviewed literature has emerged in high impact journals such as *Science* and *Nature* that represents mission-oriented science. Does this recent high impact literature represent a biased agenda, or does it represent conservation biologists' valid criticisms on the views and science of recalcitrant fishery scientists and managers? What is the quality of this high impact science? The Pinocchio Test was adopted by the *Washington Post* and first applied to claims of presidential candidates. The scores come from their website at



<https://www.washingtonpost.com/news/fact-checker/about-the-fact-checker/>. I will identify controversial papers and published responses and distribute them throughout the course. These papers may include arguments on ecosystem level effects of fishing, evolutionary effects of fishing, unsustainable aquaculture, consumption hazards, or the demise of industrial fisheries. You and a partner will be responsible for leading a 40 minute discussion (20 minutes justifying Pinocchio ranking – 6-8 slides; 20 minutes leading a discussion on assumptions, interpretations, assertions, omissions of concern). I will help the team identify relevant literature (3-5 papers) in developing their fact-checking responses.

*Seafood certification project* - Consumer choice is a strong force shaping regulations and the rise and fall of fisheries. Informing consumers is an increasing recent priority, occurring through

Seafood Certification Programs. As an early example, consumer concerns about deaths of dolphins caused by tuna harvests resulted in an early US-sanctioned program, *Dolphin Safe*, which certified that fishing practices were not harming dolphins. A dominant and controversial entity, *Marine Stewardship Council*, has emerged in many parts of the world in certifying healthy stocks and sustainable harvesting practices. The project will comprise individual and team components. Individuals will become experts and work to review criteria used by the Marine Stewardship Council for a stock of regional and international importance. This review will incorporate course material but also outside scholarship on that species. Using an evaluation matrix that emulates that of the Marine Stewardship Council, the fishery teams will identify key scientific uncertainties and management challenges. At the end of the term, each team will provide a 15-20 minute presentation on findings.



### *Grading*

Your grade will be based on the following percentages:

Homework	15%
Discussion/Pinocchio test	15%
Seafood certification project	15%
Hour exam I	15%
Hour exam II	15%
Final exam	25%

Grade scale: A, 93-100; A-, 90-92; B+, 87-89; B, 83-86; B-, 80-82; C+, 77-79; C, 73-76; C-, 70-72; D+, 67-69; D, 63-66; F, 62 or below.

*Textbook* - No textbook is required for this course - electronic copies of readings will be provided via Sakai. However, a useful reference text is: Jennings, S. and M.J. Kaiser. 2001. *Marine Fisheries Ecology*. Blackwell, 432 p.

*Sakai* - The Sakai site for this course will contain the syllabus, all lecture presentations given in class, homework, readings, and any other course materials. Any announcements for the course will also be posted on the site.

### **Course Policies:**

*Late assignments and grading:* Late homework will be accepted and read but for each (calendar) day they are late, your grade will be reduced by 10%. Electronic submissions will not be accepted. All of the written assignments will receive feedback in the form of comments; these comments are intended to help you continue to expand your understanding of the course material as well as help explain your grade. Students who wish to dispute grades on assignments must do so in writing, indicating each issue that is disputed and the reasons a different grade should be considered. Please note that I may lower as well as raise grades after reviewing disputed assignments.

*Email:* Email messages will be responded to within 48 hours of being received. When relevant, student questions about similar topics/concerns may be answered in one group email. Questions about course material may also be addressed in class, rather than through an email, though in this

case the student who sent the email will be notified as such. Please do not email me after Friday about issues pertaining to the following Monday unless there is an emergency.

*Attendance:* Attendance is mandatory. You are allowed only *two excused* absences during the semester. Please arrive to class on time. If you arrive to class more than 10 minutes late, you will be marked absent for that meeting. Missing class will negatively affect your grade. Missing more than 4 classes will result in an F for your participation grade.

*Technology:* Out of respect for fellow classmates, cell phone use will not be allowed during class. I request, therefore, that you turn off your cell phones (or, *if* you are expecting an important call, set them to vibrate for the duration of section). Laptop computers will only be allowed in the section by special permission. Notes must be taken by hand unless you are unable to take notes due to a disability. If you are determined to work on a laptop in class, you must meet with me to discuss proper computer usage in a seminar setting. Proper usage includes closing all non-course related pages and tabs, viewing only the course readings/lecture slides, and using the laptop as a tool to guide learning as opposed to distraction.

*Discussion:* Throughout the course of the semester we will be addressing a variety of issues which people will have diverse opinions on. It is critical that we respect one another's thoughts, and address comments and ideas we may differ with and not the person that holds them. No demeaning or threatening language will be tolerated. Any student who feels uncomfortable in class should contact me outside of class to discuss the issue and to find an adequate resolution.

*Plagiarism:* All submitted work must be your own. If you consult other sources (class readings, articles or books from the library, articles available through internet databases, or websites) these MUST be properly documented, or you will be charged with plagiarism and will receive an F for the paper. In some cases, this may result in a failure of the course as well. In addition, the charge of academic dishonesty will go on your record in the Office of Student Life. If you have any doubt about what constitutes plagiarism, visit the following website: <http://isites.harvard.edu/icb/icb.do?keyword=k70847&pageid=icb.page342054> and the [UNIVERSITY MANUAL sections on Plagiarism and Cheating](#). Any good writer's handbook as well as reputable online resources will offer help on matters of plagiarism and instruct you on how to acknowledge source material. If you need more help understanding when to cite something or how to indicate your references, please ask.

*Disabilities:* Any student with a documented disability is welcome to contact me as early in the semester as possible so that we may arrange reasonable accommodations. As part of this process, please be in touch with Disability Services for Students Office at 330 Memorial Union, 401-874-2098.

*Academic Enhancement Center:* To do the best you can, it's a good idea to visit the Academic Enhancement Center (AEC) in Roosevelt Hall. The AEC offers a comfortable environment in which to study alone or together, with or without a tutor. AEC tutors can answer questions, clarify concepts, check understanding, and help you to study. You can make an appointment or walk in during office hours — Monday through Thursday from 9 am to 9 pm, Friday from 9 am to 1 pm, and Sunday from 4 pm to 8 pm. For a complete schedule – including when tutors are

available specifically for this class – go to [www.uri.edu/aec](http://www.uri.edu/aec), call (401) 874-2367, or stop by the fourth floor in Roosevelt Hall.






*The Writing Center:* The Writing Center is for “all writers, all disciplines, at all levels, and all stages of writing.” If an instructor suggests that you go to the Writing Center, it is not a punishment, and does mean that you are a terrible writer. It means the instructor wants you to receive more individualized attention to your writing than s/he is able to provide, given the constraints of the class. It will only improve your grade. If possible, call ahead for an appointment (401) 874-4690. Drop-in tutorials are often available. You may make repeat appointments, requesting the same tutor each time if you wish. See their webpage: <http://web.uri.edu/aec/writing/> for tips on how to make the best of your Writing Center visit.

*Religious Holidays:* It is the policy of the University of Rhode Island to accord students, on an individual basis, the opportunity to observe their traditional religious holidays. Students desiring to observe a holiday of special importance must provide written notification to the instructor.

### Schedule of classes\*

Date	Topic
Sept 7	Syllabus distribution and course introduction
Sept 9	No class – attend seminar by Dr. Peter Mous from The Nature Conservancy
Sept 12	Fish biology
Sept 14	Fisheries sampling
Sept 16	The aquatic environment
Sept 19	The aquatic environment
Sept 21	Ecological concepts
Sept 23	Ecological concepts & 🧑‍🎓 team 1 presentation
Sept 26	Ecological concepts
Sept 28	Age and growth – individuals
Sept 30	Age and growth – individuals (HW #1, due Oct 5)
Oct 3	Population dynamics
Oct 5	Population dynamics
Oct 7	The concept of fish stocks & 🧑‍🎓 team 2 presentation
Oct 10	*** Columbus Day holiday – classes do not meet ***
Oct 12	Stock identification
Oct 14	<b>Hour exam I – to be given late in the day, covering 9/11 – 10/7</b>
Oct 17	Survival and mortality
Oct 19	Recruitment (HW #2, due Oct 24)
Oct 21	Recruitment & 🧑‍🎓 team 3 presentation
Oct 24	Mark-recapture methods
Oct 26	Mark-recapture methods (HW #3, due Oct 31)
Oct 28	Fisheries yield models
Oct 31	Fisheries yield models
Nov 2	Fisheries yield models
Nov 4	Stock assessment & 🧑‍🎓 team 4 presentation
Nov 7	Stock assessment

Nov 9 Stock assessment  
 Nov 11 \*\*\* Veteran's Day holiday – classes do not meet \*\*\*  
 Nov 14 Stock enhancement & 🧑‍🎓 team 5 presentation  
 Nov 16 Stock enhancement (HW #4, due Nov 23)  
 Nov 18 **Hour exam II – to be given late in the day, covering 10/12 – 11/9**  
 Nov 21 Multispecies analysis  
 Nov 23 Ecosystem-based fisheries  
 Nov 25 \*\*\* Thanksgiving Break – classes do not meet \*\*\*  
 Nov 28 Ecosystem-based fisheries  
 Nov 30 Ecosystem-based fisheries & 🧑‍🎓 team 6 presentation

Dec 2 Seafood certification project   
 Dec 5 Seafood certification project   
 Dec 7 Seafood certification project   
 Dec 9 Seafood certification presentations   
 Dec 12 Seafood certification presentations 


**Final Exam: Wed, Dec 14, 8:00 – 11:00 am, in our classroom**


\* class topics are subject to change as deemed necessary


## Student-led Discussion on Controversial Fisheries Topics

Some fisheries scientists argue that a poorly reviewed literature has emerged in high impact journals such as *Science* and *Nature* that represents mission-oriented science. Does this recent high impact literature represent a biased agenda, or does it represent conservation biologists' valid criticisms on the views and science of recalcitrant fishery scientists and managers? *What is the quality of this high impact science?*


The Pinocchio Test was adopted by the *Washington Post* and first applied to claims of presidential candidates. The scores come from their website at <https://www.washingtonpost.com/news/fact-checker/about-the-fact-checker/>. For examples of how this is applied in the current US Presidential race, see the website at <http://www.washingtonpost.com/news/fact-checker/>.


 **One Pinocchio:** Some shading of the facts. Selective telling of the truth. Some omissions and exaggerations, but no outright falsehoods. (You could view this as “mostly true.”)

 **Two Pinocchios:** Significant omissions and/or exaggerations. Some factual error may be involved but not necessarily. A politician can create a false, misleading impression by playing with words and using legalistic language that means little to ordinary people. (Similar to “half true.”)

 **Three Pinocchios:** Significant factual error and/or obvious contradictions. This gets into the realm of “mostly false.” But it could include statements which are technically correct (such as based on official government data) but are so taken out of context as to be very misleading. The line between Two and Three can be bit fuzzy and we do not award half-Pinocchios. So we strive to explain the factors that tipped us toward a Three.

 **Four Pinocchios:** Whoppers.

 **The Geppetto Checkmark:** Statements and claims that contain “the truth, the whole truth, and nothing but the truth” will be recognized with our prized Geppetto checkmark.

 **An Upside-Down Pinocchio:** A statement that represents a clear but unacknowledged “flip-flop” from a previously-held position.





**Verdict Pending:** There are occasions when it is impossible to render a snap judgment because the issue is very complex or there are good arguments on both sides. In this case, we will withhold our judgment until we can gather more facts. We will use this website to shed as much light as possible on factual controversies that are not easily resolved.

All judgments are subject to debate and criticism from classmates, and *can be revised if fresh evidence emerges*.

You and a partner will be responsible for leading a 40-minute discussion (20 minutes justifying Pinocchio ranking – 6-10 slides; 20 minutes leading a discussion on assumptions, interpretations, assertions, omissions of concern). I will help the team identify relevant literature (3-5 papers) in developing their fact-checking responses.

Everyone in the class must read the seminal paper for each issue, complete the notes template handout, and develop 3 questions about the findings in the paper in preparation for the discussion.

**Topics and readings are as follows:**

**Are all marine fisheries going to be collapsed by 2048?**

\*Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., and Watson, R. 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science* 314: 787-790.

Branch, T.A. 2008. Not all fisheries will be collapsed in 2048. *Mar. Pol.* 32(1): 38-39.

\*Branch, T. A. 2013. Citation patterns of a controversial and high-impact paper: Worm et al. (2006) “Impacts of biodiversity loss on ocean ecosystem services”. *PLoS ONE* 8(2): e56723.

Briggs, J.C. 2007. Biodiversity loss in the ocean: how bad is it? *Science* 316: 1282.

Hilborn, R. 2007. Biodiversity loss in the ocean: how bad is it? *Science* 316: 1281-1282.

\*Hilborn, R. 2007. Reinterpreting the state of fisheries and their management. *Ecosystems* 10: 1362-1369.

\*Hilborn, R. 2007. Moving to sustainability by learning from successful fisheries. *Ambio* 36(4): 296-303.



Hölker, F., Beare, D., Dörner, H., di Natale, A., Rätz, H.-J., Temming, A., and Casey, J. 2007. Comment on “Impacts of biodiversity loss on ocean ecosystem services”. *Science* 316: 1285c.

Jaenike, J. 2007. Comment on “Impacts of biodiversity loss on ocean ecosystem services”. *Science* 316: 1285a.

Longhurst, A. 2007. Doubt and uncertainty in fishery science: Are we really headed for a global collapse of stocks? *Fish Res.* 86: 1-5.

Murawski, S.A., Methot, R., and Tromble, G. 2007. Biodiversity loss in the ocean: how bad is it? *Science* 316: 1281.

Stokstad, E. 2009. Détente in the fisheries war. *Science* 324: 170-171.

Wilberg, M.J., and Miller, T.J. 2007. Comment on “Impacts of biodiversity loss on ocean ecosystem services”. *Science* 316: 1285b.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., and Watson, R. 2007. Response to comment on “Impacts of biodiversity loss on ocean ecosystem services”. *Science* 316: 1285d.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., and Watson, R. 2007. Response. *Science* 316: 1282-1284.

\*Worm, B., Hilborn, R., Baum, J.K., Branch, T.A., Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E.A., Hutchings, J.A., Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A.A., Watson, R., and Zeller, D. 2009. Rebuilding global fisheries. *Science* 325: 578-585.

### **Should fisheries involve balanced harvesting across all species, or be selective?**

Andersen, K. H., J. L. Blanchard, E. A. Fulton, H. Gislason, N. S. Jacobsen, and T. van Kooten. 2016. Assumptions behind size-based ecosystem models are realistic. *ICES Journal of Marine Science* doi: 10.1093/icesjms/fsv211.

Breen, M., N. Graham, M. Pol, P. He, D. Reid, and P. Suuronen. 2016. Selective fishing and balanced harvesting. *Fisheries Research* doi: 10.1016/j.fishres.2016.03.014.

\*Burgess, M. G., F. K. Diekert, N. S. Jacobsen, K. H. Andersen, and S. D. Gaines. 2015. Remaining questions in the case for balanced harvesting. *Fish and Fisheries* 10.1111/faf.12123.

Charles, A., S. M. Garcia, and J. Rice. 2015. Balanced harvesting in fisheries: economic considerations. *ICES Journal of Marine Science* doi: 10.1093/icesjms/fsv161.

\*Froese, R., C. Walters, D. Pauly, H. Winker, O. L. F. Weyl, N. Demirel, A. C. Tsikliras, and S. J. Holt. 2015. A critique of the balanced harvesting approach to fishing. *ICES Journal of Marine Science* doi: 10.1093/icesjms/fsv122.

\*Garcia, S. M., J. Kolding, J. Rice, M.-J. Rochet, S. Zhou, T. Arimoto, J. E. Beyer, L. Borges, A. Bundy, D. Dunn, E. A. Fulton, M. Hall, M. Heino, R. Law, M. Makino, A. D. Rijnsdorp, F. Simard, and A. D. M. Smith. 2012. Reconsidering the consequences of selective fisheries. *Science* 335:1045-1047.

Garcia, S. M., J. Rice, and A. Charles. 2015. Balanced harvesting in fisheries: a preliminary analysis of management implications. *ICES Journal of Marine Science* doi: 10.1093/icesjms/fsv156.

\*Jacobsen, N. S., H. Gislason, and K. H. Andersen. 2014. The consequences of balanced harvesting of fish communities. *Proceedings of the Royal Society B* 281:20132701.

Kolding, J., S. M. Garcia, S. Zhou, and M. Heino. 2016. Balanced harvest: utopia, failure, or a functional strategy? *ICES Journal of Marine Science* doi: 10.1093/icesjms/fsw060.

Law, R., M. J. Plank, and J. Kolding. 2012. On balanced exploitation of marine ecosystems: results from dynamic size spectra. *ICES Journal of Marine Science* 69:602-614.

\*Kolding, J. and P. A. M. van Zwieten. 2011. The tragedy of our legacy: How do global management discourses affect small-scale fisheries in the South? *Forum for Development Studies* 38:235-265.

Kolding, J. and P. A. M. Van Zwieten. 2014. Sustainable fishing of inland waters. *Journal of Limnology* 73(s1):132-148.

\*Law, R., J. Kolding, and M. J. Plank. 2015. Squaring the circle: reconciling fishing and conservation of aquatic ecosystems. *Fish and Fisheries* 16:160-174.

Law, R., M. J. Plank, and J. Kolding. 2015. Balanced exploitation and coexistence of interacting, size-structured, fish species. *Fish and Fisheries* doi: 10.1111/faf.12098

Pauly, D., R. Froese, and S. J. Holt. 2016. Balanced harvesting: the institutional incompatibilities. *Marine Policy* 69:121-123.

\*Zhou, S., A. D. M. Smith, and E. E. Knudsen. 2015. Ending overfishing while catching more fish. *Fish and Fisheries* doi:10.1111/faf.12077.

\*Zhou, S., A. D. M. Smith, A. E. Punt, A. J. Richardson, M. Gibbs, E. A. Fulton, S. Pascoe, C. Bulman, P. Bayliss, and K. Sainsbury. 2010. Ecosystem-based fisheries management requires a change to the selective fishing philosophy. *Proceedings of the National Academy of Sciences U.S.A.* 107:9485-9489.

### **Can fishery stock status be inferred reliably from catches alone?**

Agnew, D. J., N. L. Gutiérrez, and D. S. Butterworth. 2013. Fish catch data: less than what meets the eye. *Marine Policy* 42:268-269.

Anderson, S. C., T. A. Branch, D. Ricard, and H. K. Lotze. 2012. Assessing global marine fishery status with a revised dynamic catch-based method and stock-assessment reference points. *ICES Journal of Marine Science* 69:1491-1500.

\*Branch, T.A., Jensen, O.P., Ricard, D., Ye, Y., and Hilborn, R. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. *Cons Biol* 25(4): 777-786.

\*Carruthers, T.R., Walters, C.J., and McAllister, M.K. 2012. Evaluating methods that classify fisheries stock status using only fisheries catch data. *Fish Res.* 119-120: 66-79.

Cook, R. M. 2013. A comment on “What catch data can tell us about the status of global fisheries” (Froese et al. 2012). *Marine Biology* 160:1761-1763.

Costello, C., O. Deschênes, A. Larsen, and S. Gaines. 2013. Removing biases in forecasts of fishery status. *Journal of Bioeconomics* doi: 10.1007/s10818-013-9158-4.

Costello, C., D. Ovando, R. Hilborn, S. D. Gaines, O. Deschenes, and S. E. Lester. 2012. Status and solutions for the world's unassessed fisheries. *Science* 338:517-520.

Daan, N., Gislason, H., Pope, J.G., and Rice, J.C. 2011. Apocalypse in world fisheries? The reports of their death are greatly exaggerated. *ICES J. Mar. Sci.* 68(7): 1375-1378.

\*Froese, R., and Kesner-Reyes, K. 2002. Impact of fishing on the abundance of marine species. *ICES paper CM 2002/L:12*: 15pp.

\*Froese, R., D. Zeller, K. Kleisner, and D. Pauly. 2012. What catch data can tell us about the status of global fisheries. *Marine Biology* 159:1283-1292.

Froese, R., D. Zeller, K. Kleisner, and D. Pauly. 2013. Worrisome trends in global stock status continue unabated: a response to a comment by R.M. Cook on “What catch data can tell us about the status of global fisheries”. *Marine Biology* 160:2531-2533.

\*Hilborn, R. and T. A. Branch. 2013. Does catch reflect abundance? No, it is misleading. *Nature* 494:303-306.

\*Kleisner, K., Zeller, D., Froese, R., and Pauly, D. 2013. Using global catch data for inferences on the world's marine fisheries. *Fish and Fisheries* 14:293-311.

Martell, S. and R. Froese. 2012. A simple method for estimating MSY from catch and resilience. *Fish and Fisheries* doi: 10.1111/j.1467-2979.2012.00485.x.

Pauly, D. 2007. The Sea Around Us project: documenting and communicating global fisheries impacts on marine ecosystems. *Ambio* 34: 290-295.

Pauly, D. 2008. Global fisheries: a brief review. *Journal of Biological Research-Thessaloniki* 9: 3-9.

\*Pauly, D. 2013. Does catch reflect abundance? Yes, it is a crucial signal. *Nature* 494:303-306.

Pauly, D & D. Zeller. 2014. Accurate catches and the sustainability of coral reef fisheries. *Current Opinion in Environmental Sustainability* 7:44-51.

Srinivasan, U. T., W. W. L. Cheung, R. A. Watson, and U. R. Sumaila. 2013. Response to removing biases in forecasts of fishery status. *Journal of Bioeconomics* doi: 10.1007/s10818-013-9160-x.

Thorson, J.T., Branch, T.A., and Jensen, O.P. 2012. Using model-based inference to evaluate global fisheries status from landings, location, and life history data. *Can. J. Fish. Aquat. Sci.* 69: 645-655.

### **Are catch-share fisheries a good thing?**

*Catch share = individual transferable quotas = ITQ = IFQ = IVQ = cooperatives, etc.*

\*Branch, T. A. 2009. How do individual transferable quotas affect marine ecosystems? *Fish and Fisheries* 10:39-57.

\*Bromley, D. W. 2009. Abdicating responsibility: the deceptions of fisheries policy. *Fisheries* 34:280-290.

Bromley, D. W. 2009. The author replies. *Fisheries* 34:299-302.

\*Copes, P. 1986. A critical review of the Individual Quota as a device in fisheries management. *Land Economics* 62:278-291.

\*Costello, C., S. D. Gaines, and J. Lynham. 2008. Can catch shares prevent fisheries collapse? *Science* 321:1678-1681.

Essington, T. E. 2010. Ecological indicators display reduced variation in North American catch share fisheries. *Proceedings of the National Academy of Sciences U.S.A.* 107:754-759.

Essington, T. E., M. C. Melnychuk, T. A. Branch, S. S. Heppell, O. P. Jensen, J. S. Link, S. J. D. Martell, A. M. Parma, J. G. Pope, and A. D. M. Smith. 2012. Catch shares, fisheries, and ecological stewardship: a comparative analysis of resource responses to a rights-based policy instrument. *Conservation Letters* 5:186-195.

Grafton, R. Q., C. Costello, R. Hilborn, and T. Kompas. 2009. Comment on “Abdicating responsibility: the deceits of fisheries policy”. *Fisheries* 34:291-294.

\*Macinko, S. and D. W. Bromley. 2002. Who owns America’s fisheries? Center for Resource Economics, Covelo, California.

McCormack, F. 2016. Sustainability in New Zealand’s quota management system: A convenient story. *Marine Policy* doi: 10.1016/j.marpol.2016.06.022.

\*Melnychuk, M. C., T. E. Essington, T. A. Branch, S. S. Heppell, O. P. Jensen, J. S. Link, S. J. D. Martell, A. M. Parma, J. G. Pope, and A. D. M. Smith. 2012. Can catch share fisheries better track management targets? *Fish and Fisheries* 13:267-290.

Pinkerton, E. and D. N. Edwards. 2009. The elephant in the room: the hidden costs of leasing individual transferable fishing quotas. *Marine Policy* 33:707-713.

Turris, B. R. 2010. A rejoinder to E. Pinkerton et al., the elephant in the room: the hidden costs of leasing individual transferable fishing quotas. *Marine Policy* 34:431-436.

### **Is fishing down marine food webs a pervasive phenomenon in marine ecosystems?**

\*Alleway, H.K., Connell, S.D., Ward, T.M., Gillanders, B.M. 2014. Historical changes in mean trophic level of southern Australian fisheries. *Marine and Freshwater Research* 65, 884-893.

Branch, T. A. 2012. FAO’s State of Fisheries and Aquaculture: correcting some misrepresentations by Pauly and Froese. *Marine Policy* 36:1191-1192.

\*Branch, T.A., Watson, R., Fulton, E.A., Jennings, S., McGilliard, C.R., Pablico, G.T., Ricard, D., and Tracey, S.R. 2010. The trophic fingerprint of marine fisheries. *Nature* 468: 431-435.

\*Branch, T. A. 2015. Fishing impacts on food webs: multiple working hypotheses. *Fisheries* 40:373-375.

Caddy, J.F., Csirke, J., Garcia, S.M., and Grainger, R.J.R. 1998. How pervasive is “Fishing down marine food webs”? *Science* 282: 1383a.

\*Christensen, V. 2015. Fishing down through the food web. *Fisheries* 40:370-372.

de Mutsert, K., Cowan Jr, J.H., Essington, T.E., and Hilborn, R. 2008. Reanalyses of Gulf of Mexico fisheries data: Landings can be misleading in assessments of fisheries and fisheries ecosystems. *Proc. Natl Acad. Sci. U.S.A.* 105: 2740-2744.

\*Essington, T.E., Beaudreau, A.H., and Wiedenmann, J. 2006. Fishing through marine food webs. *Proc. Natl Acad. Sci. U.S.A.* 103(9): 3171-3175.

Foley, C. M. R. 2013. Management implications of fishing up, down, or through the marine food web. *Marine Policy* 37:176-182.

Hornborg, S., A. Belgrano, V. Bartolino, D. Valentinsson, and F. Ziegler. 2013. Trophic indicators in fisheries: a call for re-evaluation. *Biology Letters* 9: 20121050. doi: 10.1098/rsbl.2012.1050.

\*Kleisner, K., H. Mansour, and D. Pauly. 2014. Region-based MTI: resolving geographic expansion in the Marine Trophic Index. *Marine Ecology Progress Series* 512:185-199.

Levin, P.S., and Dufault, A. 2010. Eating up the food web. *Fish Fish.* 11: 307-312.

Litzow, M.A., and Urban, D. 2009. Fishing through (and up) Alaskan food webs. *Can. J. Fish. Aquat. Sci.* 66: 201-211.

\*Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres Jr, F. 1998. Fishing down marine food webs. *Science* 279: 860-863.

Pauly, D., Froese, R., and Christensen, V. 1998. Response to “How pervasive is fishing down marine food webs”? *Science* 282: 1383a.

Pauly, D., and Palomares, M.-L. 2005. Fishing down marine food web: it is far more pervasive than we thought. *Bull. Mar. Sci.* 76(2): 197-211.

Pauly, D., and Watson, R. 2005. Background and interpretation of the ‘Marine Trophic Index’ as a measure of biodiversity. *Philos. T. Roy. Soc. B* 360: 415-423.

Rountos, K.J., Frisk, M.G., Pikitch, E.K. 2015 Are we catching what they eat? Moving beyond trends in the mean trophic level of catch. *Fisheries* 40:376-385.

\*Sethi, S.A., Branch, T.A., and Watson, R. 2010. Fishery development patterns are driven by profit but not trophic level. *Proc. Natl Acad. Sci. U.S.A.* 107: 12163-12167.

Stergiou, K. I. and A. C. Tsikliras. 2011. Fishing down, fishing through and fishing up: fundamental process versus technical details. *Marine Ecology Progress Series* 441:295-301.

Tsikliras, A. C., K. I. Stergiou, N. Adamopoulos, D. Pauly, and E. Mente. 2014. Shift in trophic level of Mediterranean mariculture species. *Conservation Biology* doi:10.1111/cobi.12276.

Wilén, C. D. and J. E. Wilén. 2012. Fishing down the food chain revisited: Modeling exploited trophic systems. *Ecological Economics* 79:80-88.

### **What is the current global status of marine fisheries**

\*Branch, T.A., Jensen, O.P., Ricard, D., Ye, Y., and Hilborn, R. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. *Cons Biol* 25(4): 777-786.

Branch, T. A., J. D. Austin, K. Acevedo-Whitehouse, I. J. Gordon, M. E. Gompper, T. E. Katzner, and N. Pettorelli. 2012. Fisheries conservation and management: finding consensus in the midst of competing paradigms. *Animal Conservation* 15:1-3.

Burgess, M. G. and G. R. McDermott. 2015. Resolving disputes over ocean calamities. *BioScience* doi: 10.1093/biosci/biv147.

\*Christensen, V., M. Coll, C. Piroddi, J. Steenbeek, J. Buszowski, and D. Pauly. 2014. A century of fish biomass decline in the ocean. *Marine Ecology Progress Series* 512:155-166.

Duarte, C. M., R. W. Fulweiler, C. E. Lovelock, J. M. Pandolfi, P. Martinetto, M. I. Saunders, and S. Gelcich. 2015. Ocean calamities: delineating the boundaries between scientific evidence and belief. *BioScience* doi: 10.1093/biosci/biv088.

\*FAO. 2014. The state of world fisheries and aquaculture 2014. Food and Agriculture Organization of the United Nations, Rome.

Hilborn, R. 2006. Faith-based fisheries. *Fisheries* 31(11): 554-555.

Hilborn, R. 2007. Faith, evolution, and the burden of proof. *Fisheries* 32(2): 90-93.

Hilborn, R. 2007. Reinterpreting the state of fisheries and their management. *Ecosystems* 10: 1362-1369.



Hilborn, R. 2010. Apocalypse forestalled: why all the world's fisheries aren't collapsing. *The Science Chronicles* November 2010: 5-9.

Hilborn, R., and Stokes, K. 2010. Defining overfished stocks: have we lost the plot? *Fisheries* 35(3): 113-120.

Hilborn, R., Branch, T.A., Ernst, B., Magnusson, A., Minte-Vera, C.V., Scheuerell, M.D., and Valero, J.L. 2003. State of the world's fisheries. *Annu. Rev. Environ. Resour.* 28: 359-399.

Hutchings, J.A., Minto, C., Ricard, D., Baum, J.K., and Jensen, O.P. 2010. Trends in the abundance of marine fishes. *Can. J. Fish. Aquat. Sci.* 67: 1205-1210.

Jacquet, J., J. Estes, J. Jackson, A. E. Johnson, N. Knowlton, L. McClenachan, D. Pauly, and E. Sala. 2015. Ocean calamities: hyped litany or legitimate concern? *BioScience* doi: 10.1093/biosci/biv087.

\*Pauly, D., Christensen, V., Gu nette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R., and Zeller, D. 2002. Towards sustainability in world fisheries. *Nature* 418: 689-695.

Pauly, D. 2009. Aquacalypse now: the end of fish. *The New Republic* 28 September 2009. Available at [www.tnr.com/article/environment-energy/aquacalypse-now](http://www.tnr.com/article/environment-energy/aquacalypse-now).

Pauly, D. 2009. Beyond duplicity and ignorance in global fisheries. *Scientia Marina* 73(2): 215-224.

Pitcher, T. J. and W. W. L. Cheung. 2013. Fisheries: Hope or despair? *Marine Pollution Bulletin* doi: 10.1016/j.marpolbul.2013.05.045.

\*Worm, B. and T. A. Branch. 2012. The future of fish. *Trends in Ecology and Evolution* 27:594-599.

\*Worm, B., R. Hilborn, J. K. Baum, T. A. Branch, J. S. Collie, C. Costello, M. J. Fogarty, E. A. Fulton, J. A. Hutchings, S. Jennings, O. P. Jensen, H. K. Lotze, P. M. Mace, T. R. McClanahan, C. Minto, S. R. Palumbi, A. M. Parma, D. Ricard, A. A. Rosenberg, R. Watson, and D. Zeller. 2009. Rebuilding global fisheries. *Science* 325:578-585.

### **Does the Marine Stewardship Council effectively identify sustainable fisheries?**

\*Jacquet, J., D. Pauly, D. Ainley, S. Holt, P. Dayton, and J. Jackson. 2010. Seafood stewardship in crisis. *Nature* 467:28-29.

Agnew, D. J., N. L. Gutiérrez, A. Stern-Pirlot, A. D. M. Smith, C. Zimmermann, and K. Sainsbury. 2013. Rebuttal to Froese and Proelss "Evaluation and legal assessment of certified seafood". *Marine Policy* 38:551-553.

\*Agnew, D. J., N. L. Gutiérrez, A. Stern-Pirlot, and D. D. Hoggarth. 2013. The MSC experience: developing an operational certification standard and a market incentive to improve fishery sustainability. *ICES Journal of Marine Science* doi:10.1093/icesjms/fst091.

Christian, C., D. Ainley, M. Bailey, P. Dayton, J. Hocevar, M. LeVin, J. Nikoloyuk, C. Nouvian, E. Velarde, R. Werner, and J. Jacquet. 2013. A review of formal objections to Marine Stewardship Council fisheries certifications. *Biological Conservation* 161:10-17.

\*Froese, R. and A. Proelss. 2012. Evaluation and legal assessment of certified seafood. *Marine Policy* 36:1284-1289.

Froese, R. and A. Proelss. 2013. Is a stock overfished if it is depleted by overfishing? A response to the rebuttal of Agnew et al. to Froese and Proelss "Evaluation and legal assessment of certified seafood". *Marine Policy* 38:548-550.

\*Gutiérrez, N. L., S. R. Valencia, T. A. Branch, D. J. Agnew, J. K. Baum, P. L. Bianchi, J. Cornejo-Donoso, C. Costello, O. Defeo, T. E. Essington, R. Hilborn, D. D. Hoggarth, A. E. Larsen, C. Ninnes, K. Sainsbury, R. L. Selden, S. Sistla, A. D. M. Smith, A. Stern-Pirlot, S. J. Teck, J. T. Thorson, and N. E. Williams. 2012. Eco-label conveys reliable information on fish stock health to seafood consumers. *PLoS ONE* 7(8):e43765.

Gutiérrez, N. L. and D. J. Agnew. 2013 in press. MSC objection process improves fishery certification assessments: A comment to Christian et al. (2013). *Biological Conservation* doi: 10.1016/j.biocon.2013.06.002.

Hilborn, R. and J. H. Cowan Jr. 2010. Marine Stewardship: high bar for seafood. *Nature* 467:531.

Hough, A. and P. Knapman. 2010. Marine stewardship: fair and impartial. *Nature* 467:531.

Kaiser, M. J. and L. Hill. 2010. Marine stewardship: a force for good. *Nature* 467:531.

### **Have large predatory fish declined by 90% in the world's oceans?**

\*Myers, R.A., and Worm, B. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423: 280-283.

\*Hampton, J., Sibert, J.R., Kleiber, P., Maunder, M.N., and Harley, S.J. 2005. Decline of Pacific tuna populations exaggerated? *Nature* 434: E1-E2.

\*Juan-Jordá, M.J., Mosqueira, I., Cooper, A.B., Freire, J., and Dulvy, N.K. 2011. Global population trajectories of tunas and their relatives. *Proc. Natl Acad. Sci. U.S.A.* 108: 20650-20655.

Maunder, M.N., Sibert, J.R., Fonteneau, A., Hampton, J., Kleiber, P., and Harley, S.J. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. *ICES J. Mar. Sci.* 63: 1373-1385.

Myers, R.A., and Worm, B. 2005. Decline of Pacific tuna populations exaggerated? - Reply. *Nature* 434: E2. doi:10.1038/nature03582.

Polacheck, T. 2006. Tuna longline catch rates in the Indian Ocean: Did industrial fishing result in a 90% rapid decline in the abundance of large predatory species? *Mar. Pol.* 30: 470-482.

\*Sibert, J., Hampton, J., Kleiber, P., and Maunder, M. 2006. Biomass, size, and trophic status of top predators in the Pacific Ocean. *Science* 314: 1773-1776.

Sibert, J., Hampton, J., Kleiber, P., and Maunder, M. 2007. Response. *Science* 316: 201.

Walters, C. 2003. Folly and fantasy in the analysis of spatial catch rate data. *Can. J. Fish. Aquat. Sci.* 60: 1433-1436.