CIEE Global Institute- Cape Town

Course name:	Fisheries Biology and Sustainability
Course number:	(GI) ENVI 3005 CTSA
Programs offering course:	Cape Town Open Campus
Open campus track:	STEM and Society
Language of instruction:	English
U.S. semester credits:	3
Contact hours:	45
Term:	Fall 2019

Course Description

This course studies the state of commercial fishing and how fish populations can be managed more sustainably. Students explore how humans have traditionally exploited populations of fish and other aquatic organisms. They use data and statistics to assess the current state of fish populations and to model future scenarios. Theory and methods of defining fish growth, survival, mortality, abundance, and community interactions will be emphasized. Both freshwater and marine fisheries will be addressed, with other commercially important marine species harvested by humans, as well as bycatch. Students will explore drivers of unsustainable practices, including the role of culture. Students are expected to critique and create suggestions for more sustainable harvest considering biological principles, technology and market forces.

Learning Objectives

By participating in this course, students will:

- Model dynamics of fish populations.
- Estimate fish abundance from mark-recapture and depletion data, mortality rates from catch-at-large data and growth rates from length-at-catch data.
- Explore key attributes of fish in ecosystems, including diversity, structural complexity, productivity, food webs and movement of energy through aquatic ecosystems.
- Fit and interpret stock-recruitment curves
- Compute and interpret length frequency summaries, size structure indices and condition indices
- Describe key components of past fishing practices, including the concept of common property and the role of culture, and tie them to declining fish populations
- Appraise and describe the health of current fish stocks and the impact of commercial fishing practices on bycatch and postharvest losses
- Outline components and steps in contemporary fisheries management and aquaculture

- Recommend how fisheries management can be more sustainable using knowledge of fish biology, fisheries science, critical thinking and adaptive management principles
- Communicate principles of sustainable fisheries biology and their real-world applications

Course Prerequisites

Introductory Biology, Environmental Science, Conservation, or Wildlife Management course

Methods of Instruction

This course is taught through lecture, activities, guest lectures, discussions and small group or individual assignments. Audiovisual material and site visits will augment the learning experience. The student may at any time seek additional guidance in office hours (TBD) or by scheduling an appointment with the instructor via Canvas.

Assessment and Grading

Class Participation	20%
State of World Fisheries Presentations	5%
Population Abundance and Indices Worksheet	10%
Aquarium Visit Worksheet	5%
Current Fish Stock Appraisal	15%
Research paper on human impacts	15%
Fish as Sustainable Food Investigation	10%
Final Exam	20%

Participation

Participation is valued as meaningful contribution in the digital and physical classroom, utilizing the resources and materials presented to students as part of the course. Meaningful contribution requires students to be prepared in advance of each class session and to have regular attendance. Students must clearly demonstrate they have engaged with the materials as directed, for example, through classroom discussions, written assignments, peer-to-peer feedback (after presentations), interaction with guest speakers, and attentiveness on co-curricular and outside-of-classroom activities.

State of World Fisheries Presentations

Using online resources and the FAO report on World Fisheries and Aquaculture: Meeting the Sustainable Development Goals (2018), students will work in groups to present the state of world fisheries. Each group will explore related facets of aquatic species for commerce, including captive fish production, aquaculture production, the status of fishery resources, fish utilization and processing, fish

trade, fish consumption and governance/policy. This will serve as an introduction to exploring fisheries and how they can be made more sustainable. Each presentation will be 10 minutes using PowerPoint. Presentations must include facts, figures, graphics, photos and video highlighting major points.

Population Abundance and Indices Worksheet

Individual students will apply biological principles and statistical tools to actual past and current data sets. In doing so, they will calculate fish population growth rates, as well as abundance and mortality rates for several wild species of commercial interest. Students will use other data to fit and interpret stock-recruitment curves. Finally, they compute and interpret length frequency summaries, size structure indices and condition indices for a commercially important freshwater or marine species.

Aquarium Visit Worksheet

Students will independently visit the Aquarium to observe fish behavior, diet, interactions and morphology. While there, they will take special note of commercially important groups of fish and reflect on how their life histories and ecology differ, making some more likely candidates for sustainable harvest. They will complete a guided worksheet to fill in pertinent information on life history traits of different major fish groups. There will also be space for them to articulate which fish commercial fish groups are best candidates for sustainable harvest and why.

Current Fish Stocks Appraisal

Using Cadima (2003), students will take actual data found online to appraise the past and current state of a commercial fish or non-fish species. Students will consider both linear and exponential models, calculate biomass and yield, short-term and long-term projections of the stock, the stock-recruitment relation, biological limit and target reference points.

Research paper on human impacts

Students will produce a report of 1500 - 2000 words, summarizing human impacts on commercial fish and non-fish species. Students must use data from at least five published reports from professional journals. This report can focus on a single human driver of aquatic degradation on multiple commercial species or a single commercial species and several major drivers of human change on their population.

Fish as Sustainable Food Investigation

Following instructions by E. Bardar of TERC (Technical Educational Research Center https://www.terc.edu/display/HOME/Home) for EarthLabs (https://serc.carleton.edu/earthlabs/index.html) , students will independently

complete two activities: Plenty of Fish in the Sea (https://serc.carleton.edu/eslabs/fisheries/1.html) ? and Are You Going to Eat That (https://serc.carleton.edu/earthlabs/fisheries/2.html)? Students will use local laws and restaurants in place of those provided from the U.S. In place of a presentation, students will provide a 1000 word written summary that answers all questions posed in the original activity using at least 5 proper citations from peer-reviewed professional journals or government papers.

Final Exam

Students will take a closed book exam that will include standard short and long answer formats. This exam will include all material covered, including lectures, readings, workshops and other activities, calculations, site visits and invited speakers.

Class Attendance

Regular class attendance is required throughout the program. Students must notify their instructor via Canvas, beforehand, if possible, if they will miss class for any reason. Students are responsible for any materials covered in class in their absence. Students who miss class for medical reasons must inform the instructor and the Academic Director (or a designated staff member) and provide appropriate documentation as noted below. A make-up opportunity will be provided to the extent this is feasible.

Students who transfer from one class to another during the add/drop period will not be considered absent from the first session(s) of their new class, provided they were marked present for the first session(s) of their original class. Otherwise, the absence(s) from the original class carry over to the new class and count against the grade in that class.

CIEE program minimum class attendance standards are as outlined below. Center-specific attendance policies may be more stringent than the policies stated below. The Center / Resident Director sets the specific attendance policy for each location, including how absences impact final grades. Such policies are communicated to students during orientation and via Study Center documents. In the event that the attendance policy for host institution courses differs from CIEE's policy, the more stringent policy will apply.

- Excessively tardy (over 15 minutes late) students will be marked absent.
- Students who miss class for personal travel will be marked as absent and unexcused. No make-up opportunity will be provided.
- Attendance policies also apply to any required co-curricular class excursion or event.
- Persistent absenteeism (students approaching 20% or more of total course hours missed, or violations of the attendance policies in more than one class) may lead to a written warning from the Academic Director or Resident Director, notification to the student's home school, and/or dismissal from the program in addition to reduction in class grade(s).

Unexcused absences will lead to the following penalties:

Percentage of Total Course Hours Missed	*Equivalent Number of Open Campus Semester classes*	*Minimum Penalty*
Up to 10%	1 content class, or up to 2 language classes	Participation graded as per class requirements
10 – 20%	2 content classes, or 3-4 language classes	Participation graded as per class requirements; **written warning**
More than 20%	3 content classes, or 5 language classes	Automatic **course failure**, and possible expulsion

Weekly Schedule

NOTE: this schedule is subject to change at the discretion of the instructor to take advantage of current experiential learning opportunities.

Week 1 Sustainability Goals and Fisheries

Session 1.1: Overview and Intro to Key Ecosystem Components.

Students will review the syllabus and how it fits into the Open Campus Block structure. The instructor will provide an overview of the course, its objectives, learning outcomes and evaluation.
Students will review the United Nations Sustainability Goals for the 21st Century. They will then work in groups using online information to research and then present how fisheries are often at odds with sustainability goals.

Due: State of Fisheries Presentations

Readings - Barbier, E.B. and Burgess, J.C., 2017, FAO. 2018.

Week 2 Fish Biology and Assessing Fish Populations

Session 2.1: Fish Population Biology.

Students explore basic fish biology, population dynamics, genetic variability and community interrelationships. They will determine how reproductive age, lifespan, growth rate, reproductive output, sex ratio and

other biological determinants impact population growth rate using life table-based calculations. They will establish how variation in these life history traits favors some species for harvest over others using stock-recruitment curves. Students will then tie fish population ecology to aquatic community structure, food webs and productivity.
Reading - Morgan, M.J. 2017

Session 2.2: Fish Population Size Distribution.

Students learn basic fish morphology, related terminology and proper techniques for measuring morphological traits used in fisheries science. Students then compute and interpret length frequency summaries, size structure indices and condition indices. They explore how these indices are used to create population analyses affecting fisheries management decisions.

Due: Population Abundance and Indices Worksheet

Fieldtrip to Aquarium to observe fish behavior, diet, interactions and morphology. Students will independently visit the Aquarium. While there, they will take special note of commercially important groups of fish and reflect on how their life histories and ecology differ, making some more likely candidates for sustainable harvest.

Due: Aquarium Visit Worksheet
Readings - Brill, R.W. and Hobday, A.J., 2017, Pope, et al., 2010

Week 3. Fisheries Management

Session 3.1: Tradition and Culture in Fishing.

Students will trace the history of fishing practices in different parts of the world, including techniques developed for hand-gathering, spearing, netting, angling, trawling and trapping. They will tie fishing to culture and explore how different cultures have traditionally viewed and used aquatic animal species, including whales. They will trace the rise of human population and consumption and link them to health of fish and other stocks. They will explore the Tragedy of the Commons in this context and traditional ideas for sharing the common pool resources sustainably. They will consider ideas, like catch shares and cooperatives, as mechanisms to curb overexploitation.
Readings – Dietz, T., et al. 2003., Armitage, D., et al., 2017, Scheiber, H.N., 2018.

Watch: What is the Tragedy of the Commons?
https://www.youtube.com/watch?v=CxC161GvMPc

Due: Current Fish Stock Appraisal

Session 3.2: Modern Fisheries and Overexploitation.

Students will study current technology and practices of modern fisheries. They will explore the real state of global fish populations, uncertainties arising from discards, as well as illegal, unregulated and unreported catches. They will assess how much confidence we have in assessments of stock depletion. Students will consider bycatch and waste in modern fisheries practices. Students will also discuss the mechanisms of population collapse, the role of unreliable data, imperfect translation of scientific information into management decisions and compliance with treaties, as well as persistent destructive fishing. They will also explore why some fish populations recover after depletion while others do not.

Readings - Baggio, J., et al. 2016, Perissi, I., et al., 2017, Kareiva, P. and Hillborn, R., 2010

Watch: Will the Oceans Ever Run Out of Fish?
https://www.youtube.com/watch?v=WNdR808jMSA

Session 3.3: Visit to local fishery and market.

With the instructor, students will examine a modern fisheries facility, also receiving a talk by an engineer on the fishery and its operations. Students will have an opportunity to explore how technology, ecological science and policy work together to avoid overexploitation and population collapse. They will then go to the local fish market and note which species are for sale and if they are from threatened populations.

Readings - Bailey, J.L., et al., 2017

Watch: To Save Our Fisheries, Eat Like a Fish
https://www.youtube.com/watch?v=QO2WRPrEl6k

Report: Is the response of fisheries science appropriate to current assessments of fish stocks and their possible depletion?

Week 4. Human-Caused Aquatic Ecosystem Decline

Session 4.1: Overexploitation Case Studies.

Students will consider case studies of hook and line fishing, sport fishing, commercial coastal fishing, reef fishing and offshore fishing and others, including critical analyses of technology, key biological considerations, economic considerations, culture, policy, monitoring and management. Students will present findings to one another in ten-minute presentations.

Students will then discuss common elements to overexploitation, techniques of technologies that are more likely to lead to overexploitation, and possible ways to avoid it.
Readings – Fernandes, P.G., et al., 2017.

Watch: How to Feed the World & Save the Oceans
https://www.youtube.com/watch?v=tBoIHk7_fxg

Session 4.2: Contamination, Introduced Species and Habitat Destruction.

Students will learn the drivers, scope and repercussions of human-caused contamination, introduced species and local habitat destruction. Among other pollutants, they will consider oil spills, plastics, other trash, chemical pollution from coastal factories, agricultural runoff, and freshwater sources of pollutions. Students will also consider exotic species: how they are introduced, why certain species establish, why some species populations grow exponentially and how introduced species can alter entire ecosystems. Finally, students will see how habitat degradation impacts coral reefs, lakes and other aquatic systems. Special emphasis will be placed on how these factors affect commercially important aquatic species.
Readings – Lebreton, L., et al. 2018., Islam, M.S. and Tanaka, M., 2004, Alvarez-Filip, et al. 2015, Knight, W. and Bocking, S., 2016.

Session 4.3: Climate Change, Fish Populations and Fisheries Management.

Students will connect rising sea surface temperatures caused by greenhouse gases to changes in local temperature, pH, fish distribution, aquatic productivity, frequency and importance of El Niño events, more severe weather patterns, circulation intensity, sea level rise, flooding, drought and other effects. They will explore the role of each to fish populations, as well as other commercially important aquatic species. Students consider how fish adapt, acclimate, migrate or face extinction with climate change and what this means to fisheries around the world.

Guest Speaker: TBA. What Humans are Doing to Our Aquatic Animal Populations

Reading - Barange, M., et al. 2014

Watch: Impacts and socioeconomic consequences of climate change on marine ecosystems and fisheries.
https://www.youtube.com/watch?v=EOS_JxkxDrI

Due: Research paper on human impacts

Week 5. Commercial Non-Fish Aquatic Species, Animal Welfare and Aquaculture

Session 5.1: Harvesting Non-fish Aquatic Species.

Groups of students will apply major concepts of fisheries and their possible degradation and overexploitation to commercially important non-fish species. They investigate the status and harvesting practices of both freshwater and marine non-fish species, including bivalves, crustaceans, echinoderms, reptiles, mammals and others. They research how these species are harvested and if they are harvested sustainably. They also determine how fish and non-fish harvest impacts one another.
Reading – Spanier, E et al. 2015, Gerber, L.R., 2016

Session 5.2: Animal Welfare in Fisheries Management.

In addition to commercial, subsistence and sport fishing, fish species are farmed, used in scientific research in aquariums for public display and as pets. While commercial species are commodities, do fisheries consider animal welfare in their management policies? Should they? Students investigate fish and non-fish species, including bycatch turtles and aquatic mammals, and what animal welfare policies are in place. Students debate the role of animal welfare in fisheries science, management and practice.

Reading - Cooke, S.J. and Sneddon, L.U., 2007, Papastavrou, V., et al. 2017, Stevens, C.H., et al. 2017.

Session 5.3: Aquaculture.

As wild fish stocks declined, fisheries developed ways to rear fish in captivity. Students will explore aquaculture in this session. They will first list species that are currently raised for commercial purposes. They will review their life history characteristics to determine what makes a good candidate for aquaculture. They will do likewise for non-fish species. Students will then examine aquaculture as a science, and how technology impacts commercial raising of aquatic species. They will determine if aquaculture meets criteria for sustainable production. Finally, they discuss improvements for making aquaculture more sustainable.
Readings - Edwards, P., 2015, Havice, E. and Iles, A., 2015, Bhari, B. and Visvanathan, C., 2018

Due: Fish as Sustainable Food Investigation

Week 6 Recommendations for More Sustainable Fisheries

Session 6.1: Designing Sustainable Fisheries.

Students will use all concepts, literature and case studies to offer a critique of current fisheries practices, including aquaculture, and recommendations for how to make freshwater and marine fisheries more sustainable. They will note the impact of environment, species life history traits, technology, culture and needed policy and enforcement for their plan. Students will then discuss best practices from livestock and wildlife management and how they apply to sustainable fisheries. Beyond fisheries, students consider the role of climate change policy, reserves, conservation and non-target species in sustainable fisheries efforts.

Guest Speaker: TBD. Toward More Sustainable Fisheries.

Reading – Barner, A.K., et al. 2015, Cooke, S.J., et al. 2014, Gordon, et al. 2018

Session 6.2: The Future of Fisheries and Review.

With the instructor, students will review major concepts covered throughout the class. They will emphasize connections between topics and consider a holistic view of fisheries biology and its place in a sustainable future.

FINAL EXAM

Course Materials

Reading List

(All assigned readings will be distributed to enrolled students via Canvas and/or in class. These are suggested readings and are likely to change.)

Alvarez-Filip, L., Paddack, M.J., Collen, B., Robertson, D.R. and Côté, I.M., 2015. Simplification of Caribbean reef-fish assemblages over decades of coral reef degradation. *PLoS One*, *10*(4), p.e0126004

Armitage, D., Alexander, S., Andrachuk, M., Berdej, S., Brown, S., Nayak, P., Pittman, J. and Rathwell, K., 2017. Communities, multi-level networks and governance transformations in the coastal commons. *Governing the coastal commons: communities, resilience and transformation. Routledge, Abingdon, UK*, pp.231-251

Baggio, J., Barnett, A., Perez-Ibarra, I., Brady, U., Ratajczyk, E., Rollins, N., Rubiños, C., Shin, H., Yu, D., Aggarwal, R. and Anderies, J., 2016. Explaining success and failure in the commons: the configural nature of Ostrom's institutional design principles. *International Journal of the Commons*, *10*(2)

Bailey, J.L., Liu, Y. and Davidsen, J.G., 2017. Bridging the gap between fisheries science and society: exploring fisheries science as a social activity. *ICES Journal of Marine Science*, *74*(2), pp.598-611

Barner, A.K., Lubchenco, J., Costello, C., Gaines, S.D., Leland, A., Jenks, B., Murawski, S., Schwaab, E. and Spring, M., 2015. Solutions for recovering and sustaining the bounty of the ocean: combining fishery reforms, rights-based fisheries management, and marine reserves. *Oceanography*, *28*(2), pp.252-263.

Barange, M., Merino, G., Blanchard, J.L., Scholtens, J., Harle, J., Allison, E.H., Allen, J.I., Holt, J. and Jennings, S., 2014. Impacts of climate change on marine ecosystem production in societies dependent on fisheries. *Nature Climate Change*, *4*(3), p.211

Bhari, B. and Visvanathan, C., 2018. Sustainable Aquaculture: Socio-Economic and Environmental Assessment. In *Sustainable Aquaculture* (pp. 63-93). Springer, Cham.

Blasiak, R. and Yagi, N., 2016. Shaping an international agreement on marine biodiversity beyond areas of national jurisdiction: lessons from high seas fisheries. *Marine Policy*, *71*, pp.210-216.

Brill, R.W. and Hobday, A.J., 2017. Tunas and their fisheries: safeguarding sustainability in the twenty-first century. *Reviews in Fish Biology and Fisheries*, 27(4), pp 691-695.

Cadima, E. L. 2003. Fish stock assessment manual. *FAO Fisheries Technical Paper* 393: 1-161.

Cooke, S.J. and Sneddon, L.U., 2007. Animal welfare perspectives on recreational angling. *Applied Animal Behaviour Science*, *104*(3-4), pp.176-198

Cooke, S.J., Arlinghaus, R., Bartley, D.M., Beard, T.D., Cowx, I.G., Essington, T.E., Jensen, O.P., Lynch, A., Taylor, W.W. and Watson, R., 2014. Where the waters meet: sharing ideas and experiences between inland and marine realms to promote sustainable fisheries management. *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(10), pp.1593-1601.

Edwards, P., 2015. Aquaculture environment interactions: past, present and likely future trends. *Aquaculture*, *447*, pp.2-14

FAO. 2018. The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals. Food and Agriculture Organization of the United Nations, Rome

Fernandes, P.G., Ralph, G.M., Nieto, A., Criado, M.G., Vasilakopoulos, P., Maravelias, C.D., Cook, R.M., Pollom, R.A., Kovačić, M., Pollard, D. and Farrell, E.D., 2017. Coherent assessments of Europe's marine fishes show regional divergence and megafauna loss. *Nature Ecology & Evolution*, *1*(7), p.0170.

Gerber, L.R., 2016. Beyond the whaling stalemate. *Frontiers in Ecology and the Environment*, *14*(4), pp.182-183.

Gordon, T.A.C., Harding, H.R., Clever, F.K., Davidson, I.K., Davison, W., Montgomery, D.W., Weatherhead, R.C., Windsor, F.M., Armstrong, J.D., Bardonnet, A. and Bergman, E., 2018. Fishes in a changing world: learning from the past to promote sustainability of fish populations. *Journal of fish biology*, *92*(3), pp.804-827.

Havice, E. and Iles, A., 2015. Shaping the aquaculture sustainability assemblage: Revealing the rule-making behind the rules. *Geoforum*, *58*, pp.27-37

Hollingsworth, A., 2018. Sustainable Diets: The Gulf Between Management Strategies and the Nutritional Demand for Fish. In *Handbook of Sustainability Science and Research* (pp. 711-725). Springer, Cham.

Islam, M.S. and Tanaka, M., 2004. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Marine pollution bulletin*, *48*(7-8), pp.624-649

Kareiva, P. and Hillborn, R., 2010. Why Do We Keep Hearing Global Fisheries Are Collapsing? *Nature Conservancy*.

Knight, W. and Bocking, S., 2016. Fisheries, invasive species, and the formation and fracturing of the Great Lakes system. *The Canadian Geographer/Le Géographe canadien*, *60*(4), pp.446-457.

Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A. and Noble, K., 2018. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific reports*, *8*(1), p.4666.

Morgan, M.J. 2017. Understanding biology to improve advice for fisheries management. *ICES Journal of Marine Science*, *75*(3), pp.923-931.

Papastavrou, V., Leaper, R. and Lavigne, D., 2017. Why management decisions involving marine mammals should include animal welfare. *Marine Policy*, *79*, pp.19-24.

Pauly, D. and Charles, A., 2015. Counting on small-scale fisheries. *Science*, *347*(6219), pp.242-243.

Perissi, I., Bardi, U., El Asmar, T. and Lavacchi, A., 2017. Dynamic patterns of overexploitation in fisheries. *Ecological modelling*, *359*, pp.285-292

Pope, K.L., Lochmann, S.E. & Young, M.K. (2010) Methods for assessing fish populations. *Inland Fisheries Management in North America, 3rd edition* (eds W.A. Hubert & M.C. Quist), pp. 325–352. American Fisheries Society, Bethesda, Maryland.

Scheiber, H.N., 2018. The "Commons" Discourse on Marine Fisheries Resources: Another Antecedent to Hardin's "Tragedy". *Theoretical Inquiries in Law*, *19*(2).

Seibel, H., Weirup, L. and Schulz, C., 2018. Aspects of animal welfare in fish husbandry. In *Professionals in food chains* (pp. 165-171). Wageningen Academic Publishers.

Spanier, E., Lavalli, K.L., Goldstein, J.S., Groeneveld, J.C., Jordaan, G.L., Jones, C.M., Phillips, B.F., Bianchini, M.L., Kibler, R.D., Díaz, D. and Mallol, S., 2015. A concise review of lobster utilization by worldwide human populations from prehistory to the modern era. *ICES Journal of Marine Science*, *72*(suppl_1), pp.i7-i21

Stevens, C.H., Croft, D.P., Paull, G.C. and Tyler, C.R., 2017. Stress and welfare in ornamental fishes: what can be learned from aquaculture?. *Journal of fish biology*, *91*(2), pp.409-428

Additional Suggested Readings

Hollingsworth, A., 2018. Sustainable Diets: The Gulf Between Management Strategies and the Nutritional Demand for Fish. In *Handbook of Sustainability Science and Research* (pp. 711-725). Springer, Cham.

Lindenmayer, D., 2017. Halting natural resource depletion: Engaging with economic and political power. *The Economic and Labour Relations Review*, *28*(1), pp.41-56.

Osmundsen, T.C., Almklov, P. and Tveterås, R., 2017. Fish farmers and regulators coping with the wickedness of aquaculture. *Aquaculture Economics & Management*, *21*(1), pp.163-183.

Rowe, S. and Rose, G.A., 2017. Cod stocks: Don't derail cod's comeback in Canada. *Nature*, *545*(7655), p.412.

Scharin, H., Ericsdotter, S., Elliott, M., Turner, R.K., Niiranen, S., Blenckner, T., Hyytiäinen, K., Ahlvik, L., Ahtiainen, H., Artell, J. and Hasselström, L., 2016. Processes for the sustainable stewardship of marine environments. *Ecological Economics*, *128*, pp.55-67.