1st Hjort Summer School

Fishing and physics as drivers of marine ecosystem dynamics

at the field station Espegrend

Time	Monday 31. August	Tuesday 1. Sept	Wednesday 2. Sept	Thursday 3. Sept	Friday 4. Sept
09-11	Hjort historical backdrop *Arild Folkvord* The Barents Sea *Edda Johannesen*	Top-down processes in marine ecosystems *Ken Frank*	Top-down processes in marine ecosystems *Ken Frank*	Size-structured interactions *Anna Gårdmark*	Fisheries management in theory and practise - ecosystem based? *Katja Enberg*
11-13	Simple models of complex marine ecosystems *Frede Thingstad & Dag Aksnes*	Bottom-up processes in marine ecosystems *Hjalmar Hátún*	Bottom-up processes in marine ecosystems *Hjalmar Hátún*	Student presentations	Fisheries management: evolution and long term yield *Mikko Heino*
13-14	Lunch	Lunch	Lunch	Lunch	Lunch
14-16	Student presentations	Size-structured interactions *Anna Gårdmark*	Workshop 1 Size-structured modelling *Anna Gårdmark*	Student Presentations Trip to Bergen	Workshop 2 Fisheries management *Heino/Enberg*
16-18	Field work: Beach-seining and marine ecology	Student presentations	Student presentations	Trip to Bergen	Summary and closure
18-20	Barbecue at the beach	Dinner	Dinner	Dinner in town	Dinner

Lectures:

Ken Frank- Forces Structuring Trophic Interactions in Large Marine Ecosystems

My lectures will focus on the structural and functional dynamics of continental shelf marine ecosystems – a topic that has been of general ecological interest within a diverse array of ecosystems for over a century. At large spatial scales, major insights into these dynamics have been principally derived from analyses of changes induced from hunting, harvesting, and agricultural practices1 – so-called "natural experiments". Reduction in the abundance of apex predators has led to abnormally high densities of their former prey in a wide range of ecosystems. This has, in turn, resulted in sometimes catastrophic changes in the ecosystems occupied suggesting that large-bodied species are essential to the maintenance of ecosystem structure and stability, i.e through the action of top-down processes. The conceptual foundation for top-down control of ecosystem dynamics, established in 19602, eventually led to the development of a vast body of new knowledge highlighting the importance of apex predators to the structure and stability of ecosystems ranging from deserts to tropical forests and, ultimately to freshwater systems, the rocky intertidal, kelp forests, tropical reefs and estuaries. An important manifestation of top-down control is the extension of trophic interactions beyond predators and prey to non-adjacent trophic levels – commonly referred to as a “trophic cascade”, which was first evaluated experimentally in the rocky intertidal and in whole lake ecosystems. Top-down structuring of freshwater ecosystems was widely accepted by limnologists by the end of 1980s. However, marine biologists have generally been reluctant to embrace the concept and the ubiquity of trophic cascades there remains a hotly debated subject despite a growing body of evidence in support of top-down control of large marine ecosystems3; several reviews and meta-analyses have attempted to define which ecosystems are susceptible to such influences and what conditions lead to their formation4,5. These and other related topics6 will be reviewed during the lectures with emphasis on new research directions and approaches involving both scaling-up and scaling-down in an attempt to elucidate the patterns and predictors of trophic control in large marine ecosystems.

Short reading list:

1) Strong, D. R. and Frank, K. T. (2010) Human involvement in food webs. Annnual Review of Environmental Resources, 35, 1-23.

2) Hairston, N.G., Smith, F.E. and Slobodkin, L.B. (1960) Community structure, population control, and competition. American Naturalist, 94, 421-425.

3) Frank, K. T., Petrie, B., Choi, J. S. and Leggett, W. C. (2005). Trophic cascades in a formerly cod-dominated ecosystem. Science, 308, 1621-1623.

4) Frank, K. T., Petrie, B., Shackell, N. L. and Choi, J. S. (2006). Reconciling differences in trophic control in mid-latitude marine ecosystems. Ecology Letters, 9, 1096-1105.

5) Johannesen, E., Ingvaldsen, R. B., Bogstad, B., Dalpadado, P., Eriksen, E., Gjøsæter, H., Knutsen, T., Skern-Mauritzen, M. and Stiansen, J. E. (2012). Changes in Barents Sea ecosystem state, 1970–2009: climate fluctuations, human impact, and trophic interactions. ICES Journal of Marine Science, 69(5), 880-889.

6) Petrie, B., Frank, K. T., Shackell, N. L. and Leggett, W. C. (2009). Structure and stability in exploited marine ecosystems: quantifying critical transitions. Fisheries Oceanography, 18(2), 83-101.

Anna Gårdmark- Size-dependent population and community dynamics

Most animals grow in size during their life-time, and their physiological processes, diet and risk of predation change with body size. In this lecture you will learn how and why body size matters for population and community dynamics. Indeed, size-dependent feed-backs in animal communities can govern population responses to fishing as well as prevent re-establishment of locally extinct or overexploited populations. You will learn of examples from fish communities in lakes and exploited marine systems, and how model predictions can be tested against experimental and monitoring data to infer size-dependent mechanisms governing fish community dynamics.

Fishing effects on food-webs

Fishing ranges from a small-scale 'artisanal' activity to global enterprises ranging several oceans, and has a major impact on the world's oceans and smaller seas. How fishing affects different systems, however, depend on the ecology of the particular system. It also depends on and interacts with pressures on these systems from other human activities. Most fisheries occur in coastal areas and shelf seas, which also are the prime areas for energy and material extraction, transport and waste discharges. In this lecture you will learn of how fishing impacts ecosystems and why, of other pressures acting on coastal seas and consequent changes in their ecosystems. In mini-case studies we will also discuss aspects of management of human activities in marine systems, and ecological processes to account for when designing integrated management of such activities.

Hjalmar Hatun: Bottom up processes in marine ecosystems

The subpolar gyre is a large body of cold, low-saline subarctic water, which circulates anti-clockwise in the North Atlantic Ocean. This gyre is also a large source of nutrients and a center-of-abundance of the ecologically important zooplankton species, Calanus finmarchicus. The variable size and circulation strength of this gyre regulates the water mass composition of the north-eastern Atlantic, shifting in dominance from colder and fresher Western Waters to warmer and more saline Eastern Waters, originating from the Bay of Biscay region. This shapes biogeographical zones and the general biological production, both in this region and farther downstream towards the Arctic – the Barents Sea in the north and the Labrador Sea in the west. The course will revolve around aspects of this gyre, ranging from atmospheric forcing fields, large-scale oceanographic datasets from remote sensing, numerical modelling and in situ observations to key biogeochemical and ecosystem metrics. We will discuss how the gyre modulates both the open-ocean pelagic complex (plankton to e.g. the large mackerel stock) and on-shelf ecosystems adjacent to north-eastern Atlantic.

Required reading:

1) Hátún, H., Payne, M., Beaugrand, G., Reid, P. C., Sandø, A. B., Drange, H., Hansen, B., Jacobsen, J. A., Bloch, D., 2009. Large bio-geographical shifts in the north-eastern Atlantic Ocean: From the subpolar gyre, via plankton, to blue whiting and pilot whales. Progress in Oceanography 80,149-162.
2) Hátún, H., Sando, A. B., Drange, H., Hansen, B., Valdimarsson, H., 2005. Influence of the Atlantic subpolar gyre on the thermohaline circulation. Science 309, 1841-1844.

Additional reading:

1) Bailey, R. S., 1982. The Population Biology of Blue Whiting in the North-Atlantic. Advances in Marine Biology 19, 257-355.
2) Bainbridge, V., Cooper, G., 1973. The distribution and abundance of the larvae of the blue whiting, Micromestistius poutassou (Risso), in the north-east Atlantic, 1948-1970. Bulletins of Marine Ecology 8, 99-114.
3) Beaugrand, G., Reid, P. C., Ibanez, F., Lindley, J. A., Edwards, M., 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. Science 296, 1692-1694.
4) Häkkinen, S., Rhines, P. B., 2004. Decline of subpolar North Atlantic circulation during the 1990s. Science 304, 555-559.
5) Holliday, N. P., 2003. Air-sea interaction and circulation changes in the northeast Atlantic. Journal of Geophysical Research-Oceans 108(C8), 3259, doi:10.1029/2002JC001344

Frede Thingstad - Building complexity in the microbial food web from simple models.

There are many aspects of microbial ecosystems that are intuitively connected, but we do not really understand how, or at least we don't have the tools to describe them in a coherent manner. This includes aspects such as evolution, biodiversity, life strategies, organism traits and biogeochemistry. There is, however, a simple idealized food web "unit" sometimes referred to as "Killing-the-Winner", sometimes as "keystone predator", that contains a "little bit of everything". Starting from this I demonstrate how one can construct (relatively) simple models for the pelagic microbial food web; transparent enough to be useful in planning and analyzing experimental work.

Suggested reading

1) Thingstad, TF, E. Strand and A Larsen (2010) Stepwise building of plankton functional type (PFT) models: A feasible route to complex models? Progr in Oceanogr. 84:6-15
2) Aud Larsen,Jorun K. Egge, Jens C. Nejstgaard, Iole Di Capua, Runar Thyrhaug, Gunnar Bratbak, T. Frede Thingstad (2015) Contrasting response to nutrient manipulation in Arctic mesocosms are reproduced by a minimum microbial food web model. Limnol.Oceanogr. 60:360-374

Dag L Aksnes - Simple models of complex marine ecosystems

I illustrate how the Killing-the-Winner (KtW) food web unit can be applied for a system of zooplankton, jellyfish, zooplanktivorous fish and piscivorous fish. The generic KtW unit is combined with the different effects of water clarity on visual and tactile predation. I show how the combined model provides expectations on the structure of higher trophic levels in marine ecosystems and how these expectations might be tested.

Suggested reading

1) Sørnes, T.A and D.L. Aksnes 2004. Predation efficiency in visual and tactile zooplanktivores. Limnology & Oceanography 49:69-75.
2) Aksnes, D.L. 2007. Evidence for visual constraints in large marine fish stocks. Limnol. & Oceanogr 52: 198-203.

3) Haraldsson M, K Tönnesson, P Tiselius, TF Thingstad and DL Aksnes (2012) Relationship between fish and jellyfish as a function of eutrophication and water clarity. Marine Ecology Progress Series 471:73-85.

Katja Enberg - Fisheries management in theory and practice - ecosystem based?

In this lecture I will give an overview of practical fisheries management with examples from some of the commercially important Northeast Atlantic stocks. We will also discuss what has been and what could be done to incorporate more ecosystem considerations not only in theoretical but also in practical marine management. How are fish stocks really managed in practice? What are the most important objectives managers consider when making decisions about how to use our marine resources? Ecosystem-based fisheries management was put forward already in 1990's - have we succeeded in making it reality?

Suggested reading:

1) Botsford, L. W., J. C. Castilla and C. H. Peterson (1997). "The management of fisheries and marine ecosystems." Science 277(5325): 509-515.
2) Pikitch, E. K., C. Santora, E. A. Babcock, A. Bakun, R. Bonfil, D. O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E. D. Houde, J. Link, P. A. Livingston, M. Mangel, M. K. McAllister, J. Pope and K. J. Sainsbury (2004). "Ecosystem-based fishery management." Science 305(5682): 346-347.
3) Skern-Mauritzen, M., G. Ottersen, N. O. Handegard, G. Huse, G. E. Dingsør, N. C. Stenseth and O. S. Kjesbu (2015). "Ecosystem processes are rarely included in tactical fisheries management." Fish and Fisheries: (http://onlinelibrary.wiley.com/doi/10.1111/faf.12111/abstract)

Mikko Heino – Fisheries management: evolution and long term yield

Evidence is mounting that commercial fishing is often driving life-history evolution in wild fish populations. Commercial-scale fishing typically means that mortality rates in fish populations are much elevated relative to their natural levels, and accordingly, that the expected life span is shortened. This favours life-history variants that complete their life cycles faster than before. This is particularly well-documented for age and size at first spawning: in many fish populations, fish reach sexual maturity much earlier and at smaller sizes than before. At short times scales (few years), these evolutionary changes are negligible and masked by environmentally-induced plasticity. However, fisheries-induced evolutionary changes are typically cumulative, and changes can become significant after just few decades. From human perspective, such evolution is a double-edged sword. When fish adapt to elevated mortality, they become more resilient to excessive fishing pressure. Evolution may thus compensate for mismanagement and contribute to food security. However, this comes at a cost. Typically, fish populations adapted to fishing are less productive in terms of fisheries yield, and also characterized by less desirable, small-bodied sizes. Uncontrolled fisheries-induced evolution may therefore erode the capacity of wild fish stocks to produce food for the humankind. The costs and benefits of fisheries-induced evolution will vary from case to case, as will the management actions that may be taken to mitigate negative impacts. Evolutionary Impact Assessment is a general framework for such cost-benefit analyses.

Reading list:

1) Heino, M., L. Baulier, D. S. Boukal, B. Ernande, F. D. Johnston, F. M. Mollet, H. Pardoe, N. O. Therkildsen, S. Uusi-Heikkilä, A. Vainikka, R. Arlinghaus, D. J. Dankel, E. S. Dunlop, A. M. Eikeset, K. Enberg, G. H. Engelhard, C. Jørgensen, A. T. Laugen, S. Matsumura, S. Nusslé, D. Urbach, R. Whitlock, A. D. Rijnsdorp, and U. Dieckmann. 2013. Can fisheries-induced evolution shift reference points for fisheries management? ICES Journal of Marine Science 70:707–721. doi: 10.1093/icesjms/fst077.
2) Heino, M., B. Diaz Pauli, and U. Dieckmann. 2015. Fisheries-induced evolution. Annual Review of Ecology, Evolution, and Systematics, in press.
3) Zimmermann, F., and C. Jørgensen. 2015. Bioeconomic consequences of fishing-induced evolution: a model predicts limited impact on net present value. Canadian Journal of Fisheries and Aquatic Sciences 72:612–624. doi: 10.1139/cjfas-2014-0006.