Havforskermøtet 2020

ABSTRACTS

How to succeed in habitat restoration – linking restoration success to habitat characteristics, regional variations, pressures and restoration method – with some case study examples from Norway

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Global change and anthropogenic pressures have a major impact on ecosystems, leading to degradation of ecosystem functioning and service and loss of biodiversity. To slow down or stop the degradation within European seas, the EU Biodiversity Strategy 2020 aims to restore at least 15% of degraded ecosystems by the end of 2020. Marine ecosystems restoration is a very young discipline, although attempts have been made repeatedly all over the world in the last decade. The degree of success in habitat restoration is highly variable. If we are to reverse the trend of habitat loss and degradation, we need to develop a better understanding of the consequences of interactions between ecosystem components and multiple pressures. Here we present some of the results from the EU (Horizon 2020) funded project MERCES (Marine Ecosystem in Changing European Seas, www.merces-project.eu), on factors that impact the likelihood for habitat restoration success, thereby providing the basis for decision making. We have done this by analysing different habitats across Europe and the relationships between restoration success and failure and the habitat's characteristics, regional variation in environmental conditions, the pressures found at the sites and the restoration methods used. Our analyses show that the greatest variation among sites were related to habitat type and regional variation in environmental conditions, some areas and habitats are just easier to restore than others. The duration of the restoration work had a positive impact on the restoration success, highlighting the need for long-term restoration projects to support the restoration process. Distance to main ports had a notable impact on restoration success, meaning that anthropogenic disturbance and pressure decrease the potential for restoration success and suggest that baseline human disturbances around restoration sites should be considered when planning restoration activities. The presentation will show some case studies examples from restoration of degraded kelp forests and seagrass meadows in Norway.

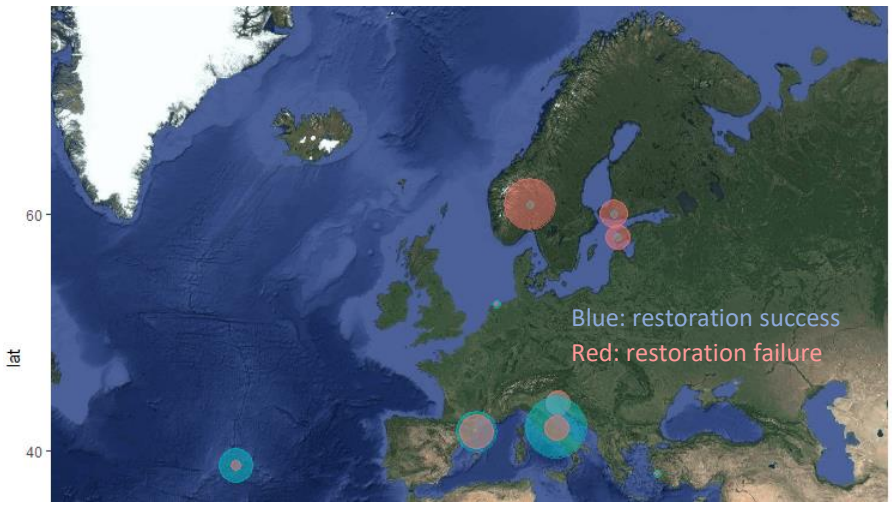

Figure 1. Map of the restoration failures and successes for different countries. The larger the circle, the higher the number. Note that areas with few case studies will be difficult to spot.

Arts- og størrelsessammensetning i fisket med småmasket trål etter målartene øyepål og kolmule i perioden 2014-2019

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Fiskeridirektoratet utførte 9 tokt om bord på 9 ulike fartøy som fisket med småmasket trål etter målartene øyepål og kolmule i Nordsjøen i perioden 2014-2019. Resultatene og konklusjonene i dette prosjektet er basert på kartlagt artssammensetning i 9 286 kg prøvemateriale og 26 933 lengdemålinger av ulike arter/kategorier i fangstene. Estimerte kvanta og prosentandeler av ulike arter/kategorier ble sammenliknet med de rapportene kvantaene og prosentandelene av artene/kategoriene rapportert i ERS og på sluttseddel. Samlet sett for alle toktene ble det registrert 74 arter/kategorier i prøvematerialet mens antall arter/kategorier rapportert på sluttsdeddel var 23. Det totale kvantumet som var ført på feil art på sluttseddel ble estimert til 143 tonn (6,1% av det totale landete kvantumet). Det var 87,3 tonn mer øyepål på sluttseddel enn det som ble estimert. Arter som gapeflyndre og vassild var ikke ført på sluttseddel til tross for at det ble estimert kvanta av disse artene på henholdsvis 30 og 34 tonn i fangstene total sett. Det ble registrert torsk og hyse i fangstene på alle toktene og sei på sju av ni tokt til tross for at det er forbudt å lande disse artene til mel- og oljeproduksjon. Det ble registrert mye liten yngel av torsk, hyse, lysing og hvitting i fangstene på mange av toktene. Resultatene i dette prosjektet vil utløse tiltak for å forbedre forvaltningen av dette fiskeriet.

Testing mesopredator effects in large mesocosms, differences in cascading pathways

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Over exploitation of top predators (e.g. coastal cod) may lead to release of smaller predators (mesopredators). Testing the effects of increasing mesopredator abundances in field is difficult, and aquarium experiments do not provide realistic conditions. Mesocosm are seminatural large ecosystems that allow for testing the impact of predators in an almost natural ecosystem. NIVA has built 12 large mesocosms where over many years diverse shallow rocky reef communities have developed. Within the mesocosm we have manipulated the densities of mesopredators (medium sized predators) like small fish (goldsinny wrasses) and green crabs in crossed experiments. The study showed a significant impact of the predators on small blue mussels and barnacles, rapidly leading to bare rocky surfaces. Furthermore, in other experiments the mesopredators may amplify eutrophication effects under certain conditions, resulting in different cascading pathways. An overview of the large mesocosms and of important results will be given.

An in-depth study of *Chrysochromulina leadbeateri* bloom in northern Norway during spring 2019.

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The toxic algal bloom of the haptophyte *Chrysochromulina leadbeateri* in spring 2019 was the largest bloom of this species in Norwegian waters and worldwide ever recorded. Starting in the Vestfjorden area in northern Norway during early May and expanding north to Balsfjorden and Tromsø area, the bloom caused a major mortality of farmed salmon, with over 13 000 tonns of fish reported as lost during the outbreak. The *C. leadbeateri* bloom in northern Norway was studied in-depth in frame of a research cruise led by Alfred Wegener Institute (Germany) and in collaboration with the University of Oslo. The cruise focused on studies of phytoplankton diversity, distribution and functional ecology in several fjord systems along the northern Norwegian coast (Lofoten-Vesterålen area, Balsfjorden, Lyngen, Porsangerfjorden, Laksefjorden, Tanafjorden). Biological and environmental data collected during the cruise allowed for detailed analyses of the blooming organism, its distribution patterns in northern Norway, and its ecology. Cultures of *C. leadbeateri* isolated from the bloom were used to determine the morphology, taxonomic identity, and phylogenetic placement of the organism, and to compare it with a *C. leadbeateri* strain isolated from the previous major bloom in 1991. Metabarcoding data, light microscopy counts and flow cytometry data were used to map the distribution and abundance of the species along the coast of northern Norway, and correlate its distribution with biotic and abiotic parameters. Preliminary results show that the blooming organism is genetically identical in marker genes to the strain from the bloom in Vestfjorden in 1991. However, both strains and *C. leadbeateri* in field material exhibit significant intraspecific genetic variability. Biogeographic mapping shows that the bloom was most pronounced in the Balsfjorden area, with maximum cell concentration of over 27 million cells L^{-1}. From an ecological perspective, *C. leadbeateri* abundance showed positive correlation with phosphate and nitrate, negative correlation with salinity and a slightly positive correlation with temperature. The results of our work provide a unique, in-depth insight into *C. leadbeateri* blooms, which may help in the monitoring, modelling and predicting similar events in the future. Ongoing work in our group focus on physiological and genetic profiling of the isolated *C. leadbeateri* strains with the aim to improve our understanding of factors triggering toxicity and bloom formation.

Development stage distribution as a growth and mortality index for first feeding Norwegian Spring Spawning herring larvae

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The estimation of growth rates in young herring larvae (*Clupea harengus)* in the field can be difficult since the primary increments in the otoliths may not be discernible or formed at a daily level. Likewise, the estimation of mortality rates of fish larvae in the field is very difficult to achieve, especially in a rigorous quantitative manner. Here we suggest the use of a stage-based proxy of feeding success, growth, and potential survival or mortality risk of field caught larvae. The stage-based proxy is derived based on observations from previous laboratory studies where larvae successfully completing start-feeding on external food sources will advance through the early development stages, while those that do not (unsuccessful larvae), remain and accumulate in the development stage preceding first feeding. The relative occurrence of larvae in the early development stages is therefore expected to reflect feeding conditions of the larvae, with higher ratios of unsuccessful larvae indicative of poor feeding success and higher mortality risk. Using field data on Norwegian Spring Spawning herring we document that the relative occurrence of larvae in the late non-feeding stage are significantly higher at lower average zooplankton concentrations, in line with our predictions. Further, there was a significant interaction effect with ambient temperature, with the ratio being higher at low zooplankton concentrations at higher temperatures. This study also suggests that these findings are not population specific as the same accumulation of non-feeding larvae in the late non-feeding stage was observed in laboratory reared larvae of both autumn and spring spawning herring populations.

Mapping atmospheric exposure in the intertidal zone with Sentinel-1

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Coastal ecosystems deliver important ecosystem services, such as coastal protection, coast stabilisation, recreation, and food production. Tidal zones, defined as the area which is exposed to air at low tide and covered by water at high tide, in particular mudflats, can have a large biodiversity and are often important areas for shorebirds and seabirds. Norway has a long coastline with locally extensive tidal zones. Because of its highly dynamic nature, traditional satellite or aerial mapping and monitoring of the tidal zone is a challenge in regard to the timing of a single satellite acquisition relative to the tidal state. The overall approach is therefore to use long dense times series of satellite acquisitions and the fact that the frequency of satellite acquisition is different than the tidal period of ~12.25h, to ensure acquisitions of the full range of tidal cycle levels. Since synthetic aperture radar (SAR) satellite imagery is independent from light and cloud cover, a consistent time series of Sentinel-1 CSAR can be statistically analyzed and will provide information over the whole range of tidal levels and as such able to map the atmospheric exposure inside the intertidal zone. This presentation will describe the general method and show examples of results from Tromsø Kommune, validated with field data. The overall goal is to apply this method to map the intertidal zone along the whole Norwegian coast.

Are nano- and microplastics a serious issue for the marine environment?

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There are millions of natural particles in a millilitre of seawater. Most of the currently available data on microplastics has clearly shown that there are many orders of magnitude less plastic particles than natural particles in the sea, with the caveat that we do not really know much about particles smaller than 10 – 100 µm. This is due to the current methods used to extract and analyse microplastics, i.e. filtration on to a filter and microscopy, combined with detectors that detect plastics. Some recent estimates suggest that there may be higher concentrations of such particles than previously assumed, but it still an open issue how they behave in seawater and whether they have properties that may distinguish them from natural particles from an ecosystem point of view. Although experimental studies generally use much higher concentrations of microplastics than will be found in the sea, there are indications that some organisms may prefer plastics to natural particles. The paper will discuss whether our current understanding of different nano- and microplastics in the oceans suggest them to be a potential environmental issue.

Exploring the emergent niche of Greater argentine (*Argentina silus*) along gradients of topography, light and advection.

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Recent studies suggest that biomass of the ocean twilight zone is far greater than previously thought, on the order of 1 to 10 billion metric tons, potentially 10-20 times that of all other fishes combined. How this oceanic production may fuel productivity of shelf sea ecosystems and contribute to sustaining commercially important fish stocks in coastal waters is not understood. The ecology of the mesopelagic is a game of 'hide and seek', where organisms with limited swimming ability, e.g. micronekton such as small fish, crustaceans, and siphonophores, try to avoid encounters with larger predators, mainly bigger fish and squid. Globally, about half of all mesopelagic micronekton is estimated to perform diel vertical migrations between daytime depths of several hundred meters and near-surface waters at night. Here we research the case of Greater argentine (*Argentina silus*), a little studied, but already commercially fished bentho-pelagic deep-water species with a distinct distribution along the continental slopes of the North Atlantic between 200-600 m depth. We hypothesize that where shallow bottom topography blocks downward migrating micronekton from reaching safe and dark waters at greater depth, a benthopelagic niche for advective feeding emerges in the mesopelagic. In the North Atlantic this niche has been filled by Greater argentine. We use a behavioural model, linking physics and biology through explicit mechanism of prey encounter and bioenergetics to make testable predictions that we confront with observations from the field.

Long-term coastal monitoring data show nutrient-driven reduction in chlorophyll

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In this study we have compiled a long-term monitoring dataset from the inner Oslofjorden and supplemented it with short-term research data from the same station. Using generalized additive models analysing the data from this time series, we have examined how chlorophyll-a, hydrography, and various nutrient concentrations have changed during 1973-2017 and how they correlate. We describe the seasonality in chlorophyll-a, nitrogen, phosphorus, Secchi-depth, temperature and salinity and how the levels of each variable have changed the last forty years. The results show specifically how levels of chlorophyll-a have decreased significantly and how this correlates with decrease in nitrogen and phosphorus levels. Our results show a significantly positive correlation between chlorophyll-a and phosphorus during spring bloom and between chlorophyll-a and nitrogen during autumn bloom. However, phosphorus levels have increased again during the last 20 years, but chlorophyll-a levels are still low, indicating that the chlorophyll-a level currently may be controlled by the continuous decreasing trend in nitrogen. If nitrogen increase again, the chlorophyll-a level may also begin to increase. The impact of increasing temperature and possible change in starting point for the growing season should be studied further.

Fisk gyter ved bestemte temperaturer – atferd eller miljø

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I 1894 kunne Premierløytnant Gustav Christian Oscar Rehbinder Gade melde hjem til sitt Department for det Indre, at Torsken i Lofoten gyter ved 5 grader, verken mer eller mindre. I bladet Science i juli 2020 kunne vi lese at det ikke bare er torsken som gyter i smale temperaturevindu, men en rekke arter, og over hele verden. En nylig foreslått hypotese er at det kan være fysiologiske begrensninger hos egg og larver som gjør at det er lite spillerom for hvor og når de kan bli gytt. Og at den gytende fisken oppsøker områder med særlig gunstig temperatur for avkommet. Ved hjelp av et stort telemetristudie av >500 torsk på Smøla finner vi at det kan være andre forhold som står bak. Torsken på Smøla gyter riktignok i et smalt temperaturvindu, men en rekke temperaturmålinger i området avdekker også at det er lite temperaturer å velge mellom. Vannet er gjennomblandet fra topp til bunn, og det er «5 grader» overalt.

Trophic levels in marine ecosystem – illusion or reality?

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The trophic level concept has become a conceptual pillar in ecosystem analysis. Trophic level estimates have been central in system ecology and trophic levels have been estimated by several methods, including mass-balance food-web models and stable isotope analysis. In a paper from 2014, Hussey et al (Rescaling the trophic structure of marine food webs. Ecol Lett 17:239-250) it was concluded that the number of trophic levels in marine ecosystems generally had been underestimated. The typical 5-trophic level marine food webs should be rescaled to food webs with approximately seven trophic levels.

To test if the rescaling hypothesis applied for the Barents Sea, I compared and analysed trophic level estimates from stable-isotopes and a mass-balance food-web model (Ecopath) for the Barents Sea Large Marine Ecosystem. The mass-balance model comprise 104 ecological groups and model input values was calculated from data on biomass and catch and diet composition input were largely calculated from stomach data. The input data was based on data from ca. 500 papers. The mass-balance model was balanced for year 2000 and modified to a 1950-model that was fitted to time-series data for ecological groups. The resulting trophic levels ranged from 1.0 for phytoplankton to 5.1 for Polar bear.

Literature search for the Barents Sea Large Marine Ecosystem revealed that 80 for publications with delta15N stable isotope data for 80 ecological groups (Ecopath groups) and 25 of the publications also had trophic level estimates. On average trophic levels from the mass-balance model were 0.09 higher than originally estimated from stable isotopes. There was a good approximately linear relationship between the delta15N values and trophic levels from the Ecopath model. I conclude that both methods for estimating trophic levels gave very similar results and that there was no signs of additional trophic levels justifying a rescaling of the trophic structure for the Barents Sea.

Enhancing marine biodiversity along urban shorelines: step-by-step guidelines, an urban blue habitat framework and a marine neighbourhood toolkit

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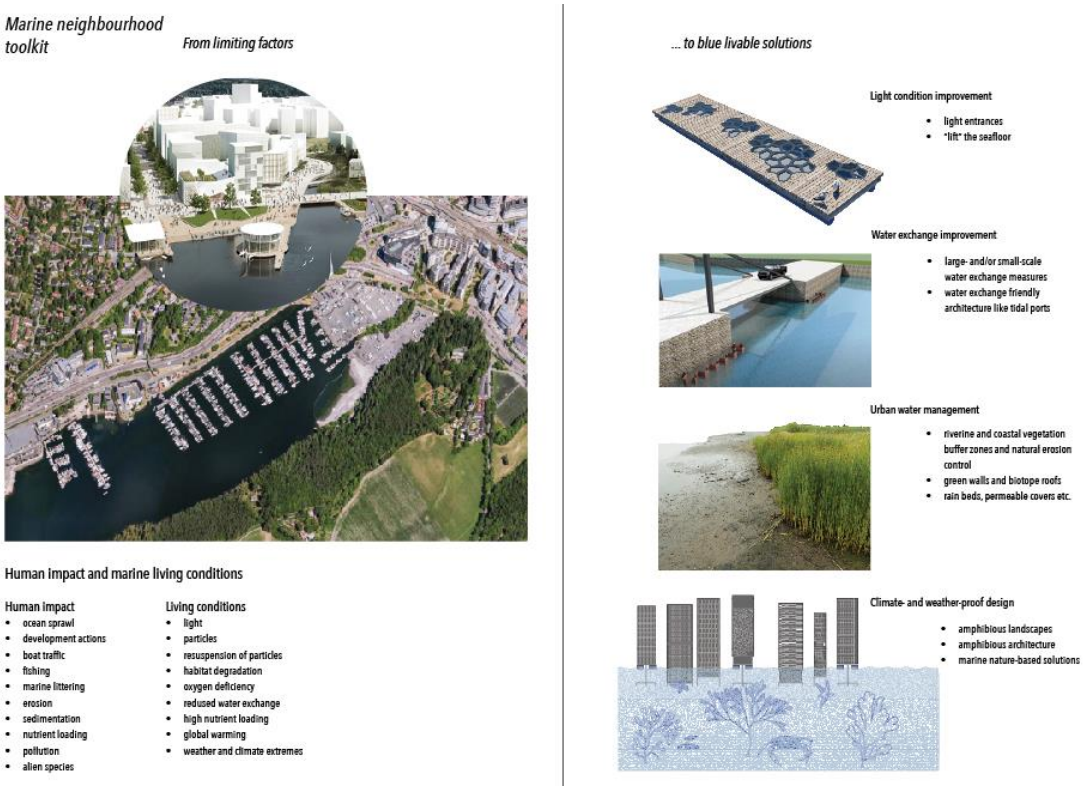
Marine species and habitats are at threat worldwide. Urbanisation and climate change accelerate the rate of these losses, imposing a large need to identify strategies and adaptive solutions to reverse this trend. To safeguard and rebuild marine life in urban sea areas, we need a common understanding of the limitations human impact imposes on marine organisms. We need to identify, design and test solutions that can be implemented in an adaptive long-term perspective. This demand bridging the gaps between disciplines and professions by establishing a common language and learning platform.

By working together for several years with redevelopment sites by the inner Oslofjord in Norway, the two authors, a marine biologist and a landscape architect, have started articulating a common language to identify and define appropriate nature-based solutions for creating healthy marine neighborhoods. Based on our experiences, that embraces cross-disciplinary cooperation with geologists, oceanographers, social scientists, urban planners, developers, architects and municipal caseworkers, step-by-step guidelines for the entire building process is outlined: from preparation and planning, to implementation and adaptation. General principles for a marine-life friendly design are introduced. The guidelines and the toolkit are centred around identifying limitations and to find solutions to the main constraints for marine life and human connectedness to marine nature in urban sea areas.



Helhetlig havforvaltning: Hva virker?

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Økosystembasert forvaltning er en av viktig form for helhetlig havforvaltning. For å bli vellykket kreves ikke bare en god diagnose av økosystemet, det må foreskrives effektiv behandling med tiltak som blir satt ut i livet. Studier av politikkutforming og gjennomføring er derfor vesentlig for å lære om hvilke tilnærminger som gir resultater. Implementeringsteori er en teoretisk plattform som er godt egnet for å undersøke case med sikte på å trekke ut lærdommer av mer generell gyldighet.

Canada var en pioner da landet i 1996 innførte helhetlig havforvaltning i lovs form. Ett departement (DFO) fikk ansvaret for gjennomføringen. Det delegerte ansvaret for prøveprosjekter i fem «Large Ocean Management Areas» til sine regionale kontorer, uten sterk involvering eller støtte fra føderalt nivå. Prosjektene ble drevet som konsensusbasert samarbeidsplanlegging. Deltakerne pakket inn uenigheter i høytsvevende målformuleringer og klarte aldri å bli enige om konkrete tiltak. De to planene jeg studerte hadde derfor ikke resultert i at noen tiltak var iverksatt, til tross for hhv 14 og 6 års arbeid. I 2013 stanset den føderale canadiske regjeringen arbeidet med helhetlig havforvaltning.

I **Norge** ble økosystembasert havforvaltning introdusert som en mekanisme for å løse langvarig politisk strid om oljevirksomheten, uten lovfesting. Arbeidet startet i Barentshavet i 2002. Regjeringen mobiliserte fagetater på tvers av sektorer til å levere fagrapporter på bestilling, mens en gruppe med representanter fra flere departementer fikk ansvar for å lage planer med mål og tiltak. Konsensus ble foretrukket, men vanskelige konflikter ble løst på høyeste nivå i Regjeringen. Planene ble lagt fram som stortingsmeldinger. I de to første om Barentshavet (2006 og 2009) er det 179 «regjeringen vil-punkter». De aller fleste av disse er gjennomført. Unntakene er bl.a. marin arealplanlegging og marine verneområder. Produksjon av denne typen planer er nå blitt rutine.

De to casene understreker betydningen av politisk vilje framfor lovfesting. Alle sektorer må mobiliseres, det må finnes ressurser til arbeidet og mekanismer for å løse konflikter og fatte beslutninger på en legitim måte. Utformingen av planene har også betydning; generelle målformuleringer har fordeler, men må suppleres med indikatorer og konkrete tiltak. Det ulike engasjementet fra de to regjeringene kan trolig forklares med at havøkonomien i de to landene har svært ulik betydning.

Referanse:
Sander, Gunnar (2018). Ecosystem-based management in Canada and Norway: The importance of political leadership and effective decision-making for implementation. *Ocean and Coastal Management, 163,* 485 – 497. https://doi.org/10.1016/j.ocecoaman.2018.08.005.

Miljøeffekter ved dyrkning av sukkertare (*Saccharina latissima*) Et taredyrkingsanleggs rolle som kunstig habitat

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Dyrkning av tare har i de siste årene utviklet seg til å bli voksende industri i Norge. Med økt fokus på klima, vil dyrkning av tare ha et potensial for lagring av store deler karbon. I tillegg til dette kan tare blir en større del av matindustrien, både som supplement i dyrefôr og i vår diett. Tare er også et viktig tilleggsprodukt i en rekke industrielle produkter. bla kosmetikk. Et manglende fokus i dag er derimot rollen et taredyrkingsanlegg kan ha som et kunstig økosystem eller kunstig tareskog, og dermed som et habitat for en rekke arter. Som en del av KELPPRO er rollen taredyrkningsanlegg gir i denne sammenheng studert. Sammenligninger har blitt gjort for å se om taredyrkingsanlegg utgjør den sammen rollen som en naturlig tareskog eller bare det samme økosystem som man finner i vannmasser i områder rundt. Resultatene viser at anlegget som helhet viser til færre arter og individer, men likevel representerer et økosystem i større grad enn vannmassene. I tillegg har det kommet fram via denne studien at et taredyrkingsanlegg kan være medium for uønskede arter. Det er derfor av stor viktighet å legge fokus på flere slike studier for å se kartlegge positive og negative sider av denne industrien.

Figur: Til venstre: Seeweed Energy Solutions (SES) taredyrkingsanlegg. Til høyre: den fremmede arten *Caprella mutica* som ble funnet i store mengder i taredyrkingsanlegget.

Havbunnen avdekkes! Maringeologenes rolle i norsk kystkartlegging (POSTER)

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Viktige næringer og aktiviteter krever stadig større arealer i kystnære havområder, og plassbehovene kan ofte være gjensidig utelukkende. For å unngå konflikter mellom verneinteresser, akvakultur, fiskerier, friluftsliv, industri og andre aktører må forvaltningen av kystsonen foregå med best mulig datagrunnlag.

Landskapet under vann er til vanlig usynlig for oss, men har like stor variasjon i terreng, sedimenttyper og livsvilkår for planter og dyr som det vi ser på land. Norges geologiske undersøkelse (NGU) har siden 2003 publisert tolkede maringeologiske kart som viser havbunnens ulike egenskaper i stor målestokk (1:10 000 – 1:50 000). Kartene er blitt nyttige verktøy både for forvaltningen og for andre som bruker kysten på ulike vis, og er allment tilgjengelige i flere formater (se www.ngu.no). Dekningsgraden langs norskekysten er imidlertid fortsatt lav, og i de fleste kystområder finnes det lite detaljert informasjon om havbunnens vekslende naturforhold.

De fysiske forholdene på havbunnen kan kartlegges i stor detalj ved å kombinere høyoppløselige sjømålingsdata fra moderne multistråleekkolodd med observasjoner og prøvetaking i felt. Blant hovedproduktene i maringeologisk kystkartlegging er flatedekkende kart over utbredelsen til de ulike typene bunnsedimenter. Hver enkelt bunntype (som slam, sand, grus, blokk eller bart fjell) er et produkt av både fortidens og dagens geologiske og oseanografiske prosesser. Ulike bunntyper har ulike tekniske egenskaper, representerer ulike sedimentasjonsmiljøer og tilbyr ulike livsvilkår for bunnlevende organismer. Fra et detaljert kart over bunntyper kan vi avlede temakart som viser spesifikke bunnegenskaper som gravbarhet, ankringsforhold og opphopning av finkornige sedimenter, og i kombinasjon med biologiske observasjoner og oseanografiske data er kartene et godt utgangspunkt for modellering av bunnhabitater.

NGU, Havforskningsinstituttet og Kartverket har i 2020 tatt fatt på pilotprosjektet *Marine grunnkart i kystsonen*, et lenge etterspurt samarbeid der de tre statlige etatene skal bidra med hver sin ekspertise til å samle inn, forvalte og formidle data og kart over havbunnens geologiske, biologiske og kjemiske tilstand. I løpet av tre år skal det publiseres kart fra utvalgte kystkommuner i Rogaland, Møre og Romsdal og Troms og Finnmark, og resultatene herfra vil avgjøre om et nasjonalt kystkartleggingsprogram kan bli en realitet fra 2023.

Reconstructing growth in Norwegian spring-spawning herring: density dependence, environmental drivers and life-history evolution (POSTER)

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The Norwegian spring-spawning stock of Atlantic herring (*Clupea harengus*) is one of the largest fish stocks in the Atlantic Ocean and has an extraordinary long history of data collection, dating back more than 100 years. However, many questions about the stock's dynamics and life-history evolution remain; the growth patterns over the last decades may therefore provide important insights on the stock dynamics and possible evolutionary changes. Here we analyzed a time series of scale measurements, directly linked to body growth, that spans from 1935 to 2014 and covers all cohorts during this period. We tested mixed-effect models describing variation in growth with age and cohort as internal variables and stock or cohort biomass, temperature, North Atlantic Oscillation, and fishing pressure as external variables. Age at capture was used to control for selective mortality. This allowed us to explore intra- and inter-cohort growth dynamics and to identify extrinsic drivers of growth. Age was found to be a key determinant in explaining growth, but our models also revealed density-dependent growth as well as an effect of temperature, especially for juveniles. A weak positive relationship between fishing and growth was also detected. Furthermore, the random effects revealed a clear temporal pattern toward slower adult growth, but no significant trend was found for juveniles. This suggests that important drivers of change in growth have not been explicitly included, and one of these drivers may be evolution. A better understanding of growth dynamics may improve the predictability of stock dynamics and thus benefit fisheries management.

Atlantic bluefin tuna spawn early to avoid metabolic meltdown in larvae (POSTER)

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The phenology of breeding evolves from trade-offs driven by seasonal cycles. To predict how environmental change shifts breeding times or cause recruitment variability, we need to know the drivers of success in offspring produced at different times of the year. At their main spawning grounds in the Mediterranean Sea, Atlantic bluefin tuna spawn when the water temperature is lower than optimal for of their progeny. Here we use a range of laboratory experiments to build a model of development, feeding and bioenergetics of Bluefin tuna eggs and larvae, and then we find the optimal time to hatch in the seasonal cycle and compare with field observations of actual spawning times. We show that Atlantic bluefin tuna spawn while the larval prey (Cladocera) is abundant and before high temperatures raise metabolic energy demands beyond the larval feeding capacity. Better food availability shifts the optimal hatching date towards later and warmer part of the season. Heatwaves, like the one in 2003, may increase larval survival potential, but shorten the viable part of the season for spawning. Atlantic Bluefin tuna – a large, highly migratory marine top predator spawn while temperatures are rising, during a subtle, but important peak in larval prey abundance – and before the late summer heat leads to very high food requirements in the larvae.

Predation risk alters life history strategies in an oceanic copepod (POSTER)

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Calanus finmarchicus is an important trophic link between primary producers and pelagic fish stocks in the North Atlantic Ocean and adjacent seas, and among the world's most well-studied zooplankton species. While numerous studies have investigated the copepod's growth and development rates, the effect of predation risk on these processes remains unknown. We experimentally tested the effects of chemical predator cues in combination with varying food availability on growth and development from *C. finmarchicus* copepodite stage C4 to adult. We used the continuous *C. finmarchicus* culture at NTNU Sealab, and incubated juvenile *Cyclopterus lumpus* (lumpfish) in a separate tank where they were fed live *C. finmarchicus*. Water from the fish tank was continuously pumped through a mesh and into the tanks with predator cue treatment. Copepods developed faster to adult stage both in response to high food and to presence of predator cues. High food also resulted in increased body size and lipid fullness, while perceived predation risk in contrast triggered reduced size and lipid fullness. Our study shows that chemical predator cues can influence life history strategies in *C. finmarchicus*. Therefore, present and future patterns in body size, lipid fullness and life cycle of oceanic copepods may also reflect differences in predation risk.

Structural and functional effects of the invasive snow crab on benthic ecosystems in the Barents Sea (POSTER)

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Since its first appearance in the eastern Barents Sea in 1996, the invasive snow crab (Chionoecetes opilio) has rapidly increased and spread towards the west and in 2017 a few individuals were caught off the coast of Svalbard, Norway. The crab is a generalist predator, feeding on a wide range of benthic epi- and infauna, shrimp and even fish. As the snow crab population continues to increase and spread, the predation can potentially have direct and indirect effects on benthic ecosystems and food-web structure in wider areas of the Barents Sea. It is therefore crucial to investigate changes in the benthic community structure and function and to obtain in-depth knowledge on snow crab diet, prey selection, trophic level and general life history. As part of a larger project investigating the current and future ecology and management of snow crab in the Barents Sea (NFR funded EISA-project), we compared the structure and function of epi- and infauna at three locations in the central Barents Sea characterized by high, intermediate and low abundance of snow crab using sea floor photos and grab samples. Preliminary results show that there was a difference in species composition of epi- and infauna between locations. Number of infaunal species and their abundance was also lower at the location with high snow crab abundance compared to the location with low snow crab abundance. Interestingly, photo analysis revealed that there was a shift toward smaller brittle star disc diameters at the location with high snow crab abundance (station A to the left in figure below), suggesting that snow crabs select for larger prey sizes. Effects on benthic community functioning related to crab abundance are evaluated using Biological traits analysis (BTA). To assess possible future effects, our findings are compared to stations outside their current distribution range. These results will also be used to validate an Ecopath with Ecosim model of the Barents Sea food-web that focuses on quantifying the direct and indirect effects of snow crab under various climatic and management scenarios.