TROMSØ 2019

SHELLFISH SYMPOSIUM

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Host: Institute of Marine Research

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SHELLFISH: RESOURCES AND INVADERS OF THE NORTH

What is the role of cold-water shellfish as a harvestable resource and important ecosystem players in the northern hemisphere cold marine ecosystems?

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Book of abstracts

Everything that you need to know about submitting your manuscript for publication in the Shellfish Symposium issue of the ICES Journal of Marine Science

Authors

Howard I. Browman

Abstract

The current status of the ICES Journal of Marine Science will be presented (competitive ranking; number of submissions; acceptance rate, etc.). A description of/insight into the Journal's editorial process will be provided: editorial policies (e.g. the type of material that is likely to be pursued through review vs. not); the peer review process; typical time from submission to first decision and time from acceptance to publication online in advance access; submission deadline and publication timeline of the Symposium issue.

Keywords

ICES Journal of Marine Science

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OPENING KEYNOTE: Dynamics of snow crab in the eastern Bering Sea and US portions of the Chukchi and Beaufort seas under climate change

Authors

Gordon H. Kruse[1*], Lauren M. Divine[2,3], Laura M. Slater[1,4], and Joel B. Webb[1,5]

Abstract

The goal of the symposium is to discuss the role of cold-water shellfish both as a harvestable resource and as important ecosystem players in northern hemisphere cold marine ecosystems. As an example we chose to focus on snow crab in the eastern Bering Sea and US portions of the Chukchi and Beaufort seas, because our understanding of these issues has recently accelerated as a result of a number of research studies on this species in these areas. Snow crab (Chionoecetes opilio) support a commercially important fishery in the eastern Bering Sea (EBS) with annual catches that have fluctuated widely between 86,000 – 1,491,000 t since 1982. Snow crab are smaller and less abundant in the U.S. portions of the Chukchi and Beaufort seas, where an Arctic fishery management plan prohibits fishing owing to ecosystem considerations and scientific uncertainty. These regions have undergone severe decadal and long-term changes in ocean temperature and sea ice extent with major ecological consequences. For example, extraordinary weather during the winter of 2017/2018 resulted in the lowest ice year ever recorded for the EBS, as well as a highly unusual lack of a bottom cold pool (<2C) that had previously formed annually as a “footprint” of winter sea ice extent. We review recent research into the dynamics of snow crab under climate change in the EBS and Arctic waters off Alaska. We focus on environmental and ecological processes that appear to determine their geographic distribution, abundance, and productivity. Specifically, we consider the effects of temperature and other environmental factors (e.g., ocean currents) on distribution, reproduction, and recruitment, as well as the potential roles of competition and predation on snow crab population dynamics. Finally, we characterize observed ongoing changes in these snow crab stocks, their implications for commercial fisheries management, and identify research needs.

Keywords

Snow crab, population dynamics, distribution, climate change, temperature, sea ice, predation, larval advection

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Shellfish in new and changing environments

Chairs

Ann-Lisbeth Agnalt, Institute of Marine Research, Norway

Bernard Sainte-Marie, Pêches et Océans Canada, Canada

KEYNOTE: The American Lobster – Poster Child of a Changing Marine Ecosystem

Authors

Richard A. Wahle

Abstract

The American lobster has become a poster child for the impacts of environmental change on coastal ecosystems and economies that depend on it. Dynamic food webs and climate are changing lobster ecology and management. Although optimal conditions have receded from southern New England with a warming climate, they have expanded into the Gulf of Maine, reinforcing the positive effects of the widespread depletion of predatory groundfish, such as Atlantic cod, to trigger an unprecedented boom in lobster production, one that has elevated the lobster to its current status as the most valuable single-species fishery in the US and Canada. The future of this fishery is far from certain, though. In southern New England mass mortality and disease induced by summer heat stress and hypoxia have led to widespread collapse of the region's fishery. And although the Gulf of Maine's fishery is at record highs, the combined effects of the northward advance of shell disease and southern predators, and changes in the pelagic and benthic food web, pose a threat to its future. With few alternatives, coastal communities in Maine and Atlantic Canada are now perilously dependent on this single fishery. But traditional single-species fishery stock assessment does not fully capture the drivers of population dynamics, and it is increasingly important to embrace ecosystem-based management and forecasting tools that account for environmental interactions. The iconic lobster therefore has broad relevance as a case study of the sometimes contrasting impacts of environmental change and exploitation on our living marine resources and coastal communities.

Keywords

Homarus americanus, climate change, Gulf of Maine, ecosystem

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Changing Shellfish Invasions Under Climate Change: characterizing and predicting distributions and harvest opportunities.

Authors

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Abstract

Marine invasions are not uniform and some locations will have conditions amenable to supporting large populations of non-indigenous species (NIS) while others will not. Since impacts are often closely related to population size for many NIS, it is important to identify the amount of habitat capable of supporting populations at an "invasive" level to inform management. In British Columbia, Canada, where NIS bivalves with different ecological tolerances and invasion histories form the core of the shellfish industry, understanding their current and potential distribution under climate change is critical for ensuring sustainable industries and healthy ecosystems. Here we characterize the relative habitat suitability (a proxy of potential abundanace) of NIS bivalves using species distribution models under current and 2075 climate change scenarios. For the commercially important Pacific Oyster (*Crassostrea gigas*) and Manila Clam (*Venerupis philippinarium*) habitat suitability increases on the West Coast of Vancouver Island, the Central Coast and in Haida Gwaii and southeast Alaska thus providing potential economic opportunities. In contrast, for species like Varnish Clam (*Nuttallia obscurata*) and Softshell Clam (*Mya arenaria*) habitat suitability decreases throughout most of British Columbia potentially compromising existing commercial and recreational shellfish harvesting. However, changes in habitat suitability were seldom uniform such that specific locations could see either increases or decreases depending on the species. Predicting suitable habitat for NIS not only holds promise for targeting limited resources towards early detection of new invaders in susceptible environments, especially if overcoming natural biogeographical barriers to larval dispersal, but also provides insights into possible exploitation options for new invaders, especially in higher latitude systems where invasions historically have been more restricted.

Keywords

invasive species, habitat suitability, climate change, bivalves

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Pacific oysters in Scandinavian waters; harvesting potential and impact on local bivalves

Authors

Ane T. Laugen, Matthias Obst, and Åsa Strand

Abstract

The Pacific oyster (*Magallana gigas*) is not only one of the world's most utilised aquaculture species; it is also extremely apt at establishing feral populations in areas to which it has been introduced. Moreover, the relative ease by which it expands its geographical range outside original introduction sites makes it a highly successful invader.

Since 2006 the Skagerrak coastlines have established, self-sustaining, Pacific oyster stocks of millions of individuals and their range is expanding northwards along the Norwegian west coast and southwards towards the Baltic Sea. Our 2007-2019 time series from western Sweden show that the Pacific oysters experience low levels of predation, survive heavy winters, and bounce back from disease. Additionally, the Scandinavian Pacific oyster stocks are underused commercially. Populations are therefore free to grow without many constraints. While effects are not uniformly negative, a number of stakeholders are concerned about impacts on local coastal-zone bivalves.

To quantify the potential overlap between *M. gigas* and local bivalves we used an ecological niche modelling approach to 1) estimate current habitat availability for, 2) detect current niche overlap between, and 3) predict future suitable habitat of the invasive *M. gigas* and the European species *Ostrea edulis* and *Mytilus spp.* Most importantly, we found major overlap between the current theoretical niches of *M. gigas* and *O. edulis,* which warrants further field-based investigations to determine the degree to which their current realised niches overlap and associated consequences. Moreover, we urgently need to solve a number of challenges that currently limit the degree to which Pacific oysters are harvested commercially.

Keywords

Pacific oysters, invasive species, climate change, bivalves

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Challenges facing a lobster stock on the 'losing' end of climate change

Authors

T. L. Pugh and R. P. Glenn

Abstract

The *Homarus americanus* lobster population in the United States is currently assessed as two separate stocks: the Gulf of Maine stock, which has recently experienced rapid growth and expansion, and the Southern New England stock, which is depleted and experiencing recruitment failure. The disparate trajectories these two stocks have experienced over the past two decades appear to be related to the changing climate, and illustrate how a single species could be both a 'winner' and a 'loser' with respect to climate change impacts. Populations living at the warmer extent of the species' geographic range are more likely to be tipped over the threshold into negative impacts, due to the degree to which environmental changes affect population vital rates. Here we will focus on the Southern New England (SNE) lobster stock and review various data sources from the published literature and the Atlantic States Marine Fisheries Commission's U.S. lobster stock assessment, as well as preliminary and unpublished datasets, to explore how changes in the environment appear to link to multiple different stressors on this resource. Recent estimates of spawning stock biomass are similar to SSB estimates from the 1980s, but have resulted in fewer recruits compared to historic recruitment levels. This regime shift in stock productivity coincides with warming inshore waters observed in time series of sea surface and bottom water temperatures since the late 1990s, and increasingly long durations of extreme summer warmth. This excessive warmth negatively impacts the quality of inshore settlement habitat and may have caused an offshore shift in the distribution of adult lobsters, which subsequently influences larval dispersal patterns. Warmer waters also appear to be related to various emerging diseases observed in inshore SNE lobsters, including the most commonly recognized epizootic shell disease. The warmer SNE environment has allowed for the northwards expansion and population explosion of black sea bass, a known lobster predator. Finally, on top of these various stressors, commercial fishing has continued; although landings, effort, and overall participation in the fishery have declined dramatically over time. From the southern extent of the species range, warming waters have presented a number of challenges to the SNE lobster stock, and the question remains as to whether this stock can stabilize at lower levels of abundance, or will continue to decline.

Keywords

American lobster, southern New England, recruitment failure, depleted stock

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Snow crab (*Chionoecetes opilio*), a new food item for North-East Arctic cod (*Gadus morhua*) in the Barents Sea?

Authors

Rebecca E. Holt, Carsten Hvingel, Ann Lisbeth Agnalt, Andrey V. Dolgov, Ann Merete Hjelset, and Bjarte Bogstad

Abstract

The snow crab (*Chionoecetes opilio*) is a new species in the Barents Sea, still considered to be in an establishing phase, increasing in both distribution and abundance in recent years. The settlement of a new large mega-decapod is expected to have significant impacts on the entire Barents Sea ecosystem, through competition, predator-prey interactions with important commercial species such as North-east Arctic (NEA) cod (*Gadus morhua*), as well as impact benthic food-web dynamics. We explore the potential importance of cod predation in structuring snow crab distribution and abundance in the Barents Sea, as well as discuss its potential impact on the snow crab fishery, through an analysis of NEA cod diet using a unique 35-year time series of stomach content data from 1984-2018. We assessed spatio-temporal patterns of snow crab within NEA cod diet across years, between seasons, as well as ontogenetic trends, including predator-prey size relationships. We find that snow crab is a new prey item for NEA cod and in recent years represents one of the most important demersal crustacean species in NEA cod diet. The proportion of snow crab within cod diet has increased over time, consistent with the increase in the snow crab population as well as catches within the commercial snow crab fishery in the Barents Sea. We find that primarily 60-110cm cod prey upon snow crab, mainly in the summer/autumn season. Furthermore, our results support the idea that the snow crab is still in an establishing phase, shifting north and westwards in distribution. We find that NEA cod has the potential to regulate the snow crab expansion and population increase but is unlikely to be in direct competition with the fishery in the Barents Sea. We suggest that cod can be used as a biological sampling tool together with other monitoring programs to elucidate how new species may affect predator-prey and food-web dynamics within an ecosystem context.

Keywords

snow crab, non-native species, predator-prey dynamics, fisheries, ecosystem impact, diet.

Contact

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Assessing the life history of soft-shell clams (*Mya truncata*) of Baffin Island, Canada: Implications for sustainable Arctic fisheries

Authors

Jessica Wood*; Meghan Donovan; Scott Grant

Abstract

In Canada's Arctic, fishery development is a priority for federal and territorial governments, indigenous organizations, and communities. The soft-shell clam (Mya truncata) is an integral part of Canadian Arctic food webs, including providing an important source of natural food to indigenous communities. Where large numbers of clams have been found to exist in coastal waters of Baffin Island, Nunavut, there is pressure to determine whether existing subsistence fisheries can support commercial development. In addition to determining biomass, development of sustainable fisheries requires an understanding of life history traits. Despite its ecological, food security, and potential economic importance, the life history of soft-shell clams in the Canadian Arctic remains poorly understood. My research will investigate key life history traits in advance of fishery development including spawning season, sex specific growth, age/size at maturity, and biological condition/yield. By putting science at the forefront of fishery development, this study seeks to provide baseline information to compare to future conditions including effects of climate change. Clams collected in 2018 with the aid of indigenous community members near Kimmirut (Hudson Strait) and Iqaluit (Frobisher Bay) are examined.

Keywords

Arctic, soft-shell clam, Mya truncata, life history

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Observations and monitoring the possible disappearance of local blue mussel populations in Norway – mussels on the move?

Authors

Tore Strohmeier*[1], Stein Mortensen[1], Ellen. S. Grefsrud[1], Lars-Johan Naustvoll[1] and Øivind Strand[1]

Abstract

Recently *M. edulis* has experienced a large shift in the geographical distribution and range edge. *M. edulis* has reappeared in Svalbard after a 1000 years of absence, linked to elevated sea-surface temperatures. At present, *M. edulis* reproduces within Svalbard, indicating that all life history stages have adapted to the new environmental conditions. *M. edulis* has also shown a geographic contraction in its southern, equatorward range edge on the west Atlantic coast, shifting the range edge approximately 350 km north of its previous limit (Cape Hatteras, North Carolina). Along the southern portion of its range, intertidal populations of *M. edulis* have experienced high mortality directly associated with summer high temperatures, and in the Gulf of Maine the population has decreased by more than 60%. During the last years, local populations of *M. edulis* have been reported to have disappeared along the South East, South West, and Western coast of Norway (about 60 observations reported to the Institute of Marine Research). This presentation will summarize the results from an observer questionnaire on the disappearance of local blue mussel population and a planned mussel monitoring program for the Norwegian coast.

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An investigation of annual and biennial reproductive cycles for Eastern Bering Sea snow crab (*Chionoecetes opilio*), 2014-2018

Authors

Jennifer Gardner, Katherine Swiney, Bob Foy and Chris Long

Abstract

The management of the eastern Bering Sea (EBS) snow crab *Chionoecetes opilio* stock assumes an annual reproductive cycle. However, crabs found in seawater temperatures below 1 °C have been found to extend the reproductive cycle to two years. With a maximum 7 years functional maturity, a shift to primarily biennial reproduction could result in females brooding only 2-3 clutches, compared to 5-7 clutches throughout their lifespan. The objective of this study was to assess what proportion of *C. opilio* in the EBS are on a biennial reproductive cycle relative to bottom temperatures. Mature female *C. opilio* were collected on the annual National Marine Fisheries Service EBS bottom trawl survey from 2014-2018. Bimodality in oocyte area frequency distribution suggests the presence of biennial crab, with colder near bottom temperature significantly correlated with larger oocyte area. We also show that the proportion of crabs that are biennial varies with latitude and among years with temperature being the most likely driver. Oocyte area was not correlated with crab age suggesting that environmental parameters may be more important than biological determinations of biennial spawning. While there was low incidence of biennial reproduction for these warm years based on our methods, colder temperatures could increase the proportion of biennial crab and reduce reproductive potential for one of the largest commercial fisheries in Alaska.

Keywords

snow crab, biennial spawning, reproductive biology

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Temporal and spatial dynamics of the invasive red king crab and native brachyuran and anomuran larvae in Norwegian waters

Authors

Helena Kling Michelsen, Einar Magnus Nilssen, Torstein Pedersen, Camilla Svensen

Abstract

This study investigates the temporal and spatial patterns of larval stages of the invasive red king crab (*Paralithodes camtschaticus*, RKC) and co-existing native brachyurans and anomurans in a Norwegian fjord. It is one of few field studies describing the larval stage of native and invasive brachyurans and anomurans in the southern Barents Sea. Larvae were collected at 6 to 18 stations at roughly 1 to 2 month intervals over a 1.5-year period. RKC was the first species among anomurans and brachyurans to release their larvae in Norwegian waters, and due to an extended larval release (January – May) their larvae occurred for the longest period of time in the water column. The native boreoarctic *Pagurus pubescens* and *Hyas araneus* also released their larvae early in the year, starting in March. In contrast, larvae of the native boreal *Pagurus bernhardus, Hyas coarctatus* and *Munida* sp. were observed later in spring and summer. The combination of protracted hatching, high fecundity and high adult abundance of RKC are likely strong contributing factors to the species' successful establishment in the southern Barents Sea. This could thus favor the dispersal of RKC further south along the Norwegian coast and potentially north into Svalbard coastal waters.

Keywords

Paralithodes camtschaticus, zoea, Pagurus, Hyas, Barents Sea, biogeography

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Stomach content of the snow crab (*Chionoecetes opilio*) from the Barents Sea

Authors

Jan H. Sundet [1*)], Caroline Aas Tranang [1)], Einar M. Nilssen [1,2)] and Maria Jenssen [1)]

Abstract

The stomach content of 349 snow crabs sampled from several locations in the eastern Barents Sea between 2007 and 2014 was analyzed to reveal their diet and investigate whether stomach content composition varies with area, depth, size (carapace width, CW) and bottom temperature. The crabs were caught by bottom trawl during autumn (August – September) and winter (February), and were in the size range of 14-148-mm carapace width. All content was allocated to taxonomic prey groups. The most frequent prey were bivalves (81.7 %), polychaetes (77.7 %) and crustaceans (53.6 %). Foraminiferans were also frequently observed (42,4 %) and the occurrence of microplastic were surprisingly high (approx. 40 %). Relatively few stomachs were empty (3.2 % males and 0 % females) and the average number of prey groups were 5.6 and 5.3 in males and females respectively.

The analyses revealed that the snow crab in the Barents Sea are omnivorous feeders on a wide range of prey of epifauna, infauna and fish.

A Fisher's exact test, robust to few observations, revealed significant differences between areas regarding several prey groups. The test also showed that the occurrence of several major prey groups varied according to crab size and area. However, the application of multivariate analyses (PERMANOVA, canonical correspondence analysis (CCA) and multidimensional scaling (NMDS)), found no significant correlation between stomach content and environmental parameters or crab size.

Our findings suggest that the diet of snow crabs in the Barents Sea resemble what is found in the Bering Sea and eastern Canada regarding prey composition, but the differences between sexes in Bering Sea crabs could not be proven in those from the Barents Sea. The diet of Barents Sea snow crabs appears to be slightly different from crabs caught at Newfoundland banks.

These findings indicate that the snow crab in the Barents Sea feed on a wide range of both sessile and mobile benthic organisms, and their continuous spreading in the Barents Sea may therefore have significant impact on the ecosystem in this area.

Keywords

Snow crab, stomach content, diet

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Temperature effects on snow crab (*Chionoecetes opilio*) growth and size after terminal molt

Authors

Bernard Sainte-Marie, Jean-François Ouellet and Hélène Dionne

Abstract

Snow crab has a terminal molt (determinate growth) and, in contrast to most marine crustacean species, its maximum size appears to decline with increasing latitude or decreasing temperature. Size-after-terminal-molt (SATM) varies among populations and contributes strongly to fecundity and productivity, so it may be key to resilience to climate change and potential for commercial exploitation in new habitats. Although temperature is thought to be a strong driver of SATM, the life stages upon which it acts are still uncertain and this undermines our ability to predict SATM in time or in space. This study examined size-at-instar and the distribution of SATM along a longitudinal temperature gradient in the Gulf of St. Lawrence (GSL), the effect of temperature on juvenile/adolescent growth-per-molt and intermolt period in the laboratory, and the relationship between SATM, crab density and bottom temperature at one GSL site through a 29-year time series. Median male SATM declined by about 30% (21 mm carapace width) along the longitudinal ≈ 1.5°C gradient of declining temperature. Size-at-instar and growth-per-molt were less sensitive to temperature than intermolt period, and the latter varied more with temperature in smaller than in larger crabs. Temperature was a better predictor of SATM than crab density, and temperature during the earliest benthic life stages was most influential. Thus, a better definition of juvenile thermal habitat holds promise for the development of SATM predictive capability to improve management of traditional and northerly expanding populations of snow crab.

Keywords

snow crab, temperature, growth, size, maturity

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Temperature effects on growth and molt regulatory genes in red king crab

Authors

Øivind Andersen[1], Hanne Johnsen[2], Tina Thesslund[1], Ragnhild Stenberg Berg[1], Sten Siikavuopio[1], Donald Mykles[3], Astrid Wittmann[4]

Abstract

Crustacean growth and molting are strongly affected by temperature and nutrition involving complex neuroendocrine regulation in the brain and eyestalk. To get knowledge about the regulatory genes and their thermal response in red king crab, we performed a gene expression study of adult male crabs kept at low (4ºC) or high temperature (10ºC) for three weeks. Transcriptome analysis of several organs identified multiple genes, including myogenic regulators, Halloween genes controlling molting hormone production, and heat shock protein (HSP) genes. Gene specific qPCR primers were designed for quantification of the expression levels in the Y-organ, eyestalk and muscle. The results will be presented and possible molecular mechanisms underlying the low temperature tolerance in red king crab will be discussed.

Keywords

Red king crab, temperature, growth, moulting, regulatory genes

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Predicting the impact of climate change on spatial patterns of early life connectivity for snow crab (*Chionoecetes opilio*) in the eastern Bering Sea using an Individual-Based Model

Authors

William T. Stockhausen[1], Michael Torre[2], Christine Stawitz[3], Albert J. Hermann[2,4], Wei Cheng[2,4], Kelly Kearney[2], Kerim Aydin[1], Cody Szuwalski[1] and Robert Foy[1]

Abstract

Snow crab (*Chionoecetes opilio*) supports an important commercial fishery in Alaska, with landings from the eastern Bering Sea (EBS) of 18,000 mt and a value of $80 million in 2016. In light of recent swings of Arctic and EBS sea ice extent and retreat timing, fluctuations in cold pools of bottom water on the EBS continental shelf, and projected increases in regional temperatures under different IPCC climate change scenarios, much uncertainty exists as to the future of the EBS snow crab stock and fishery. To address one aspect of this uncertainty, we used output from a Regional Ocean Modeling System ocean circulation model for the EBS to drive an individual-based model (IBM) for the early life stages of snow crab to evaluate decadal-scale changes in predicted connectivity across the EBS shelf between potential zooeal hatching grounds and nursery areas for small benthic instars under the RCP 4.5 and 8.5 scenarios. We compare the results to an historical hindcast (1971-2010). Stage durations in the IBM are based on the local (Lagrangian) temperature environment experienced by each simulated individual using heat summation theory, with higher temperatures resulting in shorter durations. Our results suggest that local retention within fairly large-scale (~500 km) regions on the EBS shelf may actually increase for snow crab in the future due to reduced periods for the early pelagic life stages. However, southwestern shelf areas may no longer be conducive to adults if bottom temperatures increase, leading to an overall northwesterly shift of the stock.

Keywords

snow crab, climate change, IBM

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Understanding the early life history of the invading snow crab (*Chionoecetes opilio*) in the Barents Sea

Authors

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Abstract

The snow crab (*Chionoecetes opilio*) is an invading species in the Barents Sea and since its discovery in the mid-1990s an opportune commercial fishery has emerged. The pelagic larval duration of the crab lasts several months and given its prolific initial spread throughout the eastern Barents Sea, one might expect total invasion of the Barents Sea within years. At the same time little is known of temperature and depth prevalence of the pelagic larvae of the snow crab. Thus, here we aim to build an understanding of how the dispersal dynamics and assumed life history traits of their larvae (*viz.* temperature dependent survival and growth) fares in the icy waters of the Barents Sea.

To quantify the physical environment encountered by larvae during drift we applied a coupled biophysical model of ocean currents and hydrography with a Lagrangian particle tracking algorithm. Contrary to expectations our results indicate limited transport beyond present adult distribution. Additionally, the model predicts optimal survival at a different time of hatching compared to reports in the literature, indicated by sub-optimal temperatures during the presumed spawning season (mid-summer optimum vs. April-May). We speculate that the complex large-scale circulation patterns of the Barents Sea create a unique thermal regime, setting new constraints on the snow crab early life history. The observed sub-optimal fit with known life history traits of the species, together with constraints on dispersal potential, implicates that a full-scale invasion through larval dispersal in the Barents Sea may not be as likely as previously thought.

Keywords

Snow crab, Barents Sea, Larval dispersal, Early life history

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Retention of red king crab (*Paralithodes camtschaticus*) larvae in a sub-arctic fjord system – A modeling study

Authors

Pedersen, O.P.[1], Nilssen, E.M.[2] and Slagstad, D.[3]

Abstract

A hydrodynamical model and an Individual Based Model were used to study the dispersion of Red King Crab larvae in a sub-arctic ford system (Porsanger) for three different years (2002, 2005 and 2006). The years were selected based on the amount of freshwater discharge, composed of one relatively dry year, one year with medium run-off and one relatively wet year. The dispersion of Red King Crab larvae showed great inter-annual variability. During the dry year, a large proportion of the larvae were flushed offshore, while during the wet and medium years, a larger fraction was retained within the fjord system. The analysis done in this study shows a finely tuned relationship between wind-driven surface circulation, freshwater discharge (estuarine circulation) and the timing of biological processes, e.g. hatching and vertical migration (settling). The study clearly demonstrates that wind events can have a profound effect on Red King Crab larvae in the wind-driven layer with respect to offshore dispersion.

Keywords

Paralithodes camtschaticus, recruitment, Lagrangian models, fjord circulation

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Warming in the Arctic and distribution of the northern shrimp in the Barents Sea and adjacent waters

Authors

Denis V. Zakharov

Abstract

Since 2004 the studies of the northern shrimp (*Pandalus borealis*) stock were carried out within the Norwegian-Russian ecosystem survey from August to September. The survey area covers the Barents Sea and adjacent area of the Spitsbergen and Franz Joseph land. During annual surveys 3-5 vessels conducted Campelen-1800 trawls to assess shrimp stocks.

Increases in Barents Sea temperatures observed in the last decade have caused an eastward shift in the shrimp distribution. Decreasing ice cover provides the possibility of studying shrimp aggregations in the adjacent waters of the Arctic Ocean and the Barents Sea, previously rendered difficult due to hard ice conditions.

According to recent years estimations, the share of the shrimp biomass index in the eastern Barents Sea varied from 42 to 62% (mean 55.8% ± 3.6), previously it was estimated like 30 %. The proportion of shrimp fished by trawlers in the eastern Barents Sea has also increased, from 10% in 2013 to 44 % in 2018.

Since 2013, the Russian fishery has resumed after a break since 2002. It is now conducted mainly in the eastern Barents Sea and with catches increasing over the years. According to Norwegian data, since 2009 there was decreasing fishing activity in the Hopen Deep and around Spitsbergen, coupled with increased effort further east in the international waters (NIPAG, 2018).

Keywords

Barents Sea and adjacent waters, warming, northern shrimp, distribution

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Invasion of the Atlantic rock crab (*Cancer irroratus*) to Europe

Authors

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Abstract

With the increase in global oceanic trade the establishment of non-indigenous marine organisms has become a major environmental and economic problem worldwide. In 2006, the Atlantic rock crab (*Cancer irroratus*) was reported in Icelandic waters. This is the first record of this relatively large crab species outside its natural range, i.e. the east coast of North America. The crab was most likely transferred to Iceland as larvae in ballast water and has successfully established a reproducing population in Icelandic waters. The species has now spread clockwise around the country along the southwestern coast to the east coast, more than 70% of the coastline. Our studies show that the rock crab is now established in the Icelandic coastal ecosystem. The crab is abundant on soft bottom substrates, found in density up to 0.5 crabs/m^2 which is among the highest records documented for the species in its native areas. The green crab (*Carcinus maenas*) and the spider crab (*Hyas araneus*) are the only native brachyuran decapod species commonly found in its new habitat, but despite its recent colonization the rock crab was the most abundant brachyuran in the areas studied in southwest Iceland. The size and abundance of adult crabs, their reproductive conditions, and occurrence of all larval stages, indicate that the Atlantic rock crab has successfully colonized Iceland. Whether it is due to favourable environmental conditions, food availability or lack of predators and competitors remains to be seen.

Keywords

Non-indigenous species, *Cancer irroratus*, *Carcinus maenas*, *Hyas araneus*, Decapoda, colonization

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Decadal fluctuations of *Nephrops norvegicus* in Icelandic waters

Authors

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Abstract

Northerly distributional limits of *Nephrops (Nephrops norvegius)* lies at the Southern part of Iceland. Fishery initiated during a warm period in the early 1950s and in 1963 a record of 6000 tonnes were landed. The catches remained high during 1960 – 1970 with a high fishing mortality. That period was also characterized by increased effort and reduction in CPUE. The next two decades (1970 – 1990) were defined with a colder temperature regime. The catches were regulated with TAC, but fishing mortality remained relatively high, which led to an overall decrease in biomass. More stringent management led to build up of the stock during 1990 – 2010. From 1996 there was rather sharp increase in temperature with large year-classes entering the fisheries and good catches followed. Pulses in recruitment have caused many of the short-term fluctuations witnessed in the stock, but also periods of extreme cold spells at edge fishing grounds. However, from 2005 during recent warm period all year-classes have been really small or absent. That has led to a biomass decline, which is now estimated at all time low and an increasing vulnerability of the stock. During this warm regime the distributional range of *Nephrops* has slowly been increasing to the North-Western part of Iceland and the fishery has intensified again in border areas. The future prediction of *Nephrops* distributional limits based on predicted increase in bottom temperature will be discussed.

Keywords

Nephrops, fisheries, distributional chances, recruitment

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The toxicity of the chemotherapeutant, hydrogen peroxide, on European Lobster (*Homarus gammarus)* larvae and post-larvae

Authors

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Abstract

Chemotherapeutants used to control sea lice infestations in salmonid aquaculture are a growing environmental concern. Hydrogen peroxide (H2O2) a common bath treatment used around the world, is released directly into the environment where non-target organisms are at risk of exposure. The European lobster (*Homarus gammarus*) is a species at risk of bath treatment exposures as its distribution overlaps with the salmon farms in Norway. To date, the toxicity of this compound on the *H. gammarus*, has not been studied. The aim of this study was to investigate the sensitivity of *H. gammarus* pelagic larvae and post-larvae to acute H2O2 formulations, and its sub-lethal effects on the shelter seeking behavior of post-larvae stage V, following 1-h exposures and included a 24-h post-exposure observation period. Delayed toxicity was apparent in all pelagic stages with immobilization of the larvae immediately following the exposure period. However, after the 24-h recovery period mortality was observed. Exposure to H2O2 was toxic to all the pelagic larval stages as well as the post-larvae stage IV, with estimated 25-h median lethal concentrations (LC50) values of 177 mg/L (stage I), 404 mg/l (stage II), 823 mg/L (stage III), 710 mg/L (stage IV). The 25h-LC50 values for H2O2 for *H. gammarus* pelagic larvae and post-larvae were below the recommended concentrations used to treat sea lice on salmon farms, representing 10.4%, 23.7%, 48.4%, and 41.7% of the associated aquaculture treatment concentrations, respectively. Furthermore, in this study *H. gammarus* post-larvae V were exposed to a range of H2O2 concentrations to have an overview of the likely sub-lethal effects on shelter seeking behavior and mobility. The experiment started with the release of one lobster per lane at the opposite end from the shelter. Post-larvae stage V exposed to 170mg/L and 510mg/L H2O2 needed significantly more time to locate the shelter for the first time compared to the control animals when introduced to the lanes after 1-hr exposure. The total number of inspections of the shelter was significantly different between the control and the 170mg/L and 510mg/L treatments, and no difference between the control and the 85mg/L treatment. And all 85mg/L 70mg/L and 510mg/L treatments had a significant lower distance travelled than the control. These results demonstrate that H2O2 significantly reduces exploratory behavior and mobility of post-larva V *H. gammarus*. In conclusion, the totality of these findings increases our knowledge on the potential impacts of H2O2 on non-target species. They suggest that H2O2 bath treatment exposure has the potential to cause negative effects to the pelagic lobster larvae stages, including mortality and immobilization, and increasing the predation mortality of post-larvae V, by compromising their shelter seeking behavior.

Keywords

lobster larvae, hydrogen peroxide, pesticides, aquaculture, sub-lethal effects, behavior

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The recent expansion of the Pacific oyster, *Cassostrea gigas*, in Denmark

Authors

Pedro S. Freitas*, Pernille Nielsen, Antonio A. García, Camille Saurel, Jens K. Petersen

Abstract

The successful establishment of wild and naturally spreading populations of the invasive Pacific oyster (*Crassostrea gigas, syn. Magallana gigas*) in northern Europe in recent decades, together with its recent expansion in Danish coastal waters raises concerns in Denmark from both ecological and economical point of views. The Pacific oyster is capable of significant changes to coastal ecosystems and potentially negatively impact native bivalve species from competition for resources, food and habitat, or from co-travelling predators, pathogens and parasites. This could affect the Danish shellfish fishery for blue mussels, native flat oysters and cockles that represents 94% of the shellfish production in Denmark (51 898 t in 2017). Meanwhile, the Pacific oyster has become a new fishery resource, hence a small *C. gigas* fishery started in 2017 with 10 t, while aquaculture is not permitted.

Pacific oyster was introduced for aquaculture purposes throughout Europe on multiple occasions, particularly in the second half of the 20th century. In Denmark, it was first introduced to the Limfjorden in the 1970's and over the next two decades to other areas. Small and localized wild Pacific oyster populations first appeared in the 1990's in the Limfjorden, Wadden Sea and Isefjord, which since the middle of the 2000's have increased in population size, but also been spreading to new areas. Nowadays, the Pacific oyster is widely distributed in inner Danish coastal waters, with large Pacific oyster reefs, often mixed with blue mussels, presents in the western Limfjorden and intertidal flats of the Danish Wadden Sea.

We will present the recent expansion and spread of the Pacific oyster in the Limfjorden, where dense populations and reefs have developed in non-tidal shallow (< 1m depth) coastal areas, and new smaller populations became established in both deep and shallow areas in the past 5 to 10 years. Other noticeable expansions, such as the *C. gigas* predatory oyster drill *Ocinebrellus inornatus* or of the native flat oyster *Ostrea edulis* in the Limfjorden have been recorded at the same time.

The recent and future expansion of the Pacific oyster is discussed from a Danish perspective, on the evaluation and establishment of management decisions/policies that balance multiple stakeholders' interests. These range from protection against the potential impacts on both coastal ecosystems and economically important native bivalve fisheries as well as aquaculture activities. Furthermore, the development of a new resource exploitation of the already established wild Pacific oyster populations by commercial fishing, leisure fishing and tourism events e.g. oyster safaris are growing in Denmark.

Shellfish in new and changing environments

Keywords

Crassostrea gigas, Pacific oyster, Expansion, Denmark

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Managing Shellfish Fisheries

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KEYNOTE: Norwegian fisheries management – shellfish

Author

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Abstract

The four main elements of the national fisheris management regime is; research, regulatory measures, enforcement and sanctions, taking into account international cooperation and agreements. There are two fundamental types of regulatory measures in fisheries management; *access control* to reduce the catch capacity of the fishing fleet in a long term perspective, and *technical measures* and quotas in a short term view. In general we regulate catch capacity to enhance efficiency and profitablitity for the fishing fleet, and use technical measures and quotas coupled with strict enforcement measures to ensure sustainability. Good knowledge and scientific advice is the key to good fisheries management. The scientific basics are the managers´ tool for good management. Managers must understand the scientific advice, and also understand the consequences of the space for action provided by the advice. To achieve this, due respect for their different roles, as well as a good dialogue between scientists and managers is required. Shellfish management is a special case, because we have species that are or can be categorized as introduced to the ecosystem. One example is the red king crab. We face the challenge to manage it with a goal of long-term economic sustainability on one hand, and taking its ecosystem consequences into consideration on the other. The regulations of this fishery have evolved from an initial phase where focus was on getting information about the distribution of the stock through the fishing activity and building an understanding of it. This was the basis for a second phase of more sophisticated regulations with access control as well as technical measures and quotas.The overall result of this today is a well regulated fishery in a confined area.

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KEYNOTE: How to govern ungovernable objects?

Authors

Jahn Petter Johnsen

Abstract

How do we govern ungovernable objects? Marine governance is about governing people, not the resources. In this paper I will adress how establishement of a political and legal framwork, has made marine goverance in Norway. Until the establishment of our EEZ in 1977, the reources in Norwegian waters were in principle ungoveranble, but with the new framework, peoples activities could be regulated in rather effective ways. Moreover, through this process the actors in the instry became partners in governance and over time both ablility to govern and willingness to be governed increased, so-called governmentality increased. The lesson to be learned from this story is that governablity and governementality depend on each other. Without development of governmentality, the objects we govern remain ungovernable.

Keywords

Marine resources, governability, governmentality

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Russian scallop fishery: happiness or experience?

Authors

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Abstract

The Icelandic scallop fishery in the Russian part of the Barents Sea started in 1988 by the Faroese and Norwegian vessels. Russian vessels come to the scallop fishery in 1990. The fishery was carried out mainly by vessels with automated processing of the catch, although some small-sized Russian vessels (for coastal fisheries) with manual processing were in fishery too. At total, throughout the history of fishery there were caught 138.5 thous. tons of scallops.

The main commercial scallop settlement in the Barents Sea is Svyatonosskoe settlement. By the beginning of fishery, the scallops stock here was estimated at 2.5 million tons. The annual catch varied greatly, reaching up to 13.7 thousand tons some years. As the exploitation proceeded, the size of the stock decreased and now settled at around 200 thousand tons. Due to the collapse of the scallop commercial stock, the Russian scallop fishery in the Barents Sea is banned since 2018.

The stock collapse at the Svyatonosskoe settlement cannot be explained by direct fishing mortality only - according to official data, about 127 thousand tons were caught total. Highly likely, there was a large indirect mortality due to animals wounding and clogging of gills by sand as a result of usage heavy drags re-suspending the seabed. The latent mortality was also high - due to death of young scallops during the automatic catch processing and the lack of registration of discards of nonstandard products.

Some natural factors could also play the important role in the negative dynamics of the scallop commercial stock. By the end of the 20th century, a Kamchatka crab appeared in the Svyatonosskoe settlement. Crab’s stomachs contents show that the crab in this area fed both scallop fishing waste and damaged mollusks, as well as young scallops with fragile shell attached to the seabed by byssus. The prolonged warm period in the Barents Sea could also have possible negative impact: warm water lead to increase the energy costs of the mollusk metabolism, while during the polar night the amount of incoming food is greatly reduced due to the absence of phytoplankton. In addition, during the period of fishing, succession in the bottom community was observed: as the density of the scallop decreased, the abundance of other sestonophages — competitors of the scallop for space and food — increased.

Russian scallop fishing, based on a high stock biomass and initially seemingly well planned, led to a rapid stock collapse. This is due to the lack of knowledge about the fishery impact on the ecosystem and some probably wrong administrative decisions. In our opinion, the best strategy for scallop fishery and ecosystem of scallop beds is moderate fishery (light drags and manual processing of catch only) and periodical changes of fishing grounds.

Keywords

Barents Sea, icelandic scallop, fishery, stock, fishery, negative impact

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Bycatches of the red king crab in bottom fish fishery in the Russian waters of the Barents Sea. Assessment and regulations

Authors

Alexey V. Stesko, Sergey V. Bakanev

Abstract

Main aggregations of red king crabs in the Russian waters of the Barents Sea are located in coastal zone along the Murman coast and in south-eastern part of Russian EEZ. The large part of area of red king crab is currently banned for bottom trawl fishery. At the same time significant aggregations of crabs are concentrated at waters of traditional long-term and large-scaled bottom trawl fishery. According to the Russian fishery law all bycatched crabs should be released back into the sea.

Due to the continued eastern shift in spatial distribution of commercial red king crabs and overlapping it with trawl fishing areas, the bycatch problem turns acute. The paper aimed on the estimation of red king crab bycatched by the Russian bottom trawl fishery in the Barents Sea. Some regulations of bycatch are discussed too.

Estimations are based on the Russian commercial fishery statistics, information collected by observers onboard commercial vessels and data from multispecies research surveys performed by PINRO in 2001-2017. Also data from the special red king crab trawl investigations 2017-2018 and CPUE from bottom trawl fishery in 2013-2017 were analyzed.

The annual bycatch of the red king crab during Russian bottom trawl fishery in the Barents Sea in 2010-2017 ranged from 2 to 8 thou. t, representing 0.5-6.2% of the total red king crab biomass in the Russian EEZ of the Barents Sea. The bycatch of commercial males can reach 5.9% of the crab commercial stock biomass per annum.

Keywords

Barents Sea, bottom trawl fishery, red king crab, bycatch, assessment, regulations

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Russian fishery for red king crab in the Barents Sea: results of first decades

Authors

Konstantin M. Sokolov, Sergey V. Bakanev

Abstract

The red king crab fishery in the Russian part of the Barents Sea is a whole new activity in these heavily fished waters. Since the beginning in 2004, the Russian fishery for red king crab passed through two peaks of catches and has now stabilized at about 9.2 thou. t per annum. Such rather high level should be recognized as optimal under the existing natural conditions in the southern Barents Sea and present commercial stock biomass.

Over the red king crab fishery there has been a clear spatial shift of main fishing grounds about 200 n. miles eastward. Since early 2000-th, the grounds gradually moved from coastal waters of the Varangerfjord and the Motovsky bay to the Murman Rise and the Kanin Bank probably due to warming sea and rich crab generations appearing.

The modern Russian red king crab fishing season lasts 10 – 12 weeks in Aug.-Nov. with maximum catch taken during 38-40-th weeks of each 2011-2018.

The existed Russian red king crab fishery in the Barents Sea management system had led to stabilization of the crab's commercial stock at the high level and also providing highly efficient national seasonal fishery.

Keywords

Barents Sea, red king crab, russian fishery, gears, depths, fishing grounds, catch, efficiency, regulations

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Sustainability in the management of two important arctic crabs: the red king crab (*Paralithodes camtschaticus*) and the snow crab (*Chionoecetes opilio*)

Authors

J.H. Sundet [1)] A.H. Hoel [1,2)]

Abstract

King crabs and snow crabs are important species in northern fisheries in the Arctic coastal states. In Russia, USA (Alaska), Canada, Greenland as well as Norway these crab species are subject to significant fisheries, providing income to local communities as well as export earnings. The crab fisheries in these countries occurs in Arctic waters and are subject to different domestic management regimes. Taking the biology of these crabs as the point of departure, this paper discusses the various crab fisheries in these countries and the regimes developed for their management. A pertinent question is whether these different management regimes yield different outcomes in terms of the sustainability of the fisheries - economically, socially, as well as in a biological sense.

Keywords

Management, Invasive crabs, Fishing Resources

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Snowcrab in the Barents Sea – winner or villain?

Authors

Cecilie Hansen Eide, Erik Askov Mousing, Carsten Hvingel

Abstract

The invasion of snow crab in the Barents Sea has provided the system with a new, valuable, harvestable resource. However, despite this positive result for the fisheries, the invasion may also have led to changes in the ecosystem, including structural changes and shifts in energy pathways. A possible increase in the snow crab distribution in the future has the potential to impact a larger part of the Barents Sea ecosystem than under current day conditions. Here, we apply an end-to-end ecosystem model; the Nordic and Barents Seas Atlantis; for evaluating ecosystem effects of the invasion on the system, different management strategies and how and where the species can spread and settle in the Barents Sea in the future (1995-2044). Ecosystem effects, including uncertainty around diets in predator species and spatial differences in impact will be evaluated and discussed.

Keywords

Snowcrab, Barents Sea, Atlantis end-to-end, management strategies, ecosystem effects

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Does population genetic structure in Norway lobster (*Nephrops norvegicus*) call for a revision of the current management in Kattegat, Skagerrak, and the Norwegian deep?

Authors

Jon-Ivar Westgaard, Guldborg Søvik, Torild Johansen

Abstract

Boundaries between marine commercially exploited stocks are often based on economic zones and geographic divisions, without considerations of genetic structure or migration patterns. Investigations of genetic stock structure therefore often reveal a mismatch between management units and biological units. In the “Norwegian Deep, Skagerrak and Kattegat” region Norway lobster (*Nephrops norvegicus*) is divided into two management units, for which separate quota advice is provided by the International Council for the Exploration of the Sea (ICES): the Skagerrak/Kattegat area and the Norwegian Deep. The two management units differ with regards to catches, fishing pressure, monitoring and regulation. The present study analyzed the genetic structure of Norway lobster using microsatellites and compared this structure with the present management units. Outgroup samples from Iceland, Scotland, and the Hardangerfjord (Norwegian west coast) and the Gullmarsfjord (Swedish west coast) were collected for comparison. Our study suggests no population genetic differentiation between Norway lobster from the two management units, while a shallow genetic structure was observed on a larger geographic scale when comparing with Scotland and Iceland. Overall higher genetic differentiation between females, indicated sex biased dispersal.

Keywords

Nephrops norvegicus, genetic stock structure, management units, sex biased dispersal

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Managing the Confluence of Climate and Fishing Effects in Snow Crab

Authors

Dr. Darrell Mullowney

Abstract

Male-only fisheries such as snow crab are often thought to be resilient to heavy fishing pressure. The snow crab forms an important male-only fishery for numerous nations bordering arctic and sub-arctic seas. Historically, some stocks of snow crab have been deemed overfished, but fisheries exploitation has never knowingly been severe enough to force prolonged genotypic or phenotypic changes in life-history attributes such as size-at-maturity. Moreover, evidence from several regions has shown climate to have a strong regulating effect on snow crab stock productivity, including on growth attributes of molt frequency and terminal size. In conjunction with a forecasted recruitment decline associated with ecosystem warming, fisheries exploitation rates have been increased throughout the stock range of Newfoundland and Labrador snow crab in recent years, to levels not typical for this stock or other stocks globally. This increased exploitation has been associated with broad-scale declines in size-at-terminal molt in males. In this presentation, I investigate the role that fishing may have played in promoting the outcome of a downward shift in maturation dynamics for male snow crab, and elaborate on socio-economic circumstances associated with the increased exploitation in recent years as well as harvester behavioural responses to reducing biomass. Finally, I provide perspectives and advice on best management practices for snow crab.

Keywords

snow crab, Newfoundland and Labrador, fishing, climate, management

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Walking a Tight Line: Management of a New Arctic Fishery In the Presence of Spatially Differentiated Ecological-Economic Externalities

Authors

Linda Fernandez, Brooks Kaiser and Melina Kourantidou

Abstract

This paper models bio-economic processes of the Red King Crab (Paralithodes camtschaticus, RKC) as an invasive marine species in the Barents Sea. We seek to understand the impact of management decisions over harvesting taken jointly and independently by Russia, who purposefully introduced the crab, and Norway, into whose waters the crab has migrated. At stake in the invasion are unique benthic species and co-evolved systems that have taken millennia to develop and have measured nonmarket values. This work uses a spatial dynamic model to discuss management of international invasive species challenges. Since the countries differ across multiple dimensions of dispersal of stock along with damages of the invasion, harvest costs and market options, applied game theory enables the analysis. Historical management of the RKC by the two nations reflects differing market choices (Russia targets flash-frozen large scale fishing while Norway targets small-scale mostly live crab fishery). Thus we examine actual historical management under differing empirical national costs and benefits. The RKC presents particularly interesting challenges due to its dual nature as invasive species and market commodity. Part of the strategic balancing act needed for a solution to the spread of the RKC has been directed at spatial containment, where the containment procedure depends on economic incentives of open access fisheries. This research sheds light on the economic and ecological tradeoffs faced in rapidly changing Arctic waters and the challenges presented by transboundary resources with differing net benefits to different groups. Results show each country can respond with more flexibility to competitive world market under noncooperation (and more information on rate of stock transfer) compared to past cooperation; the reduction in dramatic swings in stock may signal more ability to sustain stock amidst change. Commercial value of bycatch avoided and nonmarket valuation of benthos in both zones of Norway offer incentives to harvest. Price takers in the Barents respond to crab prices (world market for fresh and frozen) as key to increase in profit maximizing harvest. Purposeful introduction does matter as the harvests are for a long term fishery instead of for an agenda of eradication/elimination of invasive crab

Keywords

bioeconomic management, balancing fisheries and habitat

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Ecological and Economic Globalization in Arctic and sub-Arctic Crab Fisheries

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Abstract

Climate change is creating new ecological boundaries for the productive capacities of earth's ecosystems (Scheffer et al. 2001). Human responses will determine the net impacts of these shifts (Hulme et al. 1999). Traditionally abundant ecosystems face species depletions, while the same species are becoming biological invaders elsewhere (Thomas et al. 2004). In this article we show how options for natural resource management depend on economic conditions for various components of the ecosystem. The uncertainty regarding future supply of Arctic and sub-Arctic crab fisheries provides a bellwether study of the global ecological and economic connections co-evolving between nature and industry. Industry costs and biological reproduction dynamics are highly differentiated across locations harvesting these crabs. Regionally differentiated changes in transportation capacity, costs, expectations, and incentives are increasing competition and uncertainty, and increasing prices are generating overfishing pressures (Elsler et al. 2018). The large physical, industrial and disciplinary distances amongst stakeholders have deterred global perspectives, cooperation, and analysis aimed at increased sustainability. In meeting together, a group of diverse global stakeholders, ecologists, economists, resource and conservation managers, fishers and industry representatives, has established specific channels of communication that can reduce intertwined ecological and market risks in the fisheries and the ecosystems upon which they depend. Information sharing and joint research agendas should focus on: 1) fostering integrated understanding of climate related impacts on fisheries viability; 2) management options for smoothing ecological uncertainties across time and diversifying risks (international agreements, cooperative research, cost-effective stock enhancement and by-product uses); and 3) sustainability in supply chains, markets, infrastructure and other investment decisions.

Works cited:

Elsler, L. G., S. E. Drohan, M. Schlüter, J. R. Watson, and S. A. Levin. 2018. Local, Global, Multi-Level: Market Structure and Multi-Species Fishery Dynamics. *Ecological Economics* 156:185–195.

Hulme, M., E. M. Barrow, N. W. Arnell, P. A. Harrison, T. C. Johns, and T. E. Downing. 1999. Relative impacts of human-induced climate change and natural climate variability. *Nature* 397(6721):688.

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. *Nature* 413(6856):591.

Thomas, C. D., A. Cameron, R. E. Green, M. Bakkenes, L. J. Beaumont, Y. C. Collingham, B. F. N. Erasmus, M. F. De Siqueira, A. Grainger, and L. Hannah. 2004. Extinction risk from climate change. *Nature* 427(6970):145.

Keywords

Red King Crab, Snow Crab, Globalization, Markets, Economic Change, Ecological Change

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Stock Management- balancing security and innovation

Authors

Nøstvold, Bjørg and Voldnes, Gøril

Abstract

The extremely positive prognosis of the Barents Sea snow crab fisheries led to a Klondike like atmosphere. Investments for more than 100 of million Euros where done within the Norwegian fleet. Most aiming to serve a steady market for frozen clusters in Japan and USA. However, the actors leaping at this new opportunity soon met massive biological, technological, and institutional uncertainties.

In 2019 after years of negative financial results, some say that the investments already made leave them no choice other than to keep fishing and produce frozen clusters and hoping that the situation might change. Most active actors wish that the Norwegian government will make a decision to close the access to the fisheries according to recommendations for sustainable stock management. Closed access and set individual quota within the total quota are often given as the most efficient ways to ensure both economic and environmental sustainability. However, research on i.e Norwegian cod stock management reveal that under capacity in the individual vessel is one important reason for quality challenges and for not taking care of rest raw material. Establishing a new industry while considering UN sustainable development goals it is important to discuss the challenge of balancing traditional management tools and the need for avoiding under capacity, quality challenges and access for innovative actors targeting optimal exploitation of the whole resource.

Keywords

Mangement, innovation, quality

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Catches in abandoned snow crab pots in the Barents Sea

Authors

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Abstract

In 2016 approximately 9000 snow crab pots were abandoned in the Barents Sea loophole. During a retrieval cruise in June 2018, approximately 8600 pots were retrieved, which provided a rare opportunity to assess the consequences of prolonged soak time on both crabs and pots.

About 25% of the pots contained snow crab (*Chionoecetes opilio*) with an average of more than six crabs per pot. Most of the catch were alive (97%), whereas dead crabs (2.5%) and shell fragments (<0.5%) were scarce. The catch was dominated by large males with a mean carapace width of ~112 mm and only one female was observed in the subsampling of ~3000 individuals. The carapaces were overall in good condition, however substantial leg tip abrasion and loss was observed, suggesting that the crabs had been in captivity on the abrasive polyethylene netting of the pots for a prolonged time. Reflex testing showed that the crabs were vital. This was supported by a relatively high muscle content. Hepatopancreas reserves were however low indicating an energy deficit. The large size of crabs, presence of shell fragments in stomachs and elevated cadmium level suggest cannibalism inside pots.

Pots retrieved had escape panels with cotton thread, however most threads were intact and of high tensile strength. The magnitude of the catches and long soak time indicate considerable and prolonged unaccounted mortality. Measures to prevent losing pots and measures to mitigate effects if they are lost are pressing in this fishery.

Keywords

pot fisheries, soak time, unaccounted mortality, ghostfishing

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Who's on the line, please? Using telephone surveys to learn more about the southern Gulf of St. Lawrence American lobster fishery.

Authors

[1]Stephanie A. Boudreau* and David Giard

Abstract

American lobster (*Homarus* americanus) supports the most valuable commercial fishery in Atlantic Canada. Over the past decades, lobster landings and abundance indicators in the southern Gulf of St. Lawrence (SGSL) have been increasing, with landings being above the long-term median and commercial landings are expected to continue trending upward. Management of the SGSL lobster fishery is based entirely on fishing effort. The four most important measures in controlling lobster fishing effort are; (1) a fixed number of lobster fishing licenses, (2) individual trap allocations, (3) limited fishing seasons, and (4) gear (e.g. trap) specifications. Information on how this effort is deployed, coupled with regulatory changes, is nuanced and not well understood or documented.

To learn more about the spatial, temporal, and socio-economic changes in the SGSL lobster fishery, telephone surveys of lobster fishers were conducted in 1993, 2005, 2011 and 2016. Questions were constructed around five general topics; (1) vessels, (2) traps, (3) fishing patterns, (4) general opinions and, (5) captain and crew.

To highlight some of the results, in the decade between the 1993 and 2005 surveys, the fleet transitioned from wood to fiberglass vessels and, in 2016, 70% were constructed of fiberglass while 7% were wood. Inboard diesel engines were found throughout the fleet and have been the dominant engine-type since at least 1993. Engine horsepower (hp), used as an indicator of the overall fishing capacity of the fleet, has been increasing with every survey year. In 2016, the average was 358 hp, double the 183 hp of 1993. Traps have been steadily increasing in surface area and the average in 2016 was 0.681 m^2, less area than the current regulation requiring a trap not exceed 1.125 m^2. On average, more than 80% of respondents in the 1993, 2005, and 2011 surveys, and 93% in 2016, hauled all of their traps every trip. When asked about lobster habitat and fishing grounds in 2016, 70% agreed that they were expanding. With respect to the trap escape mechanisms, 68% thought that after increasing the size of the opening, the time required to sort small lobsters and return them to the water was reduced. On average, the captains were a few years older in the most recent survey, in 1993 captains were 46 years old, and in 2016 they were 53. This corresponded with increasing experience as a captain, on average 19 years in 1993 and 24 years in 2016. The average number of deckhands on board at the beginning of the 2016 fishing season was, on average, 1.7 crew, and despite the higher abundance of lobster to handle, this was only marginally higher than 2005 (1.5) and 2011 (1.4). At the end of the 2016 season there were 1.6 deckhands, and no change in 2005 and 2011.

The phone survey results have been helpful in addressing knowledge gaps, understanding the socio-economic nature of the fishery, and supporting conservation decision-making for the lobster fishery. We continue to work through the data and revise the survey questions and methodology for future applications.

Keywords

American lobster, Southern Gulf of St. Lawrence, Atlantic Canada, Phone Surveys, Lobster Fishery

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The third dimension of sustainable aquaculture: social well-being. The case of France, Italy and Spain

Authors

Marianna Cavallo*, José A. Pérez Agúndez, Pascal Raux, Katia Frangoudes

Abstract

The blue economy concept was conceived during the Rio +20 UN Conference as an extension to the oceans of the green economy and endorses the principle of ensuring human well-being and environmental sustainability. In Europe, aquaculture is among those maritime sectors that will contribute to the blue economy generating jobs and food reducing the dependence of imported seafood. Nonetheless, the increase of production of EU Member States, estimates around 25% by 2025, is facing a growing opposition by coastal communities and is competing for space with other traditional marine users. This work summarises the factors influencing the social acceptability of the aquaculture in France, Italy and Spain and which are the national strategies to improve it. The results show that a) the sector suffers from a negative image related to its environmental impacts; b) there is a lack of spatial planning that is increasing conflicts with traditional sectors and c) the need to establish more transparent and open participatory mechanisms. Even though the national strategies have clearly defined the actions to meet the objectives of EU environmental policies (mainly Common Fisheries Policy, the EMMF, the Environmental Impact Assessment and the Marine Strategy Framework Directive) the compliance of these policies relies in the hands of single business, and governments need to demonstrate their commitment to ensure that unsustainable practices will not have negative impact on the environmental and on the socio-economic system. To present, the extensive legislation has ensured healthy products and environmentally sustainable practices but with a great cost for European producers (European Parliament, 2018).

It is concluded here that there is not a single solution to enhance social well-being of aquaculture since it depends on a number of social, economic and environmental factors that are strictly related to each other and countries should move towards a more integrated approach that will improve the sustainability of the sector in all its dimensions.

Keywords

Blue Economy, aquaculture, social well-being, environmental policy, public consultation

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New ways of harvesting shellfish

Chairs

Sten I. Siikavuopio, Nofima, Norway

Svein Løkkeborg, Institute of Marine Research, Norway

KEYNOTE: The Ups and Downs of Trap Fishing

Authors

Bradley G. Stevens

Abstract

Traps have been the gear of choice for catching crustaceans over millennia, during which they have been modified into many specialized versions adapted for particular species, habitats, and fishing methods. Most traps share common traits including methods of attraction, entry, and escape, although methods of deployment may differ between fisheries. Yet for all their benefits, traps also have a downside. While much research has been conducted on methods to improve crustacean catches using traps, little research has been conducted on the response of target species to traps, or the impacts of trap fishing. Bycatch of target and non-target species has been well reported elsewhere. Across a range of target species, traps are extremely inefficient sampling devices, as only a small fraction of available organisms enter them, and those that do enter can escape at high rates, leading to extremely low relative catch. Trap impacts fall into three categories: direct impacts on target populations, impacts on non-target populations, and impacts on environment or habitat. Trap deployment and recovery often involves direct or indirect impacts on organisms, and/or dragging the trap along the seafloor, which can lead to damage and destruction of habitat components such as corals, sea pens, and other epifauna. In certain areas, trap lines are sources of whale entanglement, and there is much interest in reducing the number of vertical lines as well as their potential for entanglement. New methods for deploying, locating, and recovering traps using ultrasonic devices are now being developed. The future of fisheries that depend on traps will require investment in research on new ways to reduce their negative impacts on benthic and pelagic resources.

Keywords

Traps, Impacts, Habitat

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Sea urchin harvesting in Norway: a challenge for past and present!

Authors

Philip James

Abstract

Nofima have been researching a range of sea urchin research topics over the past two decades including fishing, roe enhancement and farming from eggs to market. A recent three year project (URCHIN), funded by the Northern Periphery and Arctic program, and focused on the sea urchin fisheries in the northern Atlantic, including Norway. The project covered a range of topics and one of these was the most suitable method of harvesting sea urchins in arctic waters. The research built on previous harvesting research carried out by Nofima over the past decades.

This presentation describes some of the research carried out in the URCHIN project regarding harvesting and searching for new fishing grounds and biomass monitoring of sea urchins. Particularly in regards to the use of trapping. Over the past decade, a range of other options for sea urchin harvesting in the Arctic have been developed and in some cases tested. These will be ommercial in regard to their likelihood of being fully ommercialized. Finally, a summary of the current state of sea urchin utilization in Norway will be given.

Keywords

Sea urchin harvesting, novel, trapping

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Alternative bait trials in the Barents Sea snow crab fishery

Authors

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Abstract

Commercial harvesting of snow crab (*Chionoecetes opilio*) in the Barents Sea started in 2014 by Russian and Norwegian fishing vessels. This new fishery has significant bait requirements, representing an emerging conservation challenge. In this study, we evaluate the performance of five alternative (natural) baits manufactured from the waste stream of existing and sustainably managed harp seal (*Pagophilus groenlandicus*) and minke whale (*Balaenoptera acutorostrata*) capture. Five different types of new bait were evaluated, including seal fat (SF), seal fat with skin (SFS), seal meat with bone (SMB), whale fat with skin (WFS) and whale meat with fat (WMF). A comparative fishing experiment was conducted onboard a commercial snow crab fishing vessel in the Barents Sea (May-June, 2016) to evaluate the performance of traditional bait (squid, *Illexs spp.*) and alternative baits at catching snow crabs. Performance of the different baits were compared on the basis of the number of commercial crab caught per trap haul (Catch Per Unit Effort, CPUE) and carapace width (CW). Our results showed that SF and SFS performed equally well to traditional bait, with no statistical difference in CPUE (p-value = 0.325 and 0.069, respectively). All of the other experimental baits significantly decreased CPUE, when compared to squid. No significant effect of bait treatment on CW was detected and the cumulative distribution of CW was the same between control traps and each of the bait treatments. Overall the results indicated that SF and SFS represent a viable alternative to replace traditional bait, addressing a key conservation challenge in this bait intensive snow crab fishery.

Keywords

Alternative baits, Seal fat, Snow crab

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Lights! Sound! Action? The Effects of Novel Stimuli on the Catch Rates of Snow Crab (*Chionoecetes opilio*)

Authors

Meghan Donovan[1], Khanh Q. Nguyen[1], Jessica Wood[1], Paul D. Winger[1], Svein Løkkeborg[2], Odd-Børre Humborstad[2], Shannon M. Bayse[1]

Abstract

We investigated a variety of stimuli as a means to improve the catch rates of snow crab (*Chionoecetes opilio*). First, we tested how luminescent netting could affect snow crab capture. Laboratory work showed that luminescent netting has a variable light emittance based on the duration of UV exposure. A fishing experiment was subsequently conducted in eastern Canada to compare the catch rate of traditional and luminescent traps, and determine how soak time affected catch rate. We found that the catch per unit effort (CPUE; measured as number of crab per trap) was significantly higher in luminescent traps compared to traditional traps with non-luminescent netting, representing a 55% increase in the legal-sized crab CPUE, with no significant difference detected for sublegal-sized animals when soak times were short. When soak times were longer, ~9 d, CPUE was increased by 21% suggesting that after the initial attractiveness of the luminescent netting wore off, the experimental traps acted no differently than traditional traps. Additionally, a recent field study was undertaken to determine if artificial sounds could also act as attractants. Promising results were observed when catch rates were low, however CPUE does not appear to be different between acoustic traps and traditional traps when catch rates were already high. Soon, CPUE studies will be paired with behavioural audiogram analyses to determine snow crab reaction thresholds.

Keywords

snow crab luminescence acoustics CPUE

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Injury scoring of King crab (*Paralithodes Camtchaticus*) and Snow crab (*Chionoecetes opilio*) after capture and live holding

Authors

Hustad. A., Thesslund T., Johansson G.S., James P., Lorentzen G., Lian F., Siikavuopio S.I

Abstract

Snow crab fishing is a new industry in Norway, and differs from king crab fisheries as snow crabs are processed onboard while the majority of king crabs are exported live. The markets demand for live crabs is the same throughout the year, but for most countries, fishing is seasonal and quality of the crabs varies through the year.

Live holding of crabs is a possible way of increasing value and prolonging the season for live export. To document the effect of different holding conditions on crabs appearance and survival, a two step system for visual scoring is developed. 1) Vitality scoring based on RAMP (reflex action mortality predictor) scoring adjusted for these species. 2) Registering type and placement of injuries. Damages are recorded as lack of limbs or segments, wearing down of dactyl on walking legs, pinching marks from aggressive behavior, and undefined injuries from handling.

This scoring system is a tool for evaluating welfare and sorting crabs for processing, live holding, export or slaughtering. Greater awareness on how handling and storing of crabs will affect the condition of the crabs and thereby the value, will contribute to a more sustainable utilization of the resource. This presentation will illustrate the use of the techniques in previous studies and how it could be implemented in snow and king crab industries.

Keywords

king crab, snow crab, injury scoring, welfare, vitality

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Live holding of red king crab (*Paralithodes camtschaticus*) — Effect of time, temperature and feeding on the quality of processed clusters

Authors

Lian, F., Lorentzen, G., & Siikavuopio, S. I.

Abstract

The red king crab (*Paralithodes camtschaticus*, RKC) is one of the major commercial species within the family Lithodidae. In Norway, the commercial RKC fishery began in 2002 and became a year-around fishery in 2016. Nowadays, around 70% of the RKC landed in Norway is exported live to high-end markets in Europe, Asia and in the USA due to the appealing quality properties of the leg meat. However, the large seasonal variations observed in terms of meat content and other quality aspects may constitute a challenge from an industrial and market standpoint. Live holding of RKC onshore can offer a new opportunity not only to enhance the quality of the crabs before live export but also to enable flexible management of this resource. At Nofima, studies have been undertaken to evaluate the effect of live holding time (up to three months), temperature, and presence or absence of feeding in two different seasons (i.e., summer and winter). Quality attributes of the leg meat of processed crab clusters were clearly influenced by live holding conditions and season. By keeping control of key parameters during live holding, the product quality can be improved significantly, thus maximizing the crab value for the industry.

Keywords

Live holding, Feeding, King crab cluster, Processing, Meat quality

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Live transport of *Pandalus borealis*

Authors

Wenche Emblem Larsen, Snorre Bakke, Anja M. Landes

Abstract

Northern shrimp (*Pandalus borealis*) is an important fisheries resource in the northern parts of the Atlantic and Pacific Ocean. Trawled by larger off-shore vessels, the species is mainly landed as a boiled and frozen product. However, for boats fishing near-shore there is a potential to land shrimps live and at higher prices. To increase our understanding about optimal post-harvest handling of live shrimps we conducted a set of simulated dry (out of water) and wet (in water) transport experiments. Live shrimps transported dry for 24 hours at temperatures -0.5 °C showed a significant lower mortality rate (14.4 ± 2.5 %) compared to shrimps transported at 2 °C (mortality: 67.8 ± 2.5%). Pre-transport treatment of shrimps with the sedative AQUI-S® did not improve survival. Simulated transport of shrimps in water (2.0 °C) at two different densities (1 and 2 kg/box, corresponding to ~80 and ~160 kg/m3) showed an overall survival of 92.5± 1.4 % after four days, with no significant difference between densities. Our results show that there is a potential to transport shrimps alive to the market, which could give an added value to this commercially important crustacean.

Keywords

Northern shrimp, Pandalus borealis, live transport

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Snow crab (*Chionoecetes opilio*) clusters, effect of processing

Authors

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Abstract

Snow crab (*Chionoecetes opilio*) is a decapod species widely distributed in the northern Pacific, northwestern Atlantic and along the marginal seas in the Arctic Ocean. The adaptation of the crab as a non-native species in the Barents Sea has prompted a rapid growth of the Norwegian fishery with 2697 tons of snow crabs captured and processed in 2018. The commercial fishery is growing fast as a response to an increasing demand, especially from the EU, USA, Japan, and South Korea.

At Nofima we have studied how different processing methods and freezing affect the quality of snow crab clusters. A cluster, or “section” includes four walking legs plus one claw. In detail, we have explored the options in applying additives to minimize discoloration (i.e. melanosis) of the clusters. Furthermore, we have tested how different cooking regimen (time and temperature), high pressure technology, a variety of freezing methods, different intervals of freezing at -20 °C, and different thawing methods influence the quality of the clusters. The combination and choice of processing method clearly affect the quality of the snow cluster in terms of melanosis, weight loss (i.e. yield), and shelf life in the following storage at 4 °C after thawing.

Keywords

Snow crab, Clusters, Processing, Quality

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How to optimally take care of a new shellfish resource? – the case of Norwegian Snow crab

Authors

Gøril Voldnes and Bjørg Helen Nøstvold

Abstract

The harvesting of snow crab in the Barents Sea represent a new resource for the Norwegian seafood industry. It is vital, both according to the UN sustainability goals and the FAO recommendations, that all marine resources are well taken care of throughout the supply chain to preserve the quality and reduce waste. This implies taking proper care of the resource every step from harvesting till reaching the end-consumer. In the largest consumer markets for Snow crab, the US, Japan and South Korea, Norway is a new supplier, competing with large players from Russia, Canada and Alaska. Due to large distances, the Norwegian industry cannot compete on price, the focus should be on high quality. Unfortunately, today the focus is production of commodity products and frozen clusters being offered in the same markets as the big suppliers. To differentiate the Norwegian Snow crab and optimally take care of this new emerging resource, the industry should be more innovative and think live handling, high-end product development and usage of the valuable by-products. In a large research project called SnowMap, all these aspects are looked into with the intent to help benefit a future lucrative and sustainable Norwegian snow crab fishery. The aim for this presentation is to present the results from an important market perspective.

Keywords

Snow crab, Norway, Market, Sustainability, Optimal value creation

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Assessment and population dynamics of shellfish

Chairs

Carsten Hvingel, Institute of Marine Research, Norway

Gordon Kruse, University of Alaska Fairbanks, United States

KEYNOTE: Challenges in assessing Bering Sea crab: a changing environment, non-stationary population dynamics, and mass mortalities

Authors

Cody Szuwalski[1]

Abstract

The Bering Sea supports some of the most valuable crab fisheries in the United States. Currently, assessments of varying complexity are used to manage 10 Bering Sea stocks. In spite of relatively precautionary management, two stocks are currently designated ‘overfished’ and several stocks are near historical lows with changes in environmental factors identified as likely culprits in several circumstances. The physical environment of the Bering Sea has warmed rapidly, distributions of crab stocks and predator species are shifting, and unidentified mass mortalities have occurred (based on historical survey data). One of the key challenges faced in assessing Bering Sea crab is estimating reference points because no clear stock-recruit relationships exist and population dynamics appear to have changed over time. I will describe specific examples of these issues and our management responses. Finally, I will conclude with a description of an open source assessment platform developed to streamline and standardize the assessment of crab stocks in Alaska, called a General Model for Assessing Crustacean Stocks (GMACS).

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The great scallop *Pecten maximus* a fishery resource on the move northwards?

Authors

Ellen Sofie Grefsrud, Tore Strohmeier, Øivind Strand

Abstract

The great scallop *Pecten maximus* is distributed along the European Atlantic coasts, reported north to Lofoten Islands in Norway (69 ^{o}N). The commercial diver-fishery developed in mid-Norway during the early 1990's, overlap the major populations in the county of Trøndelag (64 ^{o}N). Since 1999 the catch has been 400-800 tonnes with a value of 2-3 million Euro. During the recent 3-4 years catches in the county of Nordland, north from Trøndelag has increased.

The northernmost find has been reported from Andøy, about 68-69 ^{o}N, but this was a fresh-looking valve and not a living specimen (Soot-Ryen, 1951). About 20 years ago the northernmost recording of a living specimen was at Grønholmen, west off Bodø (67^{o} 16' N; 14^{o} 09' E) (Strand, personal observation). Based on knowledge from monitoring and recreational diving at that time the northernmost viable populations were assumed to be located south of Bodø.

As a part of the "National marine habitat mapping program" areas of high abundance of the great scallop *P. maximus* and Iceland scallop *Chlamys* islandica has been mapped in Norwegian coastal areas The combination of a long coast line (100 000 km including the mainland coast and islands) with high variability in bottom topography and sediment types over short distances, makes scallop mapping a challenge. The scallop beds were mapped using a vessel-towed camera platform collecting real-time video along survey lines. These lines are chosen combining topographic information from sea maps with anecdotal knowledge about scallop distribution pattern. In 2012 *P. maximus* populations was found north of Bodø at Helligvær (67^{o} 26' N; 14^{o} 3' E). In 2013 the Lofoten area was mapped and live *P. maximus* were found at low densities at Sund and Skjellfjorden (68^{o} 01' N; 13^{o} 13' E) and a small but dense population was found in Nusfjord (68^{o} 02' N; 13^{o} 21' E). This was reported as the northernmost verified live *P. Maximus*, further northward than previously registered (Grefsrud et al. 2015).

In 2018 the locations in Lofoten (Sund and Nusfjord) and coastal locations further south towards Bodø were revisited using scuba diving, in order to confirm the registrations from 2012-13 and to allow for samples of the scallops. This survey confirmed the distribution pattern from 2012-13. Surprisingly, all locations where scallops could be found showed an age distribution indicating that recruitment to these populations have been relatively stable during the recent 4-5 years. This included the northernmost locations Sund and Nusfjord. The data suggest that the conditions for recruitment of the great scallop *P. maximus* has improved in the coastal areas from Bodø to the outher part of Lofoten islands. The apparent distribution in the Vestfjord (south from Lofoten islands) will be discussed in relation to hydrographic patterns and minimum temperature fronts in the area.

References

Grefsrud ES, Jenssen M. Strand Ø. 2015. Northern distribution of *Pecten maximus* and *Aequipecten opercularis* populations in Norway. The 20th International Pectinid Workshop, 22nd-28th April 2015, Galway, Ireland

Soot-Ryen T, 1951. New records on the distribution of marine mollusca in Northern Norway. Astarte, 1: 1-11.

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The Icelandic sea urchin resources - stock assessment and management

Authors

Gudrun G. Thorarinsdottir

Abstract

The green sea urchin stock (*Strongylocentrotus droebachiensis*) in Iceland has been utilized sporadically since 1986 with fluctuating landings and no management plan until 2016. Fishery management requires information on productivity and abundance of the stock. In 2015 an assessment was conducted in the main fishing area using underwater photography and swept area method (dredge) providing information on stock size and distribution of the urchins. Information on population structure and biology (gametogenic cycle and spawning) were also gained. As a result of this investigation a management plan was conducted including catch limit, dredge constructions and size limit of the landed urchins.

Keywords

The green sea urchin, Strongylocentrotus droebachiensis

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A quantitative multi-species dive survey program for monitoring benthic marine invertebrates in British Columbia, Canada

Authors

Dominique Bureau, Janet Lochead

Abstract

Dive fisheries for four species of benthic marine invertebrates operate in British Columbia, along the western coast of Canada. The species harvested by dive are red and green sea urchins (*Mesocentrotus franciscanus* and *Strongylocentrotus droebachiensis*), giant red sea cucumber (*Apostichopus californicus*) and geoduck clam (*Panopea generosa*). Stock assessments for these species have traditionally been conducted using data from single-species dive surveys. Since some of these species share the same habitat and survey methods are similar between species, a new quantitative multi-species dive survey program is being developed to provide a more efficient survey design and to move towards ecosystem-based monitoring. Other species of interest, the endangered northern abalone (*Haliotis kamtschatkana*), the purple sea urchin (*Strongylocentrotus purpuratus*) and the sunflower star (*Pycnopodia helianthoides*, an important predator of the species of interest) as well as habitat variables (depth, substrate, algae species and abundance) are also surveyed. The goal of the program is to set up a network of index sites throughout the coast of British Columbia that will be surveyed on a rotational basis to provide a long-term time series of quantitative abundance and size data to monitor stock trends over time. The index sites will be located within commercially harvested areas and within Marine Protected Areas, to evaluate the impact of harvesting and Marine Protected Area effectiveness. In recognition of Canada's endorsement of the United Nations Declaration on the Rights of Indigenous Peoples, this survey program will be conducted in collaboration with coastal indigenous communities. Data collected through this program will be used to assess stocks in relation to fishery reference points thereby informing stock status and ensuring compliance with legislated requirements under Canada's Sustainable Fisheries Framework and Precautionary Approach policies.

Keywords

benthic invertebrate, stock assessment, monitoring, time series, reference point, dive, fishery

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Can a simple stock assessment model work? – lessons learnt through 20 years in a shrimp fishery advisory process

Authors

Carsten Hvingel[1], Ann Dorte Burmeister[2], Frank Rigét[2]

Abstract

The West Greenland shrimp stock supports the largest fishery for *Pandalus borealis* with annual catches close to or in excess of 100,000 tonnes. The revenue from this fishery represents about 70% of the Greenland economy and good resource management that supports long-term sustainability is therefore crucially important. For about twenty years, a stock production model has been the central tool of the stock management procedure. In addition to a relatively simple description of net population growth, that implicitly includes natural mortality, recruitment and somatic growth, the model also includes an explicit term for cod predation. As such it is one of the few models used in ICES and NAFO, which is based on more than one species.

The data input to the model beside annual catches are time-series of survey biomass, Catch-Per-Unit-Effort of the commercial fishery, cod abundance, overlap between the shrimp stock and the cod and a time-series of shrimp consumption by cod. These time-series are linked to the model incorporating process and observation error using a state-space modelling framework. A Bayesian approach is used to construct posterior probability distributions of model parameters and derived variables relevant for management advice.

A relatively simple stock assessment model with relatively modest data requirements has been in place for a highly valuable stock almost 20 years and begs the question: how did it work? We evaluate the historical performance of the model framework by comparisons of one-year predictions of various management reference points with the actual results of the next year assessment estimates. We also assess the model's long-term predictive capability and assess its uncertainties. The importance of including the predation by cod in the assessment model is illustrated. In the end we discuss the overall performance of the model derived fishery advice and the resulting management decisions since 2000.

Keywords

Shrimp, assessment model, performance, resource management

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Management of a small fjord shrimp population

Authors

Ingibjörg G. Jónsdóttir

Abstract

Managing northern shrimp (*Pandalus borealis*) fisheries can be challenging as shrimp is both commercially valuable but are also an important prey for several marine species. Shrimp fishing in Iceland started in north-west Iceland (Ísafjarðardjúp) in 1935 and proceeded until 2004. During this period the maximum annual catch was around 3000 tonnes. Research started in the fjord in the 1960's and since 1988 a standardized survey has been conducted in the fjord annually. The purpose of the survey is to measure the distribution and stock size of northern shrimp along with the by-catch species in the shrimp trawl. The biodiversity of the fjord has changed in the last two decades where gadoid species, Atlantic cod and haddock, have become abundant whereas the abundance of other fish species and shrimp has decreased. At the same time the distribution of the shrimp changed, as it has now been observed in relatively small areas compared with before and sometimes at very high density. Due to these changes it has been difficult to estimate the stock size and manage the shrimp fishery in the fjord.

Keywords

Northern shrimp, fjord, biodiversity, stock assessment

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Estimation of Key Population Parameters and MSY-based Reference Points for Sidestripe Shrimp (*Pandalopsis dispar*, Rathbun, 1902) in Shrimp Management Area Fraser River, British Columbia, Canada

Authors

Zane Zhang and Ken Fong

Abstract

Sidestripe shrimp (*Pandalopsis dispar*, Rathbun, 1902) is a protandric hermaphrodite and short-lived species. They are commercially harvested by bottom trawl gear in British Columbia. Fishery-independent area-swept trawl surveys have been conducted annually between late May and August on the sidestripe shrimp population in Shrimp Management Area Fraser River since 1998, providing valuable information about abundance and size distribution of sidestripe shrimp at various life stages during the survey periods. We used the survey data together with reported catch data from the fishery to estimate growth, natural mortality rate (M), and stock-recruitment relationship. Specifically, we described a new way of estimating shrimp age by taking advantage of the unique features of sidestripe shrimp life history, producing a growth model for this population. We estimated M by comparing survey-derived abundance of sidestripe shrimp for a particular life stage with predicted abundance for this life stage based on the survey data from the previous year and estimated commercial catches. M was estimated to be 0.24 y^{-1}, and is close to the lower end of M range reported for Pandalid shrimp. In addition, we showed that there is positive correlation between recruitment (abundance of one-year-old males) and spawning female biomass, and constructed Beverton-Holt stock-recruitment models. We then estimated maximum sustainable yield (MSY), fishing mortality to achieve MSY, and spawning biomass producing MSY, by projecting the population dynamics model to equilibrium under various fishing mortality rates. These estimates may prove to be useful as biological reference points for management of the sidestripe fishery in British Columbia.

Keywords

MSY-based Reference Points

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Effects of no-take zones on the dynamics of Northern shrimp (*Pandalus borealis*) – a case study from fjord systems in North-Norway

Authors

Fabian Zimmermann, Trude Hauge Thangstad, Kjell Nedreaas, Hans Kristian Strand, Guldborg Søvik

Abstract

Data on dynamics of unfished stocks rarely exist. Two fjords in North-Norway closed for commercial trawling of Northern shrimp (*Pandalus borealis*) since the early 1970's provided a unique opportunity for studying population dynamics of shrimp in absence of fishing. We compared the two no-take fjords, Porsanger- and Tanafjord with the neighboring fjord Kvænangen that has been continuously fished. All three fjords were surveyed three times during two years with catch samples from bottom trawls and traps, collecting data on density and body size of shrimp and demersal fish, as well as temperature. The results showed a clear spatial pattern with significantly larger biomass per haul in Porsanger- and Tanafjord, compared with Kvænangen. However, this pattern was partly driven by higher densities in the inner Porsangerfjord, where an isolated pocket of near-zero bottom water shapes an ecosystem different from the rest of the investigated area. Specifically, predation pressure on shrimp in this Arctic refuge is much lower due to the absence of typical predators such as Atlantic cod. Otherwise, shrimp densities tended to increase with bottom depth and indicated a weak negative relationship with cod density. Catches in traps were low compared to trawls but revealed the occurrence of shrimp outside soft-bottom habitats typical for shrimp. Contrasting expectations, the size distribution varied little among the fjords. Our study showed surprisingly little effects of no-take zones on population density and structure of Northern shrimp, suggesting that the effects of a fishing ban may be compensated by increased density dependence and predation.

Keywords

Population dynamics, shrimp fishery, MPA, fisheries management

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Populations indices of Norway lobster (*Nephrops norvegicus*) in Skagerrak and Norwegian Deep derived from trawl survey data

Authors

Carsten Hvingel[1], Guldborg Søvik, Ann Merete Hjelset

Abstract

Norway lobster (*Nephrops norvegicus*) is a fishery resource and its management require estimates of population size. The standard data collection method to acquire such estimates for *Nephrops* stocks is by underwater video surveys. *Nephrops* spends most of its time hidden in burrows in the bottom sediment, which is why the species is not so readily available to survey gear like bottom trawls. In video surveys, the characteristic openings of the burrows are recorded by cameras and by assuming that one burrow contains one *Nephrops*, the video survey generates an estimate of the total number in the surveyed area.

For various reasons a dedicated video survey for *Nephrops* is not available for some important areas of the distributional range of this species. The population dynamics of *Nephrops* in the Norwegian part of Skagerrak and the Norwegian Deep which forms a part of the stock complex in the Kattegat-Skagerrak-North Sea area exploited by several commercial fisheries, are therefore largely unknown. We try to remedy this by using data from a bottom trawl survey aimed at shrimp, but which nevertheless covers the important *Nephrops* habitats in these areas.

A prevalent feature of the survey data is hauls without any catch of *Nephrops* and the distribution of abundance in the positive hauls is highly skewed. Data such as this pose problems in statistical analysis, in particular with respect to the calculation of confidence distributions, even for the estimate of a simple statistic such as total numbers or biomass. We use a generalised-gamma-binomial model that deals with these challenges and generates probability density distributions of the annual survey estimates in the units of the raw data.

Keywords

Nephrops, abundance index, Skagerrak and Norway deep, trawl survey

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The increasing recreational trap fishery for Norway lobster (*Nephrops norvegicus*) along the southwestern coast of Norway – insights from a baseline study

Authors

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Abstract

Recreational fisheries are challenging to monitor. In Norway, this applies particularly for the data-poor recreational trap fishery for Norway lobster (*Nephros norvegicus*). We investigated the fishery by surveying identified recreational fishers between 2012 and 2014, revealing that the recreational trap fishery for *Nephrops* is an emerging activity with a low mean experience of 3.5 years, in contrast to, e.g., more than 25 years in the recreational fishery for European lobster. Overall, CPUE remained stable within and between years, however there was a clear difference between the different regions, with CPUE in West-Norway roughly double that of the Skagerrak area. Contrastingly, a smaller size composition of the catch was found in West-Norway. Size was, thus, strongly correlated with area, in addition to month and sex. In Skagerrak, the proportions of females and of berried females in the catch showed strong variation over time, peaking in the second quarter, whereas in West-Norway the proportions remained relatively stable throughout the year. Overall, only 4% of the catches were under the minimum size limit (40 mm carapax length). A comparison with catch data from the established Swedish commercial trap fishery for *Nephrops* showed a significantly smaller size distribution than in Norway but a higher CPUE than in the Norwegian Skagerrak, comparable to West-Norway. The contrast between the Norwegian areas is reflected in the commercial landings, which in recent years stem from almost exclusively traps in West-Norway but have remained trawl-dominated in Skagerrak, suggesting that the combined recreational and commercial fishing shape the *Nephrops* dynamics.

Keywords

Norway lobster, recreational fishing, data-limited fishery, landing trends, CPUE, size distribution

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From the Adriatic to Northern Norway - Geographic differences in moult increment of the European Lobster *Homarus gammarus*

Authors

Matthew T. Coleman[1,2], Michael C. Bell[1]

European lobster *Homarus gammarus* support commercial valuable fisheries across its range from the Adriatic Sea to Northern Norway, encompassing variable environmental conditions influencing regional adaptation and population biology. Despite its commercial, value little is known about geographic differences in growth at regional, national and international scales. This study compiled existing historical data on lobster moult increment from studies undertaken from the Adriatic Sea to the Northern Norway, together with new tagging data from Orkney, Scotland, encompassing the entire known distribution of the European lobster. Generalised Additive Models (GAMs) were used to investigate geographic differences in moult increment. Latitude was a significant predictor of moult increment in both males and females, albeit with low explanatory power. Smaller moult increment size was observed at southern and northern latitudes with larger increments growth observed in the centre of the species' range, suggesting optimum thermal boundary for increment size. Results of this are put into the context of important life history traits and further exploratory analysis is undertaken to understand further drivers behind the observed trend and differences in size related moult increment.

Keywords

crustacean, environmental drivers, fishery management, general additive model, growth

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Past and future population growth and range expansion of the of the introduced species of red king crab (*Paralithodes camtschaticus*) off Northern Norway

Authors

Carsten Hvingel[1*], Einar M. Nilssen[2], Ann Merete Hjelset[1], Franz Mueter[3] , and Jan H. Sundet[1]

Abstract

A population dynamic model for the Norwegian stock of king crab (*Paralithodes camtschaticus*) introduced to the Barents Sea in the 1960-70s was constructed to provide a time series of population development and as a tool for deriving fishery management advice. Information from relative sparse and sometimes missing data was boosted in a two-step process: 1) modeling the survey data using GLM techniques and 2) modeling the stock trajectory using a hierarchical model and Bayesian inference.

The colonization of coastal areas following the introduction of this new crab species to the Barents Sea has taken place in a stepwise manner: relatively well-defined areas were invaded sequentially – starting in Varangerfjorden, the eastern-most fjord close to the Russian border. Then the crab moved westwards through Tanafjorden, Laksefjorden and Porsangerfjorden. By assuming similar habitat quality in each of these areas, the period from the arrival of the first crabs and the following population growth could be treated as repetitions of similar colonization events and simulated in a hierarchical model structure. Thereby information could be "borrowed" across all units (fjords or areas) and missing data handled in a statistically coherent manner. Further, Bayesian inference allowed incorporation of prior information (i.e. information other than the available "hard data" (indices of stock size and exploitation).

The model provided estimated posterior probability distributions of stock development by fjord and area and for total core distribution area (east of 26^{o} E) and included various variables relevant for deriving management advice, such as future risk of transgressing reference points in relation to alternative management options.

The King crab is continuously expanding its range and is now found out of the "core area" making its way further west and south along the coast. We make an attempt to quantify population density also in these areas and discuss plausible future scenarios of king crab distribution inside the core area as well as outside along the Norwegian coastline and Svalbard.

Keywords

King crab, invasive species, population growth, hierachical model

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Abundance and spatioal distribution of brown crab (*Cancer pagurus*) from fishery-independent dredge and trawl surveys in the North Sea

Authors

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Abstract

Brown crab (*Cancer pagurus*) is a widely distributed crustacean that occurs around the British coastline supporting important commercial fisheries. The habitat preferences of brown crab around Scotland are poorly documented and for the purposes of stock assessment, the species is considered data-poor. Based on an analysis of dredge and trawl surveys taking place in the North Sea (2008-2018), we describe the spatial distribution of brown crab and for the first time, develop abundance and recruitment indices for the species. We make use of geostatistical methods and apply generalized additive models (GAMs) to model catch rates in relation to a number of explanatory variables (depth, distance to the coast, sediment type and year). The dredge and trawl abundance indexes were correlated showing a similar trend of increasing catch rates in the early years of the time series up to 2016 and a subsequent reduction. The recruitment index showed a gradual increase in captured juvenile crabs up to 2014 followed by a steep decrease with 2018 being the lowest value estimated. The derivation of robust indicators of stock abundance will contribute to the stock assessment of this species and enable the provision of improved fisheries management advice for brown crab around Scotland.

Keywords

brown crab, geostatistics, survey, fishery-independent data, dredge, trawl, spatial distribution, creel fisheries, Scotland

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Can cod count crabs? - Abundance of the invading snow crab in the Barents Sea estimated through cod stomach analysis

Authors

Carsten Hvingel[1], Rebecca E. Holt[2], Kristin Windsland[1], Andrey V. Dolgov[3] Ann Merete Hjelset[1], Ann-Lisbeth Agnalt[1], Bjarte Bogstad[1]

Abstract

The snow crab (*Chionoecetes opilio*) is a new and expanding species in the Barents Sea. To quantify harvest potential as well as possible ecosystem impacts, we need time series of snow crab stock size and means to predict its future development. Fundamental data to feed high quality stock assessments come from standardized scientific surveys. The Barents Sea is extensively covered annually by multiple trawl surveys. However, the selectivity for snow crab by the Campelen trawl used is low. The concern is if minor and unregistered variations in the trawling process significantly alter the selectivity for snow crab and thus bias the abundance estimates. We therefore constructed an alternative snow crab abundance index using cod (*Gadus morhua*) as an *in-situ* sampling tool.

Cod is an opportunistic predator known to prey upon snow crab, thus abundance data may be derived via stomach content analyses of cod diet data. As such, the spatiotemporal occurrence of snow crab in cod diets was examined as a potential index of relative crab abundance. Many cod had no crabs in their stomach and the number of crabs in the non-zero stomachs have a highly skewed distribution. Data were therefore analysed with a compound model, in which separate predictors were fitted for the proportion of “zeros” and for the number of crabs in the of the “non-zero stomachs”. The compound model was fitted by Bayesian methods. The distribution of the data fitted well to the model and the derived stock index showed that the population of snow crab has increased exponentially over the period 2003 to 2018. It is not possible to make an independent validation of this new time series of snow crab stock size; however, it was found largely in agreement with inferences made from the trawl survey and expert judgement.

Keywords

snow crab, abundance index, cod as biosampler, modelling stomach samples

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Seasonal variations in the meat and by-product quality of the snow crab (Chionoecetes opilio) in Barents Sea

Authors

Runar G. Solstad, Alexandre Descomps; Birth Vang; Rasmus Karstad; Sten Ivar Siikavuopio; Ragnhild Whitaker

Abstract

The snow crab (*Chionoecetes opilio*), SC is an invasive species new to the Barents Sea that expands its geographic range by larval drift and adult migration. The snow crab fishery has established itself as a new and profitable industry in Norway within the last decade. The fishery started as a year-round fishery, without any information of seasonal variation in the quality of the product. To evaluate SC in the Barents Sea, variations of the meat quality (cluster) and by-products where investigated, aiming to identify the seasons where the exploitation of different products from SC can be most profitable. The results show seasonal variations in muscle and by-product quality. The best meat quality and by-product quantity is from February to April; followed by a period (June-September) with decreasing meat and by-product quantity. Our recommendation is to capture the SC in the winter-spring period in the Barents Sea.

Keywords

Snow crab, population seasonal variation, meat content

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Posters

The effects of climate change on economically important filter feeders

Authors

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Abstract

With the warming of Arctic and Subarctic coasts the distribution of many economically important filter feeders is moving north (e.g. *Magallana gigas, Mytilus edulis Ciona intestinalis*) increasing the potential for aquaculture. However, these northern waters are also predicted to show some of the largest changes in carbonate chemistry and salinity associated with climate change. Laboratory and field experiments show that, although the level of response is species specific, in general, the elevated costs of maintaining homeostasis under elevated pCO2 and decreased salinity diverts energy away from growth and reproduction effecting the production potential and fitness of filter feeders. In addition, negative effects on absorption efficiency and clearance rate mean that filter feeders are unable to utilise available seston. We show that decreased scope for growth (SfG) and lower production in response to elevated pCO2 and reduced salinity are primarily driven by these feeding responses and will occur independently of food availability. In fact, food limitation may be beneficial under elevated pCO2, at least in the mid-term. Understanding how these stressors interact to effect physiological responses that underpin production, and furthermore how these responses differ between species, is complex. However, this knowledge is critical to “future proofing” our advice to industry on future aquiculture sites, not only to promote the production of target species but also in reducing the impact of pests.

Keywords

climate change, filter feeders, carbonate chemistry, salinity, aquaculture

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Aborigens vs. invaders: role of crabs in diet of demersal fishes in the Barents Sea

Authors

Andrey V. Dolgov, Aleksandr N. Benzik, O. Yu Chetyrkina

Abstract

Based on data from the joint Russian-Norwegian data base on stomachs content of the Barents Sea fish, the role of aborigen and new species of crabs in diet of Atlantic cod and other demersal fish was considered for the period 1984-2018. Totally 8 species of crabs and craboids inhabit the Barents Sea, some of them often registered in diet of many demersal fishes.

Aborigen species crabs *Hyas* spp. and hermits crabs *Eupagurus* spp. are traditional prey items for many fish species, but their importance was rather low. Their weight percent in cod diet was only 1.4 and 0.3 % in average in 1984-2018. One more crab species *Lithodes maja* was practically absent in demersal fish diet.

Trophic role of 3 new crabs species invaded to the Barents Sea after mid-1980s is completely different. Deep-sea crab *Geryon trispinosus* occurred in cod diet since 1984, but their role as a prey item was very low - average 0.03 % for this period, the highest weight percent - up to 0.2 %). Despite abundance of red king crab *Paralithodes camtschaticus*, introduced in the Barents Sea in 1960s, sharply increased since mid-1990s, this species appeared in cod diet only in 2000. Their role in cod diet was also very low, average weight percent was only 0.3 % for the period 2000-2018. Snow crab *Chionoecetes opilio* appeared in 2003, but this species became the most important prey item for cod among all large decapods. Their weight percent increased from 0.01-0.03 % in 2003-2008 to 1-3 % in 2011-2013 and 5.2-6.5 in 2014-2018.

Keywords

crabs, snow crabs, diet, demersal fish, cod, Barents Sea

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Red is better – northern shrimp and other shrimps in diet of fish in the Barents Sea

Authors

Andrey V. Dolgov, Aleksandr N. Benzik, O. Yu Chetyrkina

Abstract

Totally 32 species of shrimps (infraorder Caridea) occur in the Barents Sea. More than 20 species were registered in diet of almost 60 fish species in the Barents Sea. The most frequent prey items in fish diet are representatives of genus *Pandalus*, *Sclerocrangon*, *Sabinea*, Spirontocaris, Lebbeus, Pasiphaea

General information on species composition of caridean shrimps and their importance (weight percent and frequency of occurrence) in diet of various fish species in the Barents Sea will be presented. For some fish species temporal and ontogenetic dynamics of shrimps consumption will considered.

The cod was the most abundant fish predator with high impact on shrimp in the Barents Sea. The most important shrimp as prey items for cod were northern shrimp *Pandalus borealis* (5.0 % by weight in average in 1984-2018) and much lesser *Sclerocrangon* spp. and *Sabinea* spp. (0.2 % by weight each), other shrimps consisted <0.1 %. Interannual, seasonal, spatial and ontogenetic changes in cod predation on northern shrimps will also considered. Estimates of northern shrimp biomass consumed by cod in 1984 will be provided.

Keywords

shrimps, northern shrimp, diet, consumption, demersal fish, cod, Barents Sea

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Structure and long-term dynamics of zoobenthos communities on the scallop beds near the Kola Peninsula

Authors

Tatiana B. Nosova, Igor E. Manushin, Denis V. Zakharov

Abstract

The ecosystem populated by commercial species is changing not only due to environmental factors, but fishery too. It is particularly evident with regards to scallop bed. The Russian scallop fishery based on two main scallop settlements: in southern part of the Barents Sea (Svyatonosskoe settlement) and in the Voronka of the White Sea. Some significant changes in the structure of benthic communities were occurred over the history of scallop settlements exploitation. The Icelandic scallop fishery was carried out by specialized vessels - draggers near the Russian coast. The processing technology of scallops does not include separation of alive benthic fauna from the catch. As a result, the majority of bycatched animals die.

In our investigation the scallop beds were divided on four area: unexploited (near coast settlement), moderately exploited for a long time, heavily exploited for a short time and periodically exploited. In the southern area of the Svyatonosskoe settlement (moderately exploited for a long time) the recovery of zoobenthos is observed. In the northern area of the Svyatonosskoe settlement (heavily exploited for a short time in 1995 - 2004) extremely low biomasses of zoobenthos and scallop are observed. In the Voronka of the White Sea (periodically exploited) high biomass values of zoobenthos are formed mainly by mussels. In unexploited areas of scallop bed the zoobenthos biomass and biodiversity have high values.

The dynamic of the zoobenthos abundance over the past 25 years was also studied. Changes in the trophic structure of the Svyatonosskoe community (southern part of the Barents Sea) are very high. Carnivorous organisms represented up to a half of total abundance when the highest pressure of fishery was be. The percentage of sestonophages (excluding Iceland scallop), the competitors of scallop for food and habit, has increased in the Svyatonosskoe community from 10 % in early 1990-s to 70 % now. Evidently, full recovery of the common scallop and zoobenthos community to the native state will take more than a decade.

In our opinion, the best strategy for scallop fishery and ecosystem is moderate fishery (with light drags and manual processing of catch) and periodical changes of fishing grounds.

Keywords

Barents Sea, zoobenthos communities, scallop beds, scallop fishery, influence

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High values of cadmium in brown crab *Cancer pagurus* from Northern Norway: A result of a changing environment?

Authors

Martin Wiech[a], Sylvia Frantzen[a], Arne Duinker[a], Amund Maage[a,b]

Abstract

High values of cadmium in edible tissue have been documented in brown crab caught in the Salten region (~67° N) and northwards. A high consumption of brown crab from this area may pose a health risk and regular exceedings of the maximum limit in claw meat hamper commercial trading.
The brown crab invaded this area rather recently, about 50-100 years ago.
Our recent findings support the idea that the high levels of cadmium are caused by the environmental change the brown crab experiences in this area.
We found a positive correlation between crab size and cadmium which was pronounced in the North, meaning that cadmium is accumulated over time. Combined with a slower growth of the crabs in the North, this might explain the higher values in the North.
Our study also suggests a difference in the migratory pattern of brown crabs in the North compared to further South. As the brown crab is a highly opportunistic feeder and cadmium is almost solely taken up from feed, this may result in the consumption of different prey items and consequently to different levels of cadmium in the brown crab.
This example shows that even traditionally used species may develop a risk in terms of food safety due to changes in their environment and distribution expansion.

Keywords

brown crab, cadmium, health risk, distribution expansion

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Trophic level estimates of shellfish and other groups in the Barents Sea, do estimates from Ecopath mass-balance models and stable isotopes differ?

Authors

Torstein Pedersen

Abstract

Estimates of trophic level for functional groups and species are important to understand food-web structure and trophic relationships. A food-web for the arctic Barents Sea (area ca. 1.6 mill km^2) spanning ca. 5.5 trophic levels was analysed using a mass-balance model approach (Ecopath). The mass-balance models have 117 functional groups including all trophic levels ranging from phytoplankton to polar bear and separate models were parametrized for three years (1985, 2000 and 2013). Estimates of trophic levels from the mass-balance model and from 49 published data sets with stabile isotope studies (delta 15N, > 800 values) from the Barents sea for 72 ecological groups were compared to test the hypothesis that they were equal. Generally, trophic levels values derived from Ecopath and from stable isotopes were highly correlated (Pearson r of ca. 0.87) and the average difference in trophic levels for ecological groups was small (ca. 0.21). I tested if use of alternative baseline values and group- and delta 15N specific discrimination factors affected the general relationship with mass-balance model derived trophic levels. For ecological groups, especially shellfish groups, where the Ecopath and SI-derived trophic level values differed, I analysed and discussed which factors could explain the deviation pattern.

Keywords

trophic Level, food-web model, stable-isotopes

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The snow crab (*Chionoecetes opilio*) – growth potential and constraints in the Barents Sea based on benthic secondary production

Authors

M. M. Fuhrmann[1], B. Holte[1], A. H. Solberg Tanberg[2], A.M. Hjelset[1]

Abstract

The snow crab (*Chionoecetes opilio*) is native to the North Pacific Ocean and North East Atlantic. In 1996 the first observations were made in the eastern Barents Sea by Russian scientists. The snow crab is a benthic predator that prefers small infauna such as polychaetes and bivalves, which it captures efficiently with its claws from the sediment. The snow crab has established a population in large areas of the Barents Sea, but future stock size and carrying capacity of the benthic ecosystem will highly depend on the prey available to this new invader. We therefore studied in- and epifaunal secondary production at 68 stations in the Barents Sea, combining grab and beamtrawl sampling. Annual benthic community production was estimated using empirical models incorporating community traits and environmental parameters. In combination with diet information, estimates of consumption and growth known from the native areas of the snow crab we discuss the ecosystem impact and potential growth of the future Barents Sea snow crab stock on the Norwegian continental shelf in the Barents Sea.

Keywords

snowcrab, Barents Sea, invasive species, benthic production,

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Ecology and management of the invasive snow crab: Predicting expansion, impacts and sustainability in the Arctic under climate change (EISA)

Authors

Paul Renaud, Sabine Cochrane, Marta Coll, Eivind Oug

Abstract

The Research Council of Norway funded program EISA starting in March 2019 and completed an extensive field campaign in August 2019. With newly collected samples we will use molecular tools to investigate the origin of the crab populations in the central-western part of the Barents Sea, assess the genetic potential for continued dispersal, and analyze crab diets. We will study benthic faunal community structure and function along a gradient in crab density to determine the actual and potential benthic effects of their grazing activities. Further, based on actual and modelled scenarios, EISA aims to predict expansion routes and ecosystem impacts under current and changing Arctic climatic conditions. The results of this project will be important for a sustainable management of both crab populations and sea-floor environments in the Barents Sea.

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The migratory behavior and area utilization of red king crab (Paralithodes camtschaticus) in newly invaded Norwegian coastal areas

Authors

Magnus Aune, Jenny Jensen, Sten Siikavuopio, Guttorm Christensen, Kåre Tormod Nilsen

Abstract

The red king crab (*Paralithodes camtschaticus*) was introduced to Russian waters in the Barents Sea in the 1960's and has since the late 1970's expanded into Norwegian waters. It is now an important commercial species in Norwegian fisheries and is found in dense concentrations as far south as Balsfjord in Troms county. Although there is relatively good knowledge of the species' migratory behavior and area utilization in Norwegian fjords. Still there is lack of detailed information on the seasonal migratory behavior, makes it challenging to harvest the species efficiently. Therefore, acoustic telemetry was used to study in detail the migratory behavior and area utilization of 39 red king crabs in a fjord in the western part of northern Norway over a period from May to November. Some of the crabs moved quickly out of the fjord after tagging, and recaptures showed that migrating crabs could move at least 0.5 km/day in a particular direction. The individuals remaining in the fjord preferred the deeper parts of the fjord throughout the study period, particularly during the warmest summer months. However, they responded quickly to changes in water temperatures by going deeper into colder water masses in spring/summertime and shallower again response to the cooling sea temperature in the autumn. Furthermore, the crabs largely moved together within the fjord, and they displayed strong temporal variation in activity level. These data increase our capacity to predict seasonal variation in king crab habitat choice and catchability and can therefore represent an important step towards a more sustainable and efficient harvesting of the red king crab in Norwegian waters.

Keywords

King crab, telemetry, migration

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Dynamics of trap catches and spatial distribution of the red king crab males and females in the Russian part of the Varanger fjord in 2008-2018

Authors

Alexey V. Stesko

Abstract

The Varanger fjord is one of the first waters of the Barents Sea, where the red king crab took roots after the introduction in the 1960-s. Red king crab in the Russian part of the Varanger fjord is investigated by bottom conic traps generally.

The work describes the dynamics of trap catches and the spatial distribution of the red king crab in the Russian waters of the Varanger fjord in July-August 2008-2018. For analysis, all crabs were separated to categories depending on the carapace width for males (commercial, pre-recruits, juvenile) and on the presence of fertilized eggs for females (with/without). The distribution of crab catches was estimated using the spline approximation method in software Chartmaster 4.1 (“VNIRO”, Russia).

The greatest catches of commercial males were observed in northern and eastern parts of the Varanger fjord at depths 100-150 m (up to 25 spec./trap). In 2014-2018 an increase of the portion of commercial males in the catches was observed there. Catch of pre-recruits was high in 2009-2013 (more than 10 ind./trap on average), but after 2014 it decreased slightly (5-7 ind. /trap), likely due to the features of seasonal migrations or the low abundance of juveniles, these years accounted usually 2 -3 spec./trap. The catches of egged females during the survey were low (2-4 ind./trap), highly likely due to the specific of the traps setting, placed at depths of more than 50 m, while the majority of such females are usually distributed in shallow waters near the shore. Immature and juvenile females in the summer are often harvested in the deep part of the Varanger fjord, together with commercial males. In 2013-2017 their average annual catches were 3-5 ind./trap and were lower than in 2010-2011 (6-8 ind./trap).

Keywords

Barents Sea, Varanger fjord, red king crab, distribution, catches

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Development of the fishery for snow crab (*Chionoecetes opilio*) in the Barents Sea in the period 2012-2018

Authors

Ann Merete Hjelset and Hanna Ellerine Helle Danielsen

Abstract

The snow crab (*Chionoecetes opilio*) is a valued delicacy worldwide and represent important fisheries in Alaska, East Russia, Canada and Greenland. The snow crab fishery is the largest crab fishery in the world. Catches are generally declining, while there is an upward trend in the demand for snow crab in the global market. In 1996 the first observations of snow crabs were made in southeastern part of the Barents Sea, and since then the population has increased significantly in both distribution and size. A commercial fishery for snow crab in the Barents Sea commenced just a few years after the crab was first observed, with a small landing of 2 thousand tons in 2012. Total landings reached a peak of 18 thousand tons in 2015, after which changes in the fishery management lead to a slight decrease. Number of vessels participating has varied from one to 33, and the fishing gear has exclusively been conical traps. Effort and fishing grounds has varied through the period, as the resources has been explored and mapped. This process has until quite recently mainly been driven by the fishery itself.

The novel fishery for snow crab has landed < 4 thousand tons the last years, and is currently the second most valuable crab fishery in Norwegian waters. The more established fisheries for the red king crab (*Paralithodes camtschaticus*) have the smallest landings, but represents the highest export value, and the edible crab (*Cancer pagurus*) fishery which has the longest history, has the highest landings in tons but the lowest value per kg. The three fisheries have different geographical distribution, historical development and management regimes. The fishery for snow crab is the newest and is under establishment and more knowledge is needed to make good management decisions for the future.

Keywords

Fisheries, traps, commercial fishing, Loophole, non-native

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Using an individual-based model (IBM) driven by a Regional Ocean Modeling System (ROMS) to evaluate potential impacts of climate change on broad-scale patterns of larval dispersal and settlement of Snow Crab

Authors

Michael P. Torre[1], William T. Stockhausen[2]

Abstract

Oceanographic conditions in the Bering Sea are extremely dynamic and being altered as a result of climate change. Snow crab (*Chionoecetes opilio)* are a key commercial species dependent on this variable environment. However, management of this species has presented several challenges resulting from unstable populations and complex life history patterns. To explore the complexity of pelagic larval distribution and settlement into early benthic stages, an individual-based model (IBM) for early life stages of snow crab was coupled with outputs from a Regional Ocean Modeling System (ROMS). We ran this ROMS-driven IBM framework under conditions associated with a climactically altered Bering Sea ecosystem based on RCP 4.5 and 8.5 scenarios, to evaluate climate-driven impacts on broad-scale larval dispersion and settlement patterns for this species. These results were compared with hindcasted runs based on historical conditions (1971-2010). The results from these ROMS-driven IBM runs show that areas with a high rate of successful settlement from pelagic, larval life history stages into early benthic stages are receding northward under a climactically altered Bering Sea ecosystem as colder water recedes northward. These results correspond with a northward shift of the ice-created cold pool and point towards a need for adaptive management measures to cope with changing snow crab larval recruitment dynamics.

Keywords

climate change, Bering Sea, biogeography, Snow crab (*Chionoecetes opilio)*, individual-based model (IBM),

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Feeding adult Iceland scallops with particulate organic waste from fin fish aquaculture

Authors

Andersen, S., Grefsrud, E.S., Olsen, S.A. and Meier, S.

Abstract

Particulate organic waste from fin fish production (faces and excess fish feed) is continuously dispersed from the open sea cages and impacts the surrounding environment of the fish farm. Especially sedentary benthic organisms may be exposed to increased levels of organic particles. Iceland scallop *(Chlamys islandica*) populations can aggregate and form large scallop beds, representing an important habitat for a wide range of species. As the aquaculture industry in Norway is expanding northwards, it is of importance to investigate how fin fish production may affect habitats and species found in these areas. Our aim in this project was to expose both adult individuals and larvae of the Iceland scallop, trying to answer how well this species can cope with organic waste from fin fish farming. We focused on dietary effects and hence, the edible particulate size fraction.

In May 2017 and April 2018 adult Iceland scallop of shell height 55-91 mm were collected from Balsfjorden in northern Norway and transported to Austevoll on the west coast near Bergen. The scallops were kept in flowing seawater at 6$_{o}$C before the temperature was raised to 8$_{o}$C a week prior to exposure experiments. They were kept at 8$_{o}$C throughout the experiments.

The fish waste was collected from a storage tank at a salmon smolt farm and was sieved through a final mesh size of 41 µm to remove the large inedible particles sizes.

In 2017 trials were conducted to find the right feeding regime and flow for the investigation in 2018. Stocking density was 3-9 individuals per 70 L in 2017 and 20 individuals per 500 L in 2018. The diets used in triplicate were: 1) a mixture of three cultivated microalgae species, 2) a 50:50 % mixture of the microalgae and fish waste, and 3) fish waste only (in 2018). Mean particle concentration was 1.2-1.6 mill L^{-1} in 2017 and 0.5-0.8 mill L^{-1} in 2018. Duration of exposures in 2017 was 3-4 weeks and in 2018 the exposure lasted 3 months.

In general, survival was high, and no effect of diet was shown in the parameters studied, such as feeding, gonad development and fatty acid profiles. However, we do not know whether the reproductive output may be affected as we were not able to spawn the scallops successfully in 2018. Histology sections were taken from the female gonads to observe oocyte maturation stages in exposed and unexposed individuals. Fatty acid profiles were taken from the gonad of both genders to describe effects of fish waste and see if it was similar between genders, but no effects were found.

Our preliminary conclusion is that adult Iceland scallop seems very little sensitive to short exposures to the salmon waste particle sizes in the diet used in this study. The next step will be to investigate if the waste affects scallop larvae.

Posters

Keywords

Iceland scallop, bivalves, aquaculture effects, finfish waste, shellfish diets

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Recent mass strandings of krill (Euphausiacea) along the Norwegian coast

Authors

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Abstract

Mass strandings of krill (Euphausiacea) has been reported in Norway since the early 1900's. Since 2014, the Norwegian Institute of Marine Research (IMR) has systematically recorded all recent reports from the public of mass strandings of krill. These mass strandings have been reported from the whole Norwegian coast with the exception of Finnmark county and the Skagerrak coast. The number of reports increased sharply from 2017 to 2018, and reports from the first half of 2019 suggest high numbers also this year. Analyses of samples of dead krill sent to IMR reveal that all examined krill are of the species *Meganyctiphanes norvegica.* Samples have contained both juveniles, males and females. Most mass strandings have taken place in March, August, September and October. Dead krill have been reported both from fjords with and without salmon aquaculture. For all incidences in 2014-2018 we checked if chemical delousing had taken place at any fish farms in the vicinity and during the same time period as dead krill was reported. Drift of plumes of released water containing delousing chemicals from bath treatments were modelled for fish farms where chemical delousing had taken place. Causes behind the mass strandings are discussed, considering both anthropogenic impact on the fjord environment as well as natural explanations such as krill life history, and environmental variables as currents and oxygen content in water.

Keywords

Euphausiacea, *Meganyctiphanes norvegica,* mass strandings, chemical delousing, drift modelling

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Snow crab (*Chionoecetes opilio*) diet against benthic communities in the habitat of crabs in the Barents Sea

Authors

Denis V. Zakharov, Igor E. Manushin, Natalya A. Strelkova, Valeriy A. Pavlov, Tatiana B. Nosova

Abstract

Recent decades the snow crab (*Chionoecetes opilio*) has been spreading across the eastern part of the Barents Sea and the adjacent areas of the Kara Sea. Hydrological conditions for most of the Barents Sea are very close to optimum for the snow crab, there are large areas of suitable habitat and abundant sources of food. Therefore, better understanding of trophic interactions between the snow crab and native benthic fauna is important to assess any potential impacts on the ecosystem and to enable the rational management of fisheries resources in the eastern Barents Sea.

Consumption of food was estimated and compared with data from the Russian part of the Pacific. Data shows that the snow crab has very wide diet that includes almost all kinds of benthic invertebrates in the Barents Sea as in its native habitat. Stomach contents are analyzed to determine the species composition and the frequency of occurrence for various benthic taxa. Dietary differences between females and males were found, as well as juveniles and adults. Juveniles and females are preferably inhabit shallow areas with communities of bivalve mollusks (mainly *Macoma calcarea, Astarte borealis, Astarte crenata, Ciliatocardium ciliatum)*, whilst males live deeper on slopes and bottom depressions where polychaetes (mainly *Spiochaetopterus typicus*) and crustaceans (mainly Malacostraca) are the most abundant group.

Total annual grazing on macrozoobenthos by the snow crab is calculated for its current distribution in the Barents Sea. Snow crabs consume at least 30 thousand tons of benthos annually, which amounts to 0.1–0.2% of the total macrozoobenthos biomass of the study area. The snow crab population has the largest impact on benthic communities in the north-eastern part of the Barents Sea and near the south side of the Novaya Zemlya Archipelago.

Keywords

Barents Sea, snow crab, benthic communities, influence

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Size of maturity in snow crab (Chionoecetes opilio) in the Barents Sea

Authors

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Abstract

Snow crab has been present in the Barents Sea for more than 20 years and has been commercially harvested since 2012. Knowledge of essential life history parameters of the population is still scarce, and studies of these are required to ensure a sustainable management regime for the Barents Sea snow crab stock and ecosystem approach to fisheries management. As is common among the Oregoniidae, both male and female snow crab have a terminal molt to maturity. Female snow crab is functionally unable to mate until the maturity molt. The size of maturity in females influences the larva production and thus the reproductive potential of the population, as individual fecundity is closely related to female size. Studies of the physiological maturation of male snow crab in the Barents Sea show that all male crabs larger than 45 mm CW were physiologically mature. Male snow crab might be functionally mature earlier than the maturity molt size, and there is no consensus of to which extent adolescent males participate in mating. It is important to investigate the morphological maturation of the males in the population, as the molt to morphological maturity is a terminal molt. The size at which it occurs is therefore important from a fisheries management perspective, as it limits the growth of the organism and recruitment to the fisheries. We investigate the size of maturity of snow crab caught by Agassiz trawl in the Svalbard Fisheries Protection Zone in the central Barents Sea in 2019 and relate it to spatial distribution, temperature and population density.

Keywords

Life history, Maturity molt, Terminal molt

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Thermal tolerance of invasive red king crab (*Paralithodes camtschaticus*) larvae from the Barents Sea

Authors

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Abstract

The invasive red king crab (*Paralithodes camtschaticus*) is expanding its geographic range in the Barents Sea by larval drift as meroplankton and adult migration. The species is expected to spread further south along the Norwegian coast and north into Arctic shelf waters. The rearing temperature that larvae experiences often affects their hardiness to experimentally induced temperature challenges. We assessed the duration and survival for the larval stages (i.e. zoea I-IV and glaucothoe) under three temperature regimes commonly found along the Norwegian coast (4°C, 8°C and 14°C). Moreover, we tested how larvae from the respective temperature regimes tolerated acute temperature challenges across a range from -1.7°C to 30°C. Overall, results revealed that all the larval stages had the highest survival at the lowest temperatures. Moreover, larvae reared at 14°C had the higher survival at higher challenge temperatures compared to those reared at 4 and 8°C. In conclusion, the red king crab larvae tolerate a wide range of temperatures, which makes it possible for the species to expand its geographic range considerably. In particular, the hardiness of the larval stages to subzero waters suggests a strong potential for the species to invade and establish in Arctic shelf areas.

Keywords

invasive species, biogeography, rearing temperature, zoea, survival, temperature tolerance

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Energy requirements of immature male red king crab *Paralithodes camtschaticus* investigated at two different temperatures

Authors

Sten I. Siikavuopio[1*], Bjørn-Steinar Sæther [3], Maria Sparboe[2] and Jørgen S. Christiansen [3]

Abstract

The Red king crab *Paralithodes camtschaticus* is a native and valuable fisheries resource in the Bering Sea and the North Pacific. In the period 1961–1969, scientists from the former Soviet Union successfully transferred and introduced the animal from the Far East into the Barents Sea to support commercial fisheries also in the Northeast Atlantic. As part of quantitative investigations into the bio-energetic relationships of red king crab in the NE Atlantic, this study examined the effects of temperature on metabolism in order to provide insights to the basic energetic costs of living. Two groups, each of 12 immature male red king crabs, with carapace length 77-88 mm were kept individually for 111 days at either 4°C or 8°C. The animals were fed dry pellets (gross energy contents ~ 21 kJ g) in excess. No mortality was observed in this study. The red king crab in the 8°C group had a significantly higher feed intake (3.05 ± 0.11 g/animal/day) compared to the group held at 4°C (1.48 ± 0.10 g/animal /day). The mean resting metabolism differed significantly between temperature groups with 11.40 and 18.38 kJ per animal per day at 4 and 8°C, respectively.

Keywords

Temperature, Feeding, Metabolism, Red king crab

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Population dynamics and stock assessment of the soldier striped shrimp *Plesionika edwarsii* (Brandt, 1851) in the Mid-Atlantic ocean (Azores archipelago)

Authors

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Abstract

This study describes the first information about the population dynamics of the *Plesionika edwardsii* a virgin stock (unexploited) with focus in growth, mortality and yield per recruit analysis in the Mid-North Atlantic Ocean (Azores archipelago).

A total of 2191 specimens were captured (1513 females and 678 males) in the summer and autumn of 1999 and winter and spring of 2000 during a survey cruise (Crustaço Project). Specimens were weighed (g) and the cephalothorax length (CL, mm) were measured. The biometric relationships were estimated through regression analysis and the von Bertalanffy model was used for described the growth. Additionally, total mortality (Z), natural mortality (M), length at first capture (L_c), longevity ($A_{0.95}$) were determined and the maximum yield per recruit (E_{RMY}) determined by Knife-edge selection from the FISAT model. Females were larger (23.15 ± 4.26 mm) than males (21.34 ± 3.7 mm) and dominant in the largest CL classes. The biometric relationships for males, females and both sexes grouped showed a negative allometric growth. Females showed larger L_∞ (asymptotic length) and k (coefficient of growth) (L_∞ of 27.3 mm and k of 0.9 year $^{-1}$) when compared with males (L_∞ of 26.25 mm and k of 0.64 year $^{-1}$), while both sexes showed (L_∞ of 28.35 mm and k of 0.79 year $^{-1}$). In general, the mortality of females (Z = 1.53 year $^{-1}$; M = 1.39 year $^{-1}$) and both sexes (Z = 1.53 year $^{-1}$; M = 1.26 year $^{-1}$) were higher than those estimated for males (Z = 1.23 year $^{-1}$; M = 1.12 year $^{-1}$). The longevity of the males ($A_{0.95}$ = 4.68 years) was higher than the estimate for females ($A_{0.95}$ = 3.32 years) and both sexes ($A_{0.95}$ = 3.79 years). Because it is a unexploited stock, we consider M = F as an ideal model for a sustainable fishery. The parameter values resulting from the equations Lc/L∞ and M/k for both sexes (L_c/L_∞ = 0.42 ; M/k = 1.59), females (L_c/L_∞ = 0.43 ; M/k = 1.54) and males (L_c/L_∞ = 0.46 ; M/k = 1.75) were applied to the Knife-edge selection from the FISAT model. The results from the Relative Yield per Recruit analyses show exploitation ratio values for both sexes (E_{-10} = 0.50 ; E_{-50} = 0.33 ; E_{RMY} = 0.63), females (E_{-10} = 0.55 ; E_{-50} = 0.34 ; E_{RMY} = 0.63), and males (E_{-10} = 0.60 ; E_{-50} = 0.35 ; E_{RMY} = 0.69).

The results presented for the population parameters and unexploited stock status of *P. edwardsii* in the Azores Archipelago suggest a conservative approach to the management of a future fishery directed to this stock. Government agencies are advised to used points of reference to the exploitation rate values E_{-50}, where there is 50% depletion of the biomass of the stock.

Posters

Keywords

Penaeids; growth; mortality; yield per recruit; fishery; sustainability

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Biological and ecological aspects of unexploited virgin *Pleisionika edwardsii* (Crustacea: Decapoda: Pandalidae) populations in the mid-North Atlantic

Authors

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Abstract

Considering the local and international interest for the exploitation of new resources to reduce effort on traditional fishery stocks, this study provides for the first time valuable baseline information on the biological and ecological aspects of unexploited virgin *Plesionika edwardsii* (Brandt, 1851) populations inhabiting coastal areas and isolated seamounts in the mid-North Atlantic Ocean. It is a cosmopolitan species that inhabits cold temperate and subarctic waters between 50 and 680 m deep. In the Azores region (mid-North Atlantic, ICES Subarea 10a2), the striped soldier shrimp is the second most abundant shrimp species and probably the one with the highest fishing potential. However, published information on its biology and life history is still scarce. Any information about *P. edwardsii* is crucial before the development of any fishery in the mid-North Atlantic, as well as the definition of an appropriate harvest strategy and management advice for their sustainable exploitation.

In this study, we revised and analysed historical unpublished data collected during research surveys and experimental fishing procedures. Results suggested a patchy distribution possibly determined by bottom type, local hydrodynamics, topographical features and food availability. The biggest catch rates were obtained between 200 and 400 m deep. Size composition varied from 8.3 mm to 31.3 mm cephalothoracic length (CL), with a mean of 22.7 mm. Females were bigger and more abundant than males. When analysing the results of the sex ratio by depth, we verified that the females predominated in the shallow and deeper depth. Ovigerous females were caught throughout most of the year, with a peak of spawning activity in spring and summer. The size at first maturity (L50) found by Gompertz's function was 20.21 mm (CL). A proposal for *P. edwardsii* life history is presented in order to discuss the species connectivity aspects in the region. Considerations for assessment and management are outlined and discussed.

Keywords

striped soldier shrimp; population structure; management; Azores; ICES Subarea 10a2.

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New estimates of weight-at-size, maturity-at-size, fecundity, and biomass of snow crab, Chionoecetes opilio, in the Arctic Ocean off Alaska

Authors

Divine LM, Mueter FJ, Kruse GH, Bluhm BA, Jewett SC, Iken K

Abstract

Snow crab (*Chionoecetes opilio*) were identified as a potential future fishery species in the Arctic Ocean off Alaska in 2009, but the Arctic Fishery Management Plan currently prohibits commercial harvest until sufficient information is available to assess a sustainable commercial fishery. Earlier population and biomass estimates were based on limited data, but research efforts in the Chukchi and Beaufort seas over the past decade have yielded a much richer database on snow crab in those seas allowing us to generate new estimates of weight-at-size, maturity-at-size, fecundity, and biomass to recalculate sustainable yield. Weight-at-size was generally similar for male and female snow crab between the Chukchi and Beaufort seas, with males reaching overall larger sizes than females in both seas and largest male crabs occurring in the Beaufort Sea. Compared with other geographic regions, 50% morphometric maturity was reached at a slightly smaller size in the Chukchi Sea; low sample sizes in the Beaufort Sea prevented maturity-at-size analysis. Fecundity-at-size in the Chukchi Sea was similar to other regions and yielded estimated total reproductive output that suggest local reproduction may be sufficient to account for a large portion of observed small juvenile benthic snow crab abundances; yet further investigation is warranted to determine whether Chukchi and Beaufort populations are current self-sustaining. Although snow crab had high abundances in the Chukchi Sea, crab larger than the minimum marketable size (≥ 100 mm carapace width, based on Bering Sea metric) were absent in the Chukchi Sea over the study period. Our higher biomass estimates in the Chukchi Sea compared to previous estimates were at least in part due to high abundances of small crab that were greatly under-sampled with large-mesh survey. Harvestable biomass was largely limited to the slope (> 200 m depth) of the Beaufort Sea and is unlikely to support commercial harvest.

Keywords

Snow crab, Chukchi and Beaufort Seas, Arctic, maturity-at-size, fecundity, biomass

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Investigating the performance of a roller footgear in the Nunavut offshore shrimp fishery using underwater video

Authors

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Abstract

Northern shrimp (*Pandalus borealis*) located off the east coast of Nunavut (*Arctic Canada*) is currently harvested by factory freezer vessels using bottom trawls. This fishery is a major contribution to the territory's economy. However, bottom trawling is not without its ecological impact. In this fishery, bottom trawls use roller rockhopper footgear, which is known to roll in the bosom section, where the rockhoppers axis are perpendicular to the towing direction. Quarters and wings sections are know to roll to a lesser extent increasing seabed impact and species mortality. In this study, we evaluated the performance in terms of time to complete a rotation (TCR) of a bosom and quarter roller rockhopper footgear sections in hard, mixed and soft seabed using self-recording cameras. Our results showed that the footgear sections are rotating at extremely low rates, between 23.57 and 1587.63 seconds in TCR, when compared to the estimated optimal footgear rotation (1.28 seconds). Results predicted a statistically significant 184% increase in TCR as we move from the bosom to the quarter section ($p = 0.035$). TCR in hard seabed ranged from 23.57 seconds in the bosom to 43.38 seconds in the quarter section, while mixed (from 169.02 to 311.06 seconds) and soft (from 862.64 to 1587.63 seconds) seabed types produced significantly longer TCR ($p < 0.0001$). Many innovative technologies and modifications have been tested to reduce seabed impacts associated with footgear, but to our knowledge little direct video observation of existing footgear under normal fishing operations has been documented in Canada's Arctic region. This study provides evidence that roller footgear is not rotating at the rates expected by industry and offers important information to further develop and design an innovative footgear that reduces seabed impact.

Keywords

Roller footgear; Seabed impact

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Towards sustainable utilization of crab by-products

Authors

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Abstract

Crab shells are an underutilized waste fraction of the crab industry. The major components of the shell waste are proteins, carotenoids and chitin; all representing a potential of added value for the crab industry. Where industrial examples of by-product utilization exist, the industry has so far been focusing on single component approaches rather than a full utilization of the by-product resource, resulting in unfortunate waste generation. In this presentation, research targeting an industrially applicable and sustainable approach to extract all these components based on Norwegian snow crab is presented. The focus of the research has been to optimize each single extraction step, while simultaneously striving to find the best possible combination of single-component extractions. The project results will be discussed from a sustainability perspective.

Keywords

snow crab, enzymatic protein hydrolysis, by-products, astaxanthin, chitin, proteins

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Hurdles and possibilities for management of the invasive Pacific oyster in Scandinavia using small-scale fisheries.

Authors

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Abstract

Since 2006, the Pacific oyster has established self-sustaining populations in Scandinavian coastal waters. The species is considered invasive and dense populations may cause changes to coastal ecosystems. The species is, however, also of high economic value and there is a growing interest from the aquaculture and fisheries industry to realize the potential of this species as a new marine resource in Scandinavia. Activities receiving increasing attention are gastronomic tourism, harvest of wild oyster populations and aquaculture, activities that may provide income in rural areas and support local communities. The commercialization of wild Pacific oysters in Scandinavia is, however, limited by several regulatory and policy related hurdles connected to ownership of the resource, food safety issues and management of invasive species. There are also conflicting management objectives within authorities as legislation is not fully integrated between different domains. To address these hurdles, a Scandinavian oyster network was formed in 2013 to allow formation of a joint knowledge platform, dissemination of relevant management initiatives to relevant stakeholders and co-creation of innovative management alternatives based on requests from industry and governmental authorities. One alternative currently under investigation is utilization of commercial interests to provide management of selected areas of special concern where the impact of the Pacific oyster may cause the most severe effects. In this poster, the work performed within the Scandinavian network and the resulting conclusions recently presented in a Policy brief released by the Nordic Council of Ministers will be highlighted and discussed.

Keywords

Pacific oysters, food safety, harvesting rights, stakeholder conflicts, gastrotourism

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Fishery of the orange-footed sea cucumber (*Cucumaria frondosa)* in Iceland: „Klondike“ or sustainable practice ?

Authors

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Abstract

An experimental fishery for the orange-footed sea cucumber (*Cucumaria frondosa*) started in Breiðafjörður bay (W-Iceland), in 2003. Little was landed until 2008 when fishing was initiated in the bay of Faxaflói (SW-Iceland), with catches of around 800 t from that area and little over 1000 t for all areas. Since then, the catches have fluctuated, somewhat due to marketing reasons, but during the past three years they have increased steadily. Landings reached 6000 t in 2018, an almost twofold increase from the previous year. In 2009, Icelandic waters were split up into three fishing zones and three fixed licences were allocated in each zone. Two of those zones were fished, but in 2013 the Ministry of Fishery abolished the area restriction with nine open licenses applicable on all areas. In 2009, TAC was recommended for the first time on two demarcated areas in, Faxaflói and Aðalvík (NW-Iceland). Areas in the eastern part of Iceland were demarcated in 2013 and further TAC advised for the fishing year of 2013/2014. The demarcated areas have gradually been increasing in size and numbers and for the upcoming fishing year of 2019/2020, eight areas were demarcated and TAC advised. The areas cover almost all the western and eastern part of Iceland. Individual quotas have not been issued, but the areas are closed when issued TAC is met. There has been an upward trend in vessel size and now most boats operate with two beam dredges. Intense fishing in recent years on virgin undemarcated grounds (unregulated) and late closures have resulted in increased effort and catches. To make matters worse, advised area enlargements have sometimes lagged and been put forward several months later along with other changes in the fishery regulations. During this first decade of the fishery, there has been a downward threnḍ in the CPUE indices denoting that the current practices are unsustainable. There is continuous pressure from the industry to expand the fishery, at the same time limited funds are available for regular monitoring.

Keywords

Cucumaria frondosa, sea cucumber*,* fisheries, overexploitation, fisheries governance

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