Project information

Project title

Ecosystem structure and use of marine resources from bivalve and fish bone proxies

Year

2012/2013

Project leader

Michael Carroll, ApN

Participants

- Michael Carroll – Project manager and project leader for Akvaplan-niva
- Elin Myrvoll – Project leader for NIKU
- Paul Renaud – Akvaplan-niva
- William Ambrose, Beverly Johnson –Bates College (USA)
- Alan Wanamaker – Iowa State University (USA)
- Kjersti Schanche- Sametinget
- Inger Marie Holm-Olsen -NIKU

Flagship

Fjord and Coast, Theme: Structure, function and change in Arctic and boreal fjord ecosystems

Funding Source

Fram Center: 400 kNOK Iowa State University: 150KNOK

Summary of Results

1. Develop long-term chronologies with annual resolution for modern samples

Living samples of the long-lived bivalve (*Arctica islandica*; (Norsk - kuskjell; English - ocean quahog) were collected alive from Ingøya in northwest Finnmark. A subsample (n=7) of the live-collected individuals were processed in the laboratory (imbedded in epoxy, cross-sectioned) and then the annual growth bands counted. This provides both the age of each individual and interannual differences in growth. The oldest individual examined thus far was 300 years old. Raw growth rates were detrended (correcting for ontogenetic changes with age), and the growth increments from individual samples were statistically cross-matched, resulting in a master growth chronology (Fig. 1). This chronology extends from 1958-2008. A strong degree of synchronous growth is evident, emphasizing that environmental variability rather than biological noise is driving shell growth at the population level at Ingøy.

2. Examine relationships between patterns of modern shell growth and environmental variability where environmental conditions are well-constrained via instrumental time series (meteorological records, records from moorings, etc.).

(A) Fieldwork was conducted in June 2012, where temperature and salinity loggers were deployed at the bivalve collection location in order to begin a local time series of oceanographic conditions.

(B) The detrended growth index from the MSC corresponded closely with the ICOADS SST satellite dataset. After filtering both SST and MSC data with a 3-year filter, 73% of the growth variability captured in the MSC can be explained by annual SST data (Fig. 2B). A transfer function relating MSC data with annual ICOADS SST was then developed, (Fig. 2A). (Presented data are from M. Mette (graduate student, Iowa State University), and A. Wanamaker (supervisor)).

3. Isotopic proxies for food-web analysis of shell and bone material to identify environmental conditions and food-web structure of modern and Late Stone Age sites in east and west Finnmark.

Isotope results (Fig. 3) indicate strong differences in carbon source for modern cod from Ingøya and Berlevåg compared with modern Varanger and all historical sites. This may indicate a distinction between harvesting of coastal cod vs. skrei stocks, although Little Ice Age and Medieval Warming Period samples (Løkvik, Kongshavn) are also from the Berlevåg area. We are investigating the isotopic-signal integration time into bone organics as one possible explanation. Nitrogen isotopes, as a measure of trophic position, indicated similar feeding level for most samples, but showed more than a half trophic-level difference between two locations at a single Late Stone Age site. Archaeological studies offer several possible explanations including different social status (and perhaps resulting in different size of fish provided). We must look further into fish size and dating of the two deposits in more detail. Analysis of samples from a planned excavation in 2013 can help in this objective.

Figure 1:

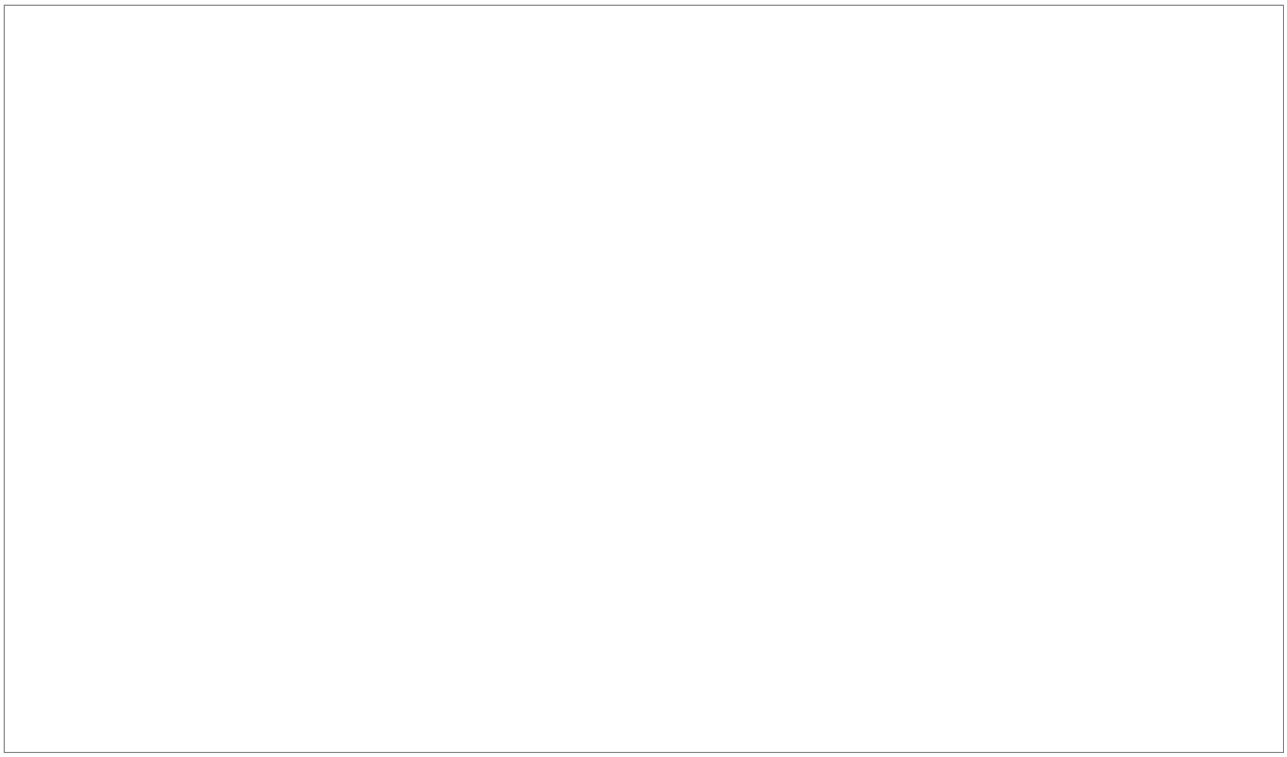


Figure 2:

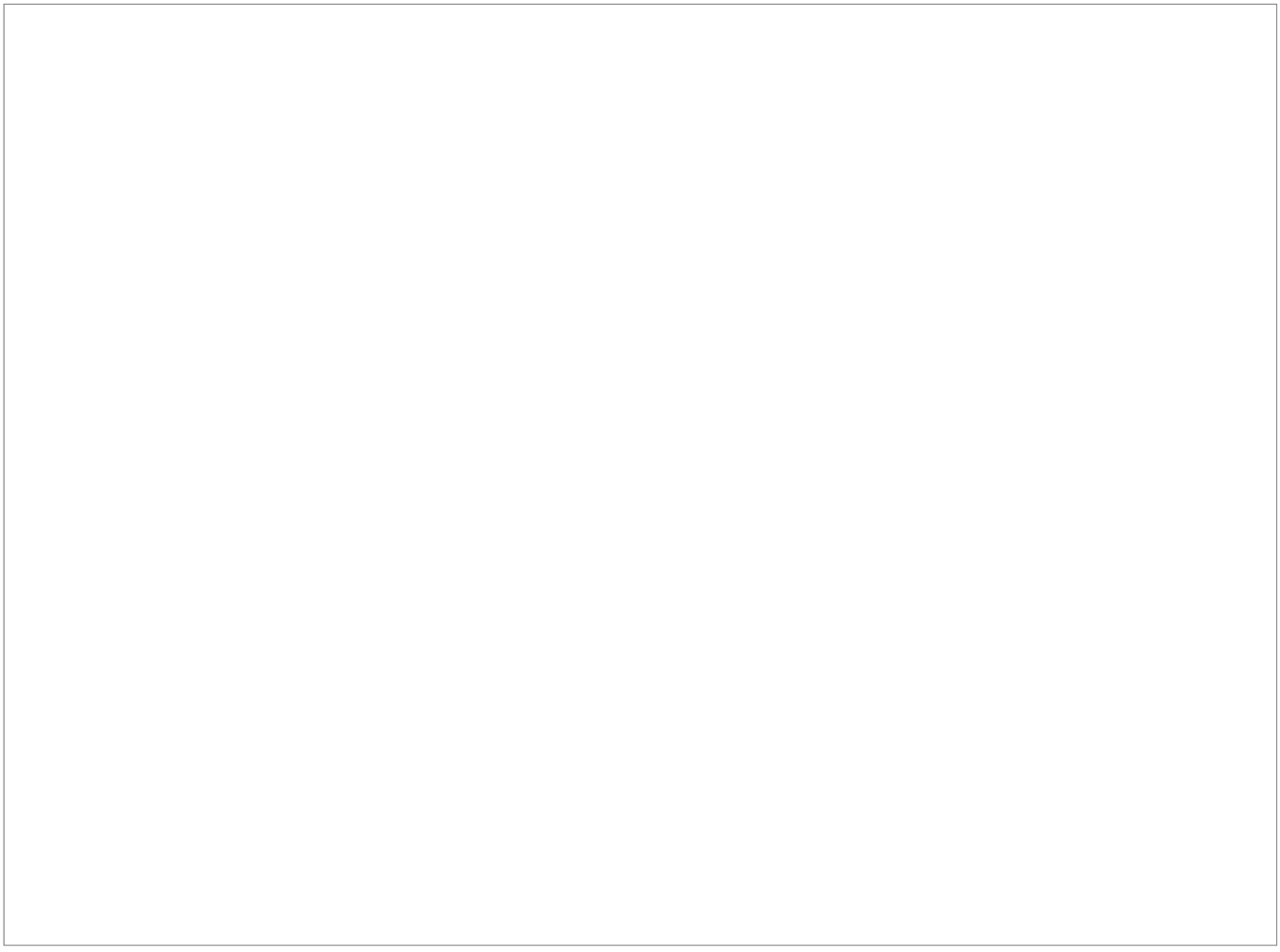
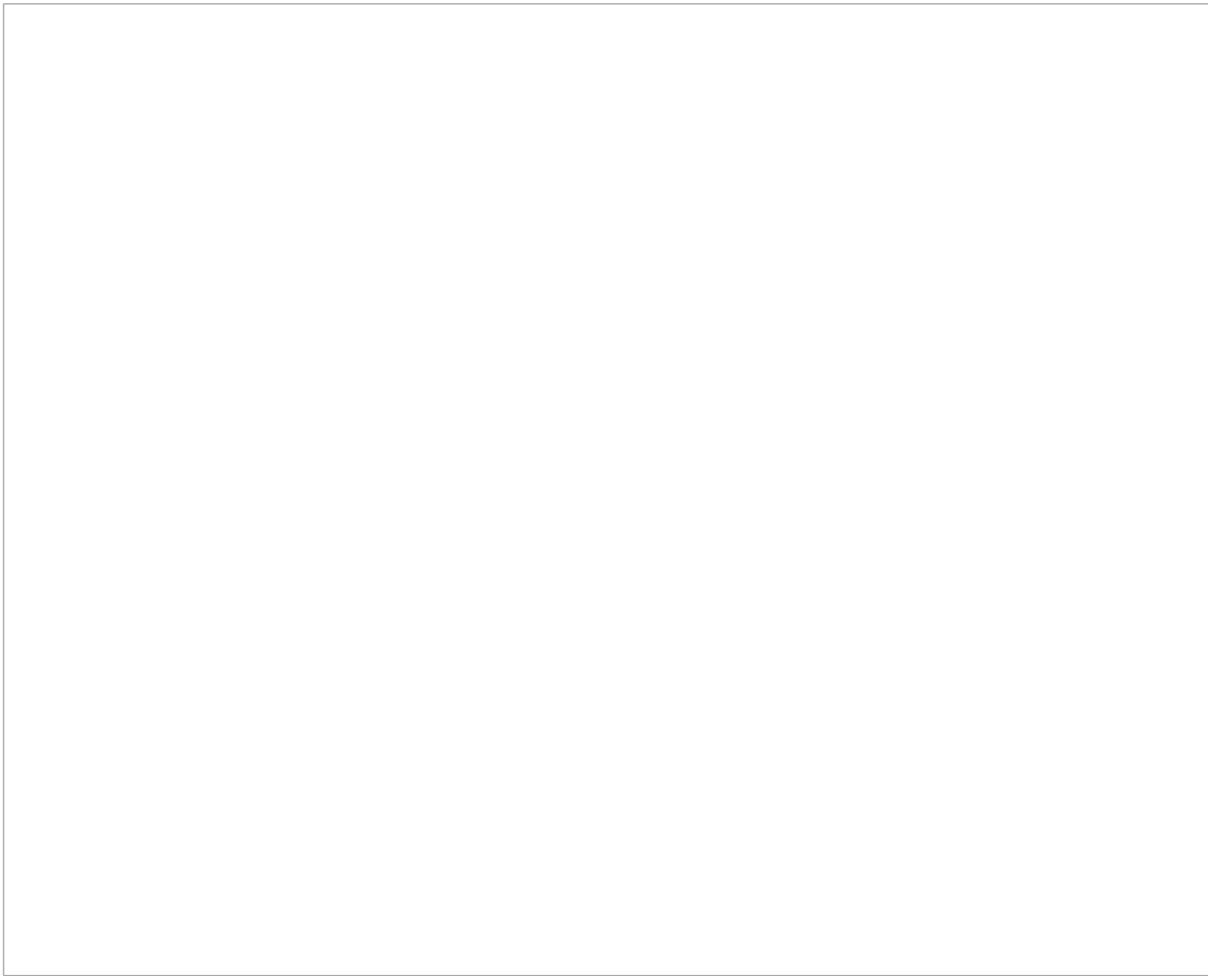


Figure 3:



Published Results/Planned Publications

- Mette, M., A.D. Wanamaker, W.G. Ambrose, M. Retelle, M. Carroll, B. Locke. 2012. Shell growth strongly coupled with positive Arctic Oscillation and North Atlantic Oscillation phases: insights from a sclerochronological and geochemical study from northern Norway (Ingöy). Abstract, Ocean Sciences Meeting. Feb. 2012, Salt Lake City, USA
- Carroll, M.L., W.G. Ambrose, W. Locke, S. Ryan, B.J. Johnson. 2012. Reading between the Lines: Bivalve growth rate and isotopic variability across the Barents Sea Polar Front. International Polar Year 2012: From Knowledge to Action -Final Meeting, 22-27 April 2012. Montreal, Canada (oral).
- Carroll, M.L., W.G. Ambrose, W. Locke, S. Ryan, B.J. Johnson. 2012. Reading between the Lines: Bivalve growth rate and isotopic variability across the Barents Sea Polar Front. AGU/ASLO/TOS Ocean Science Meeting, 20-24 February 2012. Salt Lake City, Utah, USA (poster).

Communicated Results

Local outreach, June 2012. Ingøya Finnmark. Described our project to local residents of the community.

Interdisciplinary Cooperation

The project is extremely interdisciplinary in nature, combining not only a diverse group within the natural sciences (marine ecologists, biogeochemists, and paleoceanographers), but also though linking the natural and social sciences (archaeology).

It is also quite international in scope, with much of the relevant instrumentation and analytical expertise existing outside Norway. In this project, the analytical work is taking place at Bates College (laboratory preparation, image and isotopic analysis), and Iowa State University (growth increment analysis, isotopic analysis, statistical cross matching).

Budget in accordance to results

The funding from the Fram Center provided a necessary boost for the mid stages of this project. It allowed us to process samples of bivalves collected from coastal regions in northern Finnmark in 2009. This, combined with funding provided by Iowa State University, resulted in the development of the first bivalve chronologies from *Arctica islandica* in Norway, the first shell stable isotopic and mineralogical time series from this species in Norway, and allowed identification of the intra-annual (seasonal) patterns of this species. The project funding also supported the stable isotopic analysis of cod bone samples from modern times, allowing a discrimination of coastal and offshore cod populations, as a basis for identifying cod source populations for ancient inhabitants.

Additional funding is required to complete all the tasks in the original project outline. Proposals are currently under review. The Ingøya chronology work forms the basis for a proposal to the US National Science Foundation (NSF) on climatic reconstruction. This proposal was submitted originally in 2011, and a resubmission was delivered in October 2012. A companion proposal to the Norwegian Research Council (US-Norway Bilat) for the Norwegian participation will be submitted on 28 November 2012.

If Yes

Mineralogical patterns in bivalve shells are a result of a suite of environmental factors at the time the shell material is laid down. These factors can be related to natural environmental phenomena (changing temperature, salinity, or availability of organic material). But chemical ratios in the shell may also indicate exposure to anthropogenic constituents (e.g. Barium, Lead). Changes in the concentrations in such constituents may allow reconstruction of the time history of such industrial-based discharges. This has not yet been realized in the present project, but could be a commercialization of the present technology. This links directly to a current project in the Fram Center Contaminants Flagship, where freshwater Pearl Mussels (*Margaritifera margaritifera*) and *Arctica islandica* from the Pasvik watershed and adjacent marine waters are being analyzed for metal concentrations related to the Nikel smelter in adjacent Russia.

Conclusions

Understanding the causes and consequences of present environmental changes currently taking place, as well as their effects on human societies that rely on local resources, require an understanding of natural scales of variability in natural systems. Analysis of shell growth rings over long time scales provides a relevant ecosystem monitor, not only of growth (biological effect), but also environmental changes over long time scales (temperature, salinity, seasonality, food availability). The combined approach of sclerochronological environmental reconstruction along with stable isotopic analysis of midden remains of marine resources used by early inhabitants of northern Finnmark provides a dual proxy that can shed light on human-environmental interactions.