# Meeting the eye-witnesses of ocean change

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Members of the German research network BIOACID (Biological Impacts of Ocean Acidification) are developing a model that links ecosystem changes triggered by ocean acidification and climate change with their economic and societal consequences. Workshops and interviews with stakeholders from the Norwegian fishing industry and tourism sector, the government and environmental organisations help them to identify key aspects for their assessment.

During the past ten years, scientists have learned a lot about the effects of ocean acidification on marine ecosystems. It has become obvious that with rising carbon dioxide emissions from human activities, oceans absorb larger amounts of this greenhouse gas and become more acidic. The increase of acidity, rising water temperatures and other stressors may alter marine ecosystems dramatically – with consequences for economy and society.

Do stakeholders of the economic sectors which depend on the sea already observe signs of ocean change? Which are their most urgent questions towards science? Within the framework of the German research network BIOACID (Biological Impacts of Ocean Acidification), scientists from the University of Bremen investigated stakeholders' state of knowledge and identified focal points for further research. Between March and November 2013, they held workshops and interviewed more than 30 Norwegian fishers, representatives from fishing associations, aquaculture, tourism, environmental organisations and governmental agencies. They aim to develop a model that yields insights into the overall impacts of ocean change for ecosystems and the

services they provide to human societies.

"Taking a systems view can help to analyse socio-economic impacts of ocean acidification and find ways to mitigate them and adapt to them", Dr. Stefan Gößling-Reisemann, researcher at the Sustainability Research Center (artec) at the University of Bremen explains. "This is why we connect stakeholders and scientists and adapt further research to the demands of society." Norway was chosen because the fishing industry, a branch that is likely to be hit first by effects of climate change, plays a very important economic role there. Also, tourism is strongly connected to coastal regions and fjords. The analysis of this region, for which earth system models predict early impacts of ocean acidification and warming, can serve as an example for other social-ecological systems.

Obvious effects of climate change are already perceived by the stakeholders in the northward range shifts of cod and mackerel stocks and the immigration of sardines into Norwegian waters. Fishers also noticed variations of timing and location of spawning. "It was impressive to see how much knowledge fishers have about ecological links and changes", Stefan Koenigstein, marine biologist in the research project points out. "Based on their experience, fishers wondered if future changes in the ecosystem will be abrupt or if there will be time to adapt. These are exactly the questions that the scientists in the field are concerned with. People who are actually affected by the changes in their livelihoods can contribute a lot with their first-hand experience and should be taken along in the research process."

To prepare properly for future conditions, fishing associations asked for an assessment that incorporates dynamics of different life stages and the availability of food for commercial species. "Because of the complexity of marine food webs, questions were posed on how interactions between species would change, what would happen if key species were impacted and what chain reactions might happen", Koenigstein summarizes.

Changes in fish stocks would also have dramatic socio-economic impacts, the scientists conclude from their interviews. The number of fishers has steadily been reduced to keep up the fisheries' productivity – this step might be taken again to cope with shrinking or moving stocks. In Northern Norway, where fishery is a coastal activity, most boats are too small to follow stocks if they move from coastal waters to the open sea. "Especially in remote regions, alternatives to earn a living are very limited", Koenigstein explains. "Also, fishing is important for the coastal Sami culture that is still vivid in the far North of the country, but in many fjords, fish stocks have disappeared. To these people, losing this aspect of their lives means losing part of their identity."

With its coastline, islands and fjords, with game fishing as an important recreational activity both for locals and guests and with busy whale watching companies, Norway benefits strongly from the sea in its tourism sector. A decrease of biodiversity was regarded as major threat.

After their survey, the scientists took a lot of homework back to their offices. "Our analysis yielded much insight on the connections and interactions between the ecosystem, economy and society", Dr. Gößling-Reisemann concludes. The researchers are now busy incorporating as many as possible of the elements identified through this study into their model, which aims to explain mechanisms and uncertainties, identify critical parameters and explore possible futures and adaptation strategies. "In any case, we have already learned a lot from the people that are in contact with the oceans every day."

**More information:** The full report can be downloaded at zenodo.org/record/8317 and www.bioacid.de/upload/download … port_Norway_2014.pdf