The sceptical optimist: challenges and perspectives for the application of environmental DNA in marine fisheries

Application of environmental DNA (eDNA) analysis has attracted the attention of researchers, advisors and managers of living marine resources and biodiversity. The apparent simplicity and cost-effectiveness of eDNA analysis make it highly attractive as species distributions can be revealed from water samples. Further, species-specific analyses indicate that eDNA concentrations correlate with biomass and abundance, suggesting the possibility for quantitative applications estimating abundance and biomass of specific organisms in marine ecosystems, such as for stock assessment. However, the path from detecting occurrence of an organism to quantitative estimates is long and indirect, not least as eDNA concentration depends on several physical, chemical and biological factors which influence its production, persistence and transport in marine ecosystems. Here, we provide an overview of basic principles in relation to eDNA analysis with potential for marine fisheries application. We describe fundamental processes governing eDNA generation, breakdown and transport and summarize current uncertainties about these processes. We describe five major challenges in relation to application in fisheries assessment, where there is immediate need for knowledge building in marine systems, and point to apparent weaknesses of eDNA compared to established marine fisheries monitoring methods. We provide an overview of emerging applications of interest to fisheries management and point to recent technological advances, which could improve analysis efficiency. We advise precaution against exaggerating the present scope for application of eDNA analysis in fisheries monitoring, but also argue that with informed insights into strengths and limitations, eDNA analysis can become an integrated tool in fisheries assessment and management.
Artsspecifik sporing og kvantificering af eDNA fra marine fisk i Østersøen

General information
State: Published
Authors: Knudsen, S. W. (Ekstern), Ebert, R. B. (Ekstern), Hesselsøe, M. (Ekstern), Kuntke, F. (Ekstern), Hassingboe, J. (Ekstern), Mortensen, P. B. (Ekstern), Thomsen, P. F. (Forskerdatabase), Hansen, B. K. (Intern), Eg Nielsen, E. (Intern), Møller, P. R. (Ekstern)
Publication date: 2017
Event: Abstract from Dansk Havforskermøde, Helsingør, Denmark.
Main Research Area: Technical/natural sciences

Den skeptiske optimist: Udfordringer og perspektiver i anvendelse af eDNA til marin monitering og fiskeriforvaltning

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources
Authors: Eg Nielsen, E. (Intern), Bekkevold, D. (Intern), Hansen, B. K. (Intern)
Publication date: 2017
Event: Abstract from Dansk Havforskermøde, Helsingør, Denmark.
Main Research Area: Technical/natural sciences
Steps toward nation-wide monitoring of non-indigenous species in Danish marine waters under the Marine Strategy Framework Directive

This report is the outcome of MONIS 2 – or in full, “Monitoring of Non-Indigenous Species in Danish Marine Water, phase 2” – and includes three deliverable: (1) a national Target Species List including 50 species, (2) a draft Technical Guidance Report, and (3) in silico designed and tested primers and probes for 48 of the 50 species on the Target Species List. The list is based on discussions at a workshop and subsequent scoring and ranking of relevant species. The draft Technical Guidance report is anchored in existing Standard Operating Procedures (i.e. protocols for sampling, storage and analysis) and adapted to the requirements of the Danish NOVANA programme. In addition, the report includes suggestions for next steps to take to implement and improve monitoring and assessment activities in regard to non-indigenous species in Danish marine water.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources
Authors: Andersen, J. H. (Ekstern), Møller, P. R. (Ekstern), Kallenbach, E. (Ekstern), Hesselsæ, M. (Ekstern), Knudsen, S. W. (Ekstern), Bekkevold, D. (Intern), Hansen, B. K. (Intern), Thaulow, J. (Ekstern)
Number of pages: 122
Publication date: 2016

Publication information
Publisher: NIVA
Original language: Danish
Main Research Area: Technical/natural sciences
Source: FindIt
Source-ID: 2304751245
Publication: Research › Report – Annual report year: 2016

Projects:

An icean of: Assessing environmental DNA to monitor aquatic organisms in marine environments

National Institute of Aquatic Resources
Period: 01/10/2015 → 01/12/2018
Number of participants: 3
PhD Student:
Hansen, Brian Klitgaard (Intern)
Supervisor:
Bekkevold, Dorte (Intern)
Main Supervisor:
Eg Nielsen, Einar (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Optimising and enhancing the integrated Atlantic Ocean Observing Systems (AtlantOS) (39243)
The vision of AtlantOS is to improve and innovate Atlantic observing by using the Framework of Ocean Observing to obtain an international, more sustainable, more efficient, more integrated, and fit-for-purpose system. Hence, the AtlantOS initiative will have a long-lasting and sustainable contribution to the societal, economic and scientific benefit arising from this integrated approach. This will be achieved by improving the value for money, extent, completeness, quality and ease of access to Atlantic Ocean data required by industries, product supplying agencies, scientist and citizens. The overarching target of the AtlantOS initiative is to deliver an advanced framework for the development of an integrated Atlantic Ocean Observing System that goes beyond the state-of –the-art, and leaves a legacy of sustainability after the life of the project.

The specific task of DTU Aqua is to conduct analysis of environmental DNA (e-DNA) using an Environmental Sample Processor (ESP). All living organisms secrete DNA to the surrounding environment. Recently it has been shown that such “e-DNA” can be extracted from seawater and used to identify the organisms present within a designated sea area. The “ESP” is a moored automated DNA laboratory, which can be deployed for up to three months for in-situ analysis and at the same time send back real-time analytical results. Hitherto it has been used for identification of marine bacteria, phyto- and zooplankton with very good results. We will modify the ESP to allow its use for e-DNA analysis. The aim is to conduct unprecedented “proof of concept” of e-DNA sensors for monitoring of important species in a number of sea areas and time periods.
The population of whitefish (Coregonus lavaretus) in Ringkøbing Fjord: Effects of fishery, stocking and natural reproduction (38827)

Objectives of the project are to improve our knowledge on the whitefish population in the Ringkøbing Fjord Lagoon and effects associated with the commercial exploitation of the population, i.e. to what extent the traditional gill-net (46 mm monofilnet) fishery for whitefish affect both the whitefish population and otherspecies of fish in the lagoon. Another goal is to establish how much natural reproduction and stocking of hatchery reared fry contributes to the adult population. These results will provide a much better basis for the management of whitefish populations in Denmark in general and in Western Jutland in particular.

The natural population of whitefish in the Ringkøbing Fjord Lagoon has been the subject of an extensive fishery for more than 100 years. The fishery is primarily performed by commercial fishermen, but estimated from the number of recreational fishers in the area, a substantial amount is caught by this group as well. The lagoon holds the largest population of whitefish in Denmark. The official landing statistics (only covering the commercial catches) shows that the catch through the 20th century typically has varied between 10 and 60 tons per year (e.g. mean 1980-2000 25.1 tons per year). Since 2001 the landings have increased to a mean of 55 tons per year (range 14-94 t), with a mean value of 1.2 m DKK. This constitutes 75-95 % of the total Danish whitefish fishery.

Since 1986 ca. 4 million hatchery reared fry has been stocked in the lagoon each year. 3.6 million are stocked as newly hatched larvae in April. 0.4 million are raised to a size of 3-4 cm before stocking in late May.

The population of sea trout (Salmo trutta) in the main tributary of the lagoon, the River Skjern, is much smaller than expected, considering the environmental conditions of both the river and the lagoon and the size of the river. One possible reason is by-catch in the whitefish fishery. The landing of sea trout and the endangered salmon (Salmo salar) from the lagoon is prohibited and the discard mortality for sea trout is considered to be very high. Investigations on the subject of by-catch in gill-nets set for whitefish in the Baltic Sea supports this hypothesis.

In the project we estimate the catch of whitefish and the by-catch of other fish species in the whitefish gill-net fishery, with special emphasis on salmonids, by a combination of experimental fishery, monitoring selected commercial fishing trips and a questionnaire the fishermen on their effort. A number of different approaches re time and place of fishing and net construction is tested to describe how much by-catch can be minimized.

The result of natural spawning in River Skjern is investigated by a combination of catching newly hatched larvae with drift-nets and e-DNA analysis of water samples from the river. The latter method is a very novel approach. Through the experimental fishing, supplemental data on the whitefish, salmonids as well as other species (less detailed) are collected to describe population dynamic parameters (size and age distribution, growth, condition etc.), primarily of whitefish and salmonids.

The results show, that by-catch of sea-trout in the whitefish gill-net fishery is unavoidable, but also that the by-catch can be reduced substantially by employing specific gears and methods. The by-catch of salmon is insignificant while the by-catch of other species, especially flounder is substantial. These results will be reported in autumn 2016. The investigation on natural reproduction in the River Skjern is still ongoing and will be reported in 2017.

This project is coordinated by DTU Aqua.

The project is funded by the Danish Rod and Net Fishing License Funds.
National Institute of Aquatic Resources

Section for Freshwater Fisheries Ecology
Period: 01/01/2011 → 31/12/2016
Number of participants: 4

Research areas: Freshwater Fisheries and Ecology & Population Genetics

Project participant:

Eg Nielsen, Einar (Intern)
Phd Student:

Hansen, Brian Klitgaard (Intern)
Project Manager, academic:

Berg, Søren (Intern)
Støttrup, Josianne Gatt (Intern)

Project