

Using GIS in fishery science at the Danish Institute for Fisheries Research

Abstract

In this presentation, examples of the use of GIS in the Danish Institute for Fisheries Research (DIFRES) are given. There are projects with very different objectives and use of different GIS software going on at DIFRES at the moment. One of the projects that will be presented is called CODYSSEY (Cod spatial dynamics and vertical movements in European waters and implications for fishery management). One of the objectives of the project is tracking of single cod in the Bornholm Basin in the Baltic Sea with the help of Electronic Data Storage Tags. Data is displayed with the help of Tracking Analyst and 3D Analyst for ArcGIS. Other maps that are results of analysis carried out as a part of this project show the distribution area of cod in the Bornholm Basin in the Baltic Sea since the 1950'ies. Three maps from the CODYSSEY project are shown in the ESRI Map Book 2004. Two other projects at DIFRES that will be presented are using GIS for the placement of mariculture and shellfish production in Denmark. In both cases, a model that rated the suitability of different areas for mariculture and shellfish production respectively was established with Spatial Analyst for ArcGIS.

Presentation of DIFRES

DIFRES is part of the Ministry of Food, Agriculture and Fisheries. DIFRES advises the ministry, other authorities, international commissions, the fishing industry and fishing organizations concerning sustainable exploitation of live marine and fresh water resources. The institution employs approximately 270 persons, distributed on 8 different geographical locations. The institution includes four research departments; the Department of Marine Ecology and Aquaculture, the Department of Marine Fisheries, the Department of Inland Fisheries and the Department of Seafood Research.

GIS at DIFRES

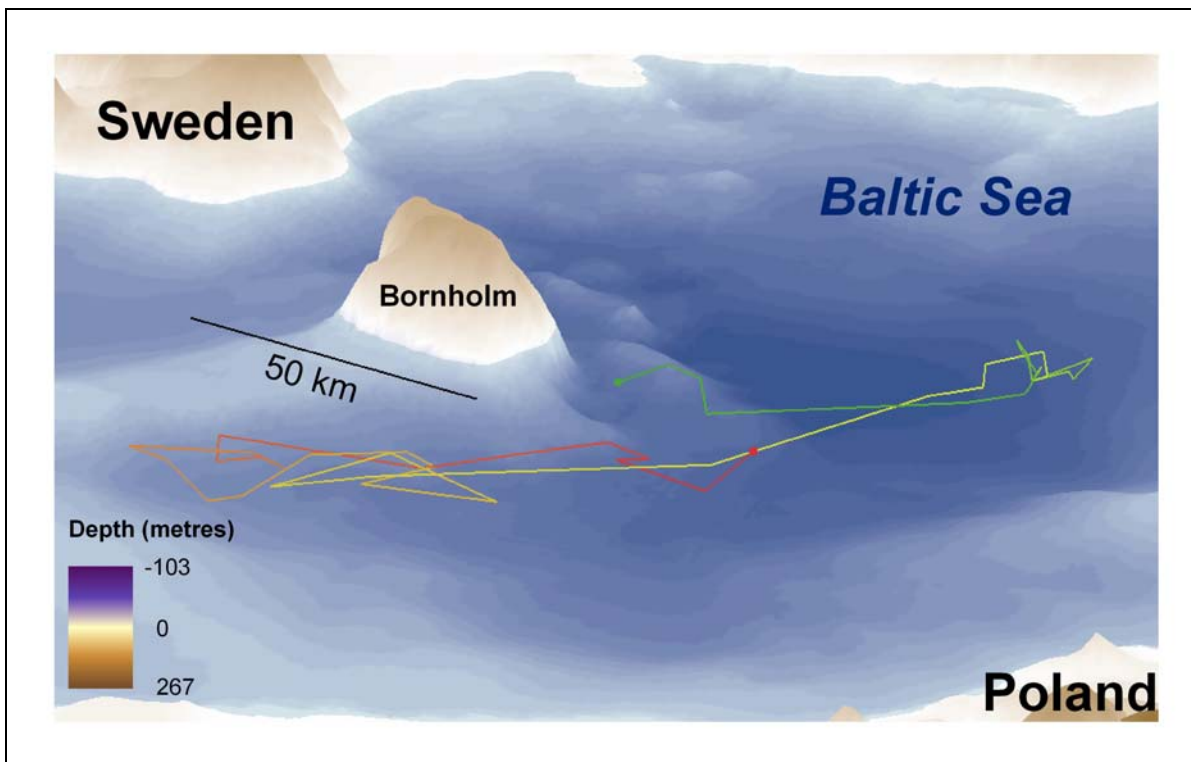
A few years ago, GIS was only used by very few people and for a limited number of applications. All the data was saved in non-geographical databases. The majority of this data has a geographical position and can therefore be value-added by being presented on maps. The use of GIS has made it much easier to analyze the vast amount of data available at DIFRES. Relational databases can be very useful, but they have a tendency to loose clarity when the amount of data increases. Having access to geo-data makes it possible to create illustrative maps. Like diagrams, maps have the ability to give a good overview of large amounts of data.

The investment in time (and money) lies in making the scientists see the possibilities there are in using GIS. GIS in the marine world is not nearly as widespread as it is on land. Limitations of the software to 2 and 2½ dimensions have made it challenging to use all the information held in the databases. Also, marine biologists are not by tradition used to work with GIS and do not think geographically as a habit; hence examples on uses of GIS in marine science are generally not well-known by marine biologists. Showing marine scientists what can be done in GIS with their own data has been very successful at DIFRES. Sometimes just making a relatively simple map to illustrate the data of a project is enough to illustrate a point or reach a conclusion. Other times the map will point the user in a specific direction in order to take a closer look at the data, e.g. what sort of analysis could be carried out, helping in setting up a new thesis or pointing out where more investigation of an area is necessary.

Examples of projects

CODYSSEY (Cod spatial dynamics and vertical movements in European waters and implications for fishery management)

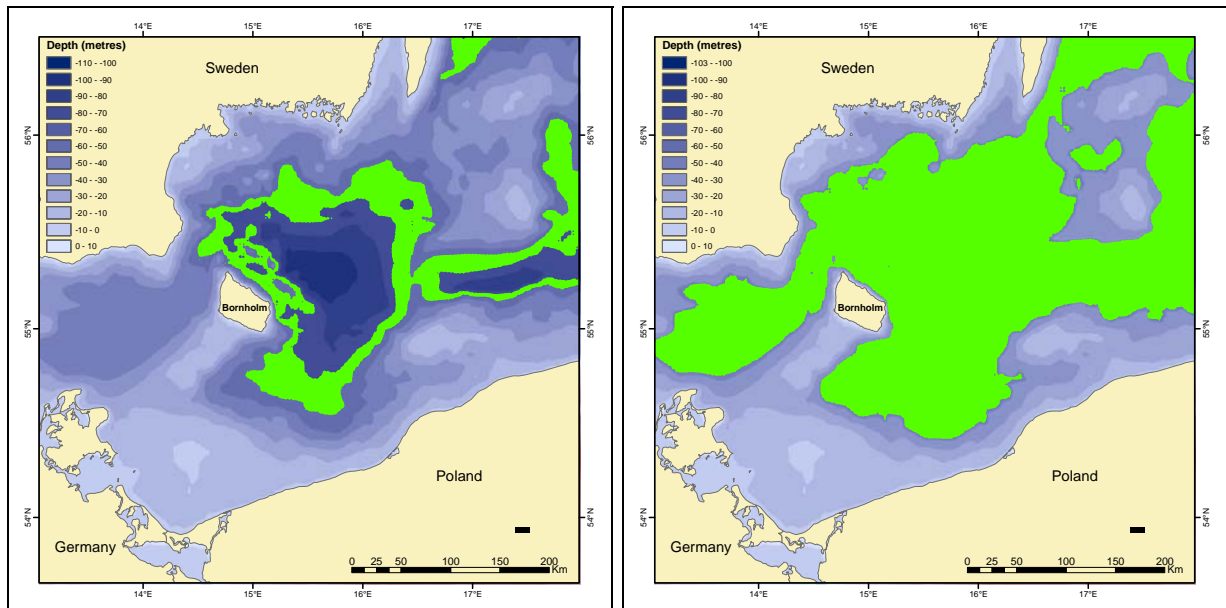
DIFRES participated in a television program about threatened and endangered fish species on the national Danish Channel DR2 shown in March 2004. The program focuses on biologists' work in estimating stock size for different fish species. One of the items produced for the show by DIFRES is a video clip in which ArcView 3D Analyst was used to show the movements of a single tagged cod.



Movement of a single cod in the Bornholm basin

The three-dimensional picture shows the movement of a single cod for 55 days from April to June 2003. The cod was tagged with an electronic data storage tag (green dot on picture) and caught (red dot on picture) at locations approximately 27 kilometres from each other. The three-dimensional visualization illustrates the movement of the cod showing that the cod mainly stayed in two different locations: one location to the southeast of Bornholm where it was found in the water column and another location to the southwest of Bornholm where it was found at the bottom. The scientific interpretation of these results is that the cod was probably spawning in the water column while residing in the first area and feeding at the bottom while residing in the second area.

The full video clip can be seen on the DIFRES home page at www.difres.dk. There is also another video clip produced with ArcView Tracking Analyst for the same television program. This clip shows the distribution area of cod in the Bornholm Basin in the Baltic Sea since the 1950s.

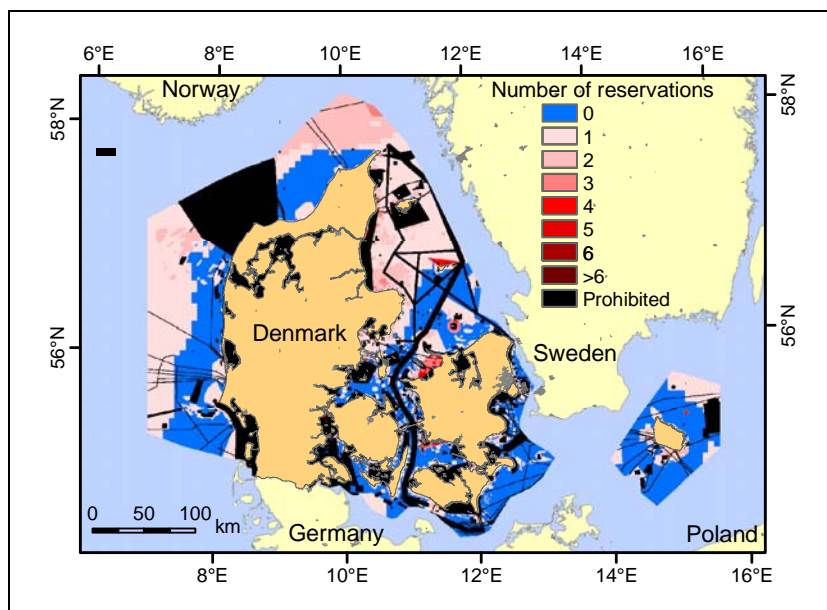


Extent of cod distribution in two different years in the Bornholm Basin

The two maps explicitly show the geographic extent of the bottom area covered by water with an oxygen concentration greater than two milligrams per litre and a salinity greater than 11 in the Bornholm Basin of the Baltic Sea during the 44 years that the video clip covers. Biological surveys along with measurements of physical and chemical parameters indicate that these conditions, highlighted by the bright green area on the maps, characterize the main cod distribution area in this region. In 1971, the area for cod distribution was at its lowest with an area less than 9,000 square kilometres. In 1968 and 1974 the area was at its largest extension with approximately 33,000 square kilometres. The average for the 44 measured years is approximately 20,000 square kilometres per year.

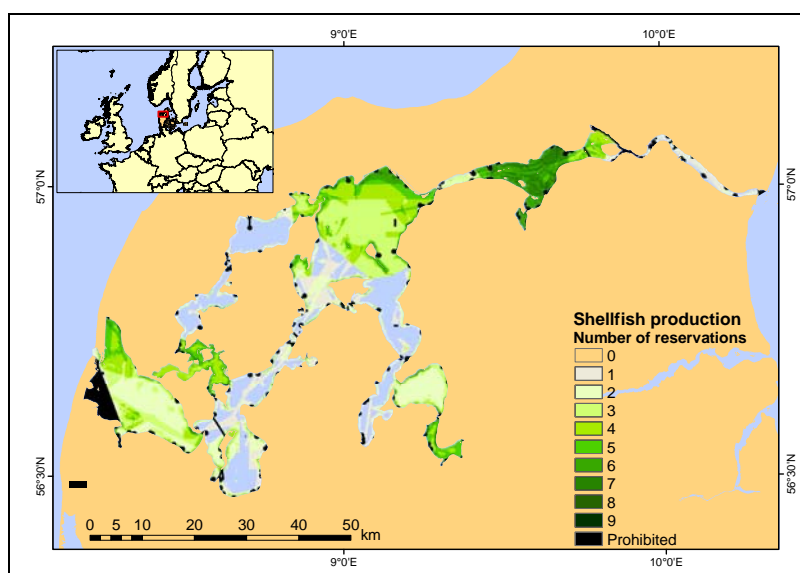
Use of GIS for the placement of rainbow trout culture and management of shellfish production in Denmark

DIFRES participated in a working group tasked with finding new areas suitable for the placement of rainbow trout culture in net cages or wire crates. DIFRES provided most of the GIS work and prepared all the maps for the final report published by the group. Data were collected from different sources, most of them governmental. For the analysis, all data were overlaid as rasters. Data were allocated different weights so that the presence of certain data would rule out the placement of mariculture in that specific area, while the presence of other data would lead to different kinds of considerations. As a result of the analysis, several maps were prepared that showed the status of the different areas. Some areas were marked as restricted areas, while other areas were assigned a number based on the number of considerations overlapping in that area. The areas that were considered most suitable for the placement of mariculture were those where the technical requirements were met and where there were no restrictions or considerations. Areas with one to ten considerations are in principle less suitable, where there has to be a specific evaluation of each application for placement of a rainbow trout culture for that area.



Map on entire reservations. Dark blue shows areas with no reservations. Light blue is outside of the analysed area. Red colours show the number of overlapping themes from one (light) to ten (dark). The number of seven to ten reservations is represented with one group. Areas where there is prohibition against the placement of mariculture are shown with black. Light yellow shows land areas of Denmark and surrounding countries.

The following project was from a GIS technical point of view quite similar to the mariculture project. The Minister for Food, Agriculture and Fisheries established an expert committee that analysed the potential for and ecologically and economically sustainable production of shellfish in Danish waters in 2003. The aim of the project in DIFRES is to describe the production potential of shellfish production based on a GIS integration of data on habitat-characteristics, legislation and physical restrictions and information about the area specific fishery. The GIS system established is covering the Limfjord.



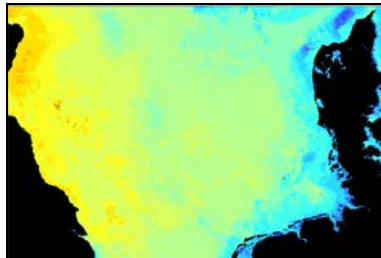
Map on entire reservations. Light blue shows areas with no reservations. Green colours show the number of overlapping themes from one (light) to nine (dark). Areas where there is prohibition against the placement of shellfish production are shown with black. Light yellow shows land areas of Denmark and surrounding countries.

Illustrations in other projects

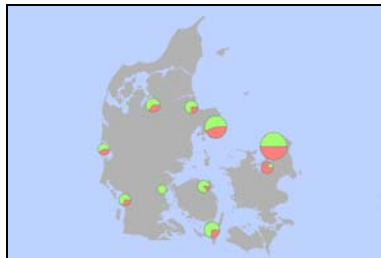
The following maps are examples taken from the many maps that are produced at DIFRES this year.



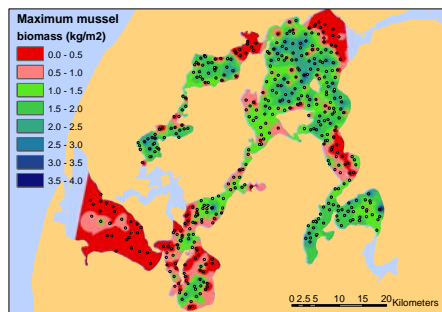
Area closed for drag-net fishing at Faeroe Islands



Sea Surface Temperature in the North Sea (IMPRESS project - Interactions between the Marine environment, PREdators, and prey: implications for Sustainable Sand eel fisheries)



Distribution of the parasite *Anguillicola crassus* in European eel (*Anguilla anguilla*) at different locations in Denmark



Maximum biomass of blue mussels (*Mytilus edulis*) in Limfjorden, Denmark from 1993 to 2003

Implementing strategy

The strategy on how to implement GIS in DIFRES has been quite clear from the very start of the process. The plan was to start a couple of relatively small projects to give the employees at DIFRES "a taste of GIS". The projects have been driven by the users of the research departments where the GIS employee was working in agreement with the researchers' wishes. The GIS employee would draw the researchers' attention to the possibilities with GIS in the given project and do most of the actual GIS work. The researcher would be the driving force in the project where GIS is one of the pieces used to analyse and visualize the data. Parallel with these projects the GIS laboratory is also in charge of organizing GIS licenses, obtaining data and teaching GIS. For the teaching of the researchers, workshops have been proven very useful. In the beginning, a sort of standard GIS courses following the tutorials that come with the program were held, but the researchers were clearly more interested in working with their own data. Motivation to learn for example about map projections was much greater when the researchers saw the need for reprojecting their own data whilst working with them. That way the researchers get only to know the part of ArcGIS that they actually need. At the same time, many of the routines between the researchers were the same, for example the need to add a x, y dataset to a map or to calculate an area. For these routines, small guides have been written by the GIS laboratory and put on a common server. On this server, all the commonly available GIS data are stored as well. As time goes on, the amount of data on this server is growing very big. More than 220 GB of information are available at the moment (September 2004), nearly 90 GB being geographical data. SST data and aerial photography are the big "sinners" when it gets to filling up space as raster data usually make up much bigger files than vector data. A 1 terra byte raid system was obtained to make sure that space will not be a limiting factor for quite a while. In order to decrease network traffic, the users take copies of the data they need to their workstations, which has some disadvantages e.g. that the users have to keep themselves up to date and that the data is taking up space on their computers as well.

An effect of the first projects has been an immense interest for GIS in the organisation. The employees at DIFRES already involved with GIS can see a lot of possibilities of what GIS can do for them and think GIS into their future projects. Other employees, that have not been involved in GIS projects yet are becoming interested and are inspired by what their colleagues can achieve with GIS. This has lead to more and more people becoming a part of the GIS laboratory. At the beginning, only one person was working full time with GIS, at the moment 3 full time staff are working with GIS and a student has been employed to help people with their GIS tasks.

Plans for the future

One of the plans for the future is that, little by little, metadata for all the available geo-data will be provided. For this purpose, a metadata editor has been programmed to suit the needs for metadata at DIFRES. Further programming in the future will automate often used task and thus make them easier accessible to the researchers. An example of that is the calculation of an area for a polygon shapefile.

As a part of the effort to make DIFRES more visible to the general public, the DIFRES homepage has been modernized. In the future, more and more ArcIMS services will be part of the homepage, visualizing a lot of the data researchers are working with. The first of these services is visualizing the results of the shellfish production placement project, which can be seen at <http://gis.dfu.min.dk/website/Limfjord/viewer.htm>.

Another effort that is going on at the moment is to phrase the GIS strategy for the next few years more explicitly in order to be able to integrate the GIS strategy in the overall planning process for DIFRES. Planning and coordinating the GIS effort in the future projects as well as the general service is an ongoing process that needs to be attended.

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