KNOWLEDGE-BASED DECISIONS IN COASTAL ZONE MANAGEMENT

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Abstract

The coastal zone is an area with many values and many stakeholders. To manage it in a rational and sustainable way and to minimize conflicts we need to know about its habitats, its inhabitants and about their ecological relationships.

Today we know a lot about the most important commercial species, but even for these we need more knowledge e.g..about their vulnerability to human activities. For habitats and species with less direct economical value, much less is known, and much of the knowledge we have is hidden in reports not easily accessible.

Two ongoing projects are described: One aiming at mapping and putting information relating to undersea habitats, organisms and resources into electronic form. This project represents an effort both to acquire new knowledge, and to make present knowledge available in GIS (Geographical Information System) format. The other one aims at making information required for management (e.g. legislation, ecology, biological resources etc.) easily available and understandable for those who need it. This is done through a web page, partly by writing short descriptions of the marine environment and its inhabitants and the legal background for management, and partly

by giving procedures and examples of management. The Internet page also provides links to available databases .

Introduction

The costal zone in northern Europe is generally densely populated, with extensive land areas being used for industrial activities, settlement and recreation. Simultaneously the coastal zone has high biological diversity and productivity and holds a number of resources. Therefore, many stakeholders with many conflicting interests meet in the coastal zone. During recent years a number of changes, some of them irreversible, have taken place in the coastal zone. Some of these changes have been deliberate and well planned; others are the result of lack of knowledge and poor management. It is a primary goal for future management to use the coastal zone in a sustainable way, to maximize the benefits from it and to minimize conflicts.

A rational and sustainable management of the coastal zone must be based on knowledge, and in the present paper we shall look at the following questions:

- What kind of knowledge do we need?
- What kind of knowledge do we have?
- How can we make the knowledge available to those who need it?

We shall also look at what should be managed in the coastal zone; we shall give some examples of present knowledge, and of how this knowledge can be made available to those who are responsible for the management.

Why is the coastal zone so valuable?

There are many types of resources and assets that have to be managed in the coastal zone. Some of them are:

- Biological resources
- Oil, minerals etc.
- Areas for recreation
- Areas for rural development
- Industrial areas
- Transportation areas
- Protected areas

Here we shall concentrate on the biological recourses, and on how the management of these should be based on knowledge on their distribution, their dynamics and on the ecological systems and processes of which they are parts.

The biological resources can be divided into two main groups; permanent inhabitants and transient visitors. In the first group we find algae, mussels, crustaceans, echinoderms and coastal fishes. The whole lifecycle of these organisms is spent in coastal waters. Visitors spend most of their time in oceanic areas, but come to the coast during specific stages of their life cycles. Most of these visitors are fish, and some of them give rise to economically important coastal fisheries. Typical examples are Atlantic cod (Gadus morhua) and herring (Clupea harengus) that come to the coast to spawn, and have nursery areas along the coast, but spend most of their adult life in the open sea. They feed in the open oceans and the biomass they produce is utilized at the coast either as they are fished, eaten by coastal animals, or as their their surplus spawning products are recycled as nutrition for plants. These and other similar

species, therefore, are very important as transporters of biomass and nutrients from the open ocean to coastal waters.

What kind of knowledge do we need?

To manage the costal zone we need knowledge about the resources and their environment. We must know how the components of the ecosystem interact and we must know how vulnerable they are to human activities; we need some basic knowledge of their biology, primarily ecology and population dynamics. Here we shall look at some examples of the knowledge available that is related to some types of fisheries, and to some other biological resources and activities.

Further we need knowledge on laws and other national and international legislation, and on human sociology and economics. This part of the knowledge-base will, however, not be treated here.

What kind of knowledge do we have?

The great fisheries; large cod and herring stocks

The Artic-Norwegian cod have their feeding area in the Barents Sea and in the Svalbard region but they spawn on the coast of northwestern Norway, mainly in the Lofoten area. These cod have an estimated spawning stock biomass of about 430 000 tonnes (ICES,2003), and most of the stock arrives in Norwegian waters to spawn in early spring. (For comparison, the total weight of the Norwegian human population is around 300 000 tonnes.) The Norwegian spring-spawning herring, which feed in the

Norwegian Sea and spawn along the coast of western Norway, has an estimated spawning stock of nearly 6 million tonnes (ICES, 2003).

This migration from feeding areas to the coast results in a tremendous transport of biomass and energy from the open ocean to coastal areas. Simultaneously, the conditions in coastal waters – food and shelter, currents and temperature conditions, predators etc. - have a profound effect on the recruitment to these and similar stocks.

We have very good knowledge of the large cod and herring stock, and on many of the other fishes subjected to large fisheries. Therefore, it is also possible to estimate the possible effects of destroying spawning and nursery areas for these species, e.g. through pollution or other harmful effects in the coastal zone. However, we still have insufficient knowledge of the vulnerability of spawning grounds and of eggs and larvae.

Small, local fisheries; Cod at the Skagerrak coast

Our knowledge on the coastal cod of the Norwegian Skagerrak cost has increased considerably during the last few years, and probably a large part of this knowledge is applicable to coastal cod stocks in other areas too (Fig. 1).

Fig. 1. Cod is a very important resource in many coastal areas (Photo Øystein Paulsen).

Based on genetical studies we know that the coastal stocks are distinct from North Sea Cod and there are strong indications that each fjord has separate cod stocks (Knutsen et al. 2003). We also know that the costal cod spawn at fixed locations, and that recruitment is highly variable (Fromentin et al. 2001). Furthermore, we know that they have fast growth and very high mortality (Gjøsæter 1990).

Still there is lots of information lacking, for example we have very vague ideas of stock size, and of catch rates. Although there are fairly good data on catches taken by professional fishermen, we know little on landings by tourist and leisure fishermen, although they obviously take a large part of the total yield. We also know that seals and cormorants take a lot of cod, but this is very difficult to quantify.

Along on the Swedish West coast and the easternmost coast of Norway there has been a substantial reduction in the abundance of adult cod. Apparently anintensive fishery is the main reason (Svedäng et al. 2001), but large stocks of seals and cormorants may also be a part of the problem (Institute of marine research, unpublished data).

There are a lot of stocks where a similar pattern of knowledge as for the Skagerrak coastal cod exists; we know much about general biology and of the commercial fisheries, but there is still a lot to be learnt about stock structure and size, location of spawning and nursery areas and on non-commercial landings.

Unconventional fish resources; wrasses

Following the increase in salmon farming, there has been an increasing demand for wrasses, mainly corkwing (Crenilabrus melops) and goldsinny (Ctenolabrus rupestris) that are used as cleaner-fish to remove sea lice (Copepoda, Caligidae) from the fish. By now we know quite a lot on their biology and life history and on their habitat selection (Sayer et al. 1996). We also have some fragments of knowledge on their abundance and on reaction to fisheries (Gjøsæter 2002 a, b). For these and other fish species that are unexploited or where exploitation has just begun we know much less then desirable on their distribution, abundance, dynamics and place in the coastal ecosystems to manage them in a rational way.

Sea urchins; a resource, but also a threat to the environment

Sea urchins (mainly *Strongylocentrotus droebachiensis*) is in an unusual position; they are an important potential resource for harvesting and farming, but in some areas they have increased in number and destroyed vast areas of algal stands. In parts of the northwestern Norway they have changed the ecosystem from one with large kelp forests with a wide variety of fish and other animals, to barren plains with few organisms except the sea urchins. And the sea urchins from such areas are too small and too full of parasites to be of any value. Several hypotheses have been put forward

to explain why the sea urchins have got out of control (e.g. that their predators such as cod and wolf-fish (*Anarhichas lupus*) have been heavily exploited), but we have no answer.

Aquaculture; huge potentials, but very area consuming

Aquaculture and sea ranching are major industries in coastal areas, and they will assume increased in importance in the coming years. Marine aquaculture needs a lot of space and clean water. Such installation will, therefore, compete with many other users of the coastal zone. Sea ranching will also exclude fishermen, both professional and others from large areas where organisms such as lobster or various shellfish are grown or harvested.

At present most fish farming is conducted in open pens. To avoid polluting the environment and spreading of diseases, these types of fish farm have to be widely spaced, and a given area can only hold a limited number of farms. By using closed system both pollution and diseases can be more easily controlled, and farms can be better protected from external pollution and from the effect of toxic algae blooms. Today we know how to manage traditional salmon (*Salmo salar*) farms. There are, however, many open questions on how to treat other types of fish farms: What kind of environment do they need? How will they influence the environment?

Sea ranching also poses new problems, both of biological and legislative natures. Giving one part exclusive rights to release and thereafter harvest an organism in an area will give a number of conflicts. Some of these problems are: How large should

the area of exclusive rights be? What kind of gears should be permitted within such an area? What should be the time span for such rights?

How can we organize the knowledge and make it available?

Two projects to organize our knowledge of the coastal zone and to make it available to managers and stakeholders are now are conducted in Norway. The aim of the first one ("Tvedestrandsprosjektet", named after the municipality where it is conducted) is to organize all information relating to costal resources and coastal use in maps. The other project ("Manual of ecological planning in the coastal zone") aims to provide information on how and where relevant knowledge about the coastal zone can be found available, demonstrate how to use it and distribute it via the Internet.

Recording and mapping information on marine habitats, communities and resources

Planning and management of terrestrial areas has been supported by detailed knowledge and extensive data on habitats and their inhabitants for many years. Much of the information is displayed on maps so that it can easily be used for local, regional

and national management. For

Fig. 2. Scuba divers surveyed the coastal areas and collected organisms for identification (Photo Øystein Paulsen).

undersea areas only maps showing bathymetric features and sometimes data from physical and chemical oceanography have been available.Information on nature types, habitats and resources has been found in scattered reports or not at all . Recently a project was launched in the municipality Tvedestrand on the Norwegian Skagerrak coast. This project has been set up to map the underwater habitats and resources in Tvedestrand, and to develop a system to make this information available on maps in an easily retrievable way. The information has been collected using a variety of techniques including scuba diving and underwater video to describe habitat types and to collect and identify demersal flora and fauna, fishing with pots and various types of nets to characterise locally important fished resources, collection of fish eggs and larvae

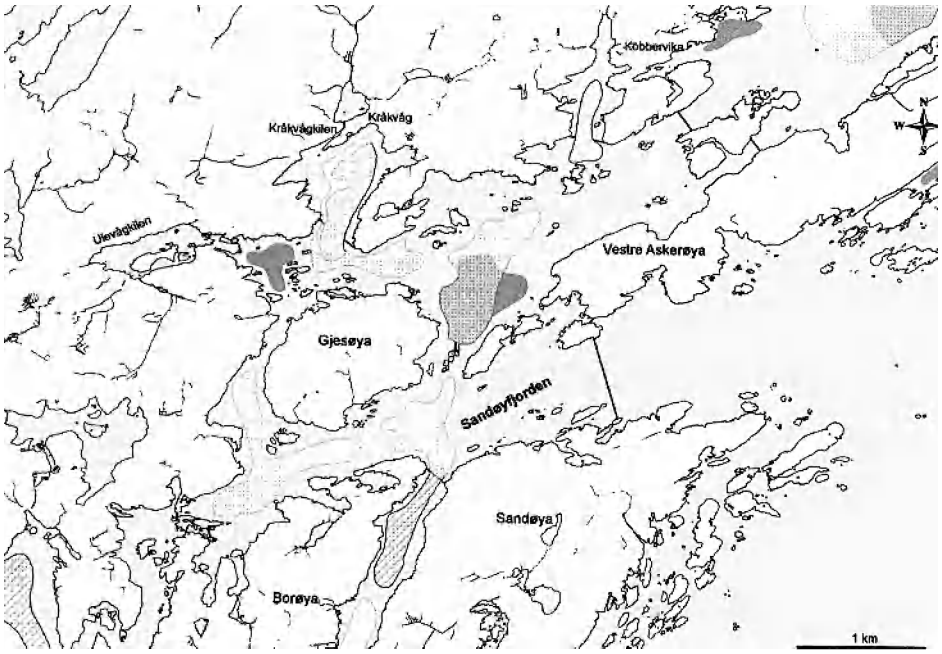

Fig. 3. Map showing various uses of the coastal zone in the Tvedestrand area. Circles with crosses indicate places where various nets are used. Circles with a lobster symbol means pots, and areas marked with crossed lines indicate where seining is commonly conducted.

using plankton gears and acoustic tracking of bottom profiles and softness using echo sounders (Fig. 2). During the Tvedestrand project special emphasise has been put on finding spawning grounds and habitats important for nurseries areas for commercial fishes (Fig 3). To find the spawning grounds, we first carried out an interview survey with local fishermen. They pointed out a number of spawning grounds. In these areas we fished and looked for eggs during the spawning season, and if spawning fish and eggs were found in an area, this was verified as a spawning area. Cod, the most important fish at the Skagerrak coast, seem to spawn in deep basins where eggs are mainly situated below threshold depth (generally 10 – 30 m). This probably protects them from being washed out by the coastal currents.

Nursery areas were mapped using pots and beach seines to collect fry. Eelgrass beds and kelp forests seem to be the most important nursery areas for the important fish species.

During the Tvedestrand project, emphasis was also given to finding habitats with particularly high biodiversity, and special habitats worth protection.

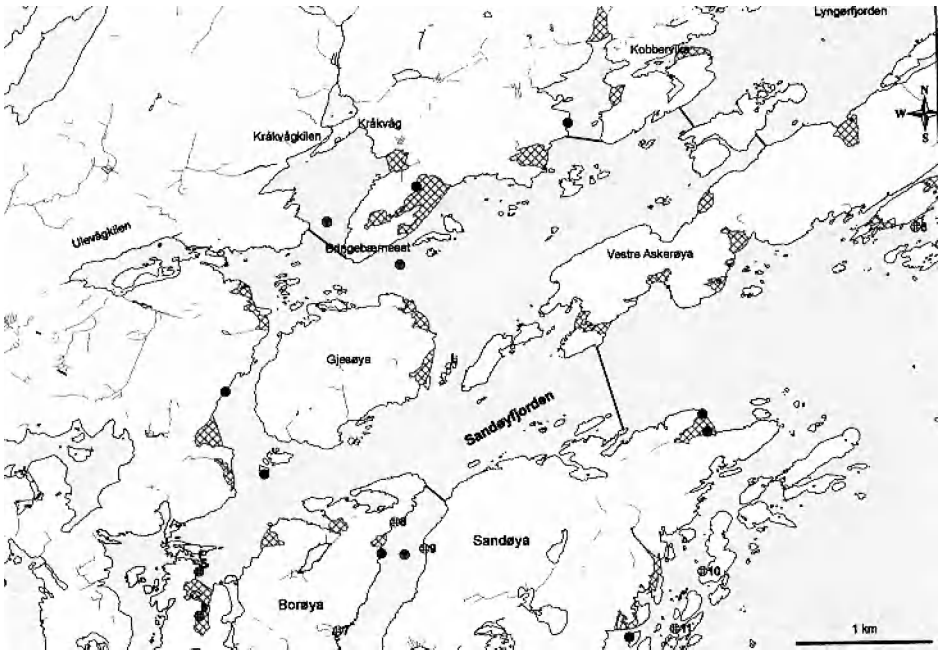

Fig. 4. Map showing spawning ground for various fish species in the Tvedestrand area. Different symbol indicate different fish species (cod, flatfish (mostly place (*Pleuronectes platessa*)), whiting (*Merlangius merlangus*), pollack (*Pollachius pollachius*)

This fieldwork was followed by classification of areas and putting them into a digital coordinate system and showing them on maps. For this purpose the AREALIS system was used. AREALIS is an initiative to establish a nation-wide Geographical Information System (GIS), making area, environment and planning data more accessible to politicians, the public and to local, regional and national administration. Thematic information connected to map data gives new possibilities for comparing of area values, analysing of area conflicts and to present this in an easily understandable way (Fig. 4).

Guide to marine-ecological planning and management of the coastal zone

The Institute of Marine Research, Flødevigen Marine Research Station, has got the responsibility of making a "Guide to marine-ecological planning and management of the coastal zone", in cooperation with the Directorate of Fisheries in Norway. The Guide is meant as a tool for knowledge-based management of the coastal zone, and it will support a proper balance between use and protection of the coastal zone Many scientists from research institutions and Universities have participated in writing it.

The Guide, which is available electronically on the Internet (www.kystsone.no), will, for example:

- Be a basis for promoting acceptable, "environmentally friendly" projects
- Contribute to asking the right questions and to making the appropriate considerations when planning and carrying out projects in the coastal zone
- Indicate where to find necessary expertise and data, both generally and for specific areas
- Emphasize important resources and environmental qualities in the coastal zone
- Indicate factors of importance to the natural biological production and diversity along the coast
- Refer to typical ecosystems/environments in the coastal zone and their importance as spawning, nursery and feeding areas, and for biological diversity
- Give knowledge about vulnerability of coastal systems to human activities
- Refer to relevant parts of the legal framework and international agreements, which should be applied to coastal zone management.

The guide has a chapter on the legal background for coastal management, giving references to national and international laws and regulations. This chapter also

identifies typical conflict areas, and explains how similar problems have been solved in other areas.

A chapter on activities in the coastal zone, explains the most important uses of the coast and the activities there, e.g. fishery, aquaculture and stock enhancement, transport, recreation, coastal-based industry, fishery industry, technical installations (cables, water pipes etc.), energy extraction (wave power), settlements, protected areas, and research.

A chapter on the environmental background explains what types of environments we have, and how topography, hydrographical conditions and other physical factors can influence the coastal zone.

Similarly the biological background is treated: What types of plant- and animal-communities do we find, how important are they, and how vulnerable are they to anthropogenic effects? This chapter also treats the biological resources in the coastal zone.

Finally the guide gives examples of practical management and, explains some of the principles behind it.

Conclusions

Knowledge is important for managing the coastal zone in a rational and sustainable way. Much knowledge is available, in particular about commercial species. However, very little is known about the habitats and inhabitants of the areas below the sea

compared to those on the land areas. There also remain a lot to be done to make the knowledge easily available to stakeholders and to authorities.

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