Summary of reports 2008/09:RFR4 and 2009/10:RFR2
Committee on Environment and Agriculture

Swedish Fish Populations
– Challenges for the Future
Preface

In the autumn of 2007, the Committee on Environment and Agriculture decided to commission a research review highlighting the ecological consequences of fishing in Swedish waters. The overall purpose of the review is to give members of the Riksdag (Swedish Parliament) a more detailed knowledge base for decision-making on fisheries. The review was conducted in two parts; part 1 contains research on the environmental factors both with direct and indirect effects on fish populations and part 2 contains scenarios for the future, highlighting the way in which climate change and future fisheries management can affect fish populations. The authors alone are responsible for the contents of the report. The reviews have been published as part of the Reports from the Riksdag series (RFR). Part 1, Fish populations in Swedish waters – How are they affected by fishing, eutrophication and contaminants? (2008/09:RFR4), was presented to the Committee in December 2008, and Part 2, Swedish fish stocks with a focus on the future (2009/10:RFR2) in December 2009. This brochure provides a summary of the authors’ conclusions from both reports. The full reports may be downloaded from the Riksdag website (www.riksdagen.se).
In view of the major effect that fishing has on both target species and on the ecosystem as a whole, it is crucial that our fish populations are sustainably managed. It has been proven that management based on short-term decisions leads to both ecological and economic losses.

**Fishing – the most important structuring factor**

Human activities have had an impact on life in seas and lakes for many thousands of years. Since the mid-20th century this impact has increased as a result of population growth, technical developments and the increasing geographical scale of exploitation. In many of the world’s aquatic ecosystems, dramatic changes have occurred through overfishing, eutrophication, the spread of contaminants and decimation of marine mammals. During the 20th century, overall Swedish catches have gone from being dominated primarily by herring to fishing largely based on catches of fish for reduction, so-called trash fish\(^1\) (Figure 1).

**Figure 1** Total Swedish landings expressed in tonnes broken down into the most important species

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\(^1\) Fishing for the production of fishmeal and oil, also known as feed fish.
The most important commercial fishing species are cod, herring and sprat. Major changes in the fish community of the Baltic Proper occurred in the latter part of the 20th century and early 21st century. The fish community, previously dominated by cod, has devolved into a community dominated by sprat. After a period of decreasing fishing pressure, populations of herring, which were previously heavily fished and showed a dramatic decline between the end of the 1970s and late 1990s, have once again started to increase (Figure 2).

**Figure 2** The biomass of cod, herring and sprat in the Baltic between 1974 and 2007. Data from ICES

As a whole, research shows that fishing is the single most important factor impacting fish populations in Swedish lakes and marine areas. This applies primarily to fishing of commercially important species such as cod, herring and sprat. Overfishing has led to smaller cod populations and selective fishing for large individuals has also had a significant impact on the age structure of the remaining stocks. For fish stocks, this can lead to impaired reproductive potential and a reduced ability to cope with natural fluctuations in their habitat. Inten-
sive fishing has affected other organisms in the food web, which may have a far-reaching impact on the functioning of the entire ecosystem. Certain types of fishing – primarily fishing with fine-meshed bottom-trawls – have a considerable impact on the rest of the ecosystem because of by-catches and mechanical impact on the seabed.

**Environmental factors**

Regulation of fishing is thus of decisive importance for the future of our fish stocks, but environmental factors can also affect their growth and distribution. Inflows of saline and oxygen-rich water from the North Sea, eutrophication, contaminants, (long-term) climate change and the introduction of foreign species are some of the environmental factors that can play an important role for fish populations.

**Inflows of saline water**

Persistent and heavy westerly winds can result in large inflows of saline, oxygen-rich water to the Baltic. Even though these inflows often involve no more than around 1 per cent of the Baltic’s water volume, they affect the entire habitat and conditions of a large number of Baltic species. Cod is one example of a marine species that is dependent on saltwater inflows as they affect the reproductive potential of the species. Fisheries management should therefore be adapted to take into account changes in inflow of saline water.

**From the management perspective**

- Spare large female cod individuals. Large female cod produce larger eggs which float higher up in the water column, where oxygen supply is better. This means that they have better chances of survival than smaller eggs. Strategies and instruments to spare the largest and oldest cod individuals may therefore be significant in future management plans for cod populations.
- Management in combination with favourable environmental conditions. During the last few years, there has been a small
increase in the eastern cod stock. This is attributed to a fortunate combination of favourable reproductive conditions in recent years owing to inflow of saline and oxygen-rich water, combined with increasing fishing control measures. In the last two years, decided catch-levels have also complied with the management plan for Baltic cod.

**Eutrophication – long-term measures required**

The effects of eutrophication on fish populations are complex and can, at an initial stage, be positive for many species as access to food tends to increase. However, a number of long-term effects of eutrophication have had a negative impact on our fish populations, including depleted oxygen levels, overgrowth in shallow archipelagic areas and changes in the species composition in the food web.

Long-term measures are needed to limit the effects of eutrophication. Reduced discharges of both phosphorus and nitrogen are needed and require both national and international measures. It is also crucial to take into account both external sources and internal processes in the sea. The nutrient dynamics are complex and our understanding of all the processes involved is insufficient. Different marine areas, coastal areas and lakes have different properties, and measures must be adapted to these specific conditions and the impact on the entire ecosystem must be taken into account. New research also shows that a lack of predatory fish, such as cod, can aggravate the effects of eutrophication. A decline of predatory fish can, in the same way as an increased discharge of nutrients, lead to a higher abundance of phytoplankton or macro-algae and, in the long run, cause oxygen depletion and dead zones.

*From the management perspective*

- Reduced discharges of nutrients are the only long-term solution to the problem of eutrophication.
Fisheries management should take into account ecological conditions in a broad sense, such as competition between species, food availability and the how reproduction is dependent on oxygen levels in deepwater.

In-depth research is needed for a better understanding of the correlation between eutrophication and changes in fish populations regarding size and composition.

Contaminants – a cocktail of substances

Contaminants can cause damage to fish and can, for example, negatively affect their reproductive potential. Such damage has been observed in areas surrounding industries or other sources of emissions. Pharmaceuticals in emissions from water treatment plants in the marine environment may affect the reproductive potential of fish. Today, however, no large-scale effects on fish populations can be directly linked to contaminants or pharmaceuticals.

Many fish populations in Sweden have undergone major structural changes in which both heavy fishing pressure and eutrophication have an important role. In an ecosystem which has already undergone major change, contaminants can potentially affect the capacity of fish populations to recover. Diffuse emissions of contaminants, both water-bound and air-bound, can have a greater impact on fish populations than we have knowledge of today.

From the management perspective

Continued environmental monitoring, screening and research are needed for understanding of how individual contaminants and cocktails of substances affect our ecosystems.

Climate change

Temperature, oxygen and salinity are important factors for the distribution and survival of fish stocks and these factors can change with a warmer climate. Changed levels of precipitation directly affect salinity,
which is one of the most important physical factors for organisms in the Baltic Sea. Higher temperatures in the Baltic can have numerous biological effects. All species are not directly affected by a rise in temperature, but may be indirectly affected when other species are favourably or unfavourably affected.

As well as having an impact on salinity, temperature and oxygen levels, acidification of the sea is an additional problem which arises as a result of increased levels of carbon dioxide. Today, however, knowledge of the effects of acidification on marine ecosystems is very limited, but new research indicates that, in the long term, acidification may involve considerable problems for organisms with calcium in their shells. Acidification may also lead to reproductive difficulties for a number of species of plankton. It is important to have an overall understanding of the way in which the ecosystem functions in order to be able to predict potential effects of climate change as well as any possible cascade effects that may arise.

From the management perspective

− In the short term – year-to-year variability. In the next 20 to 30 years, conditions will rather be governed by year-to-year variability in external factors. For example, a lack of saltwater inflows may have an impact on the reproductive potential of cod.

− In the long term – adapting management to large-scale changes in external factors. In the longer term, it is important to adapt management to permanent changes, for example, in salinity and oxygen levels, which will affect stocks.

Introduction of foreign species

The concept of foreign species refers to the growing problems associated with new species introduced in ecosystems where they have not previously existed. The greatest source of problems in the aquatic ecosystem is shipping traffic and its discharge of ballast water. More than 120 foreign species have been recorded in the Baltic Sea, 80 of
which have become established. The economic consequences of undesired foreign species are very difficult to calculate and no such estimate has been made for the Baltic Sea. Examples from other regions (for example the USA), however, show that the cost of ecological damage as well as the cost of controlling the inflow of new species may amount to billions.

One example of a recently introduced species that may have an impact on the fisheries industry is the round goby, found in Swedish waters for the first time in 2008. It is highly tolerant to variations in salinity and temperature, which is a great advantage for its establishment in the brackish water of the Baltic. The round goby may become a significant component in the diet of many predatory fish, such as cod and perch. Thus there are potential positive effects connected with the introduction of the round goby. However, also negative effects in the form of elimination of domestic species, may become a reality in the long term.

*From the management perspective*

- The primary reason for problems with the introduction of foreign species in waters is discharges of ballast water from shipping traffic. The best way of dealing with the problem, therefore, is preventing, limiting and eliminating discharges of ballast water. In its bill “Anslutning till och genomförande av barlastvattenkonventionen” [Accession to and implementation of the Ballast Water Convention] the Government proposed that Sweden should accede to the Ballast Water Convention, and in 2009, the Bill was approved by the Swedish Parliament.

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Swedish fishing and fish populations in the future

Fisheries management in transition

The formulation of the objectives for fisheries management has changed over time, shifting from focus on the industry to the promotion of the resource. Since the 1970s, our most important fishing populations have been managed on the basis of annual catch limits – Total Allowable Catch (TAC). The maximum size of these catches is determined by biologically-based advice from the International Council for the Exploration of the Sea (ICES). Decisions on the TAC for the following year (and other regulations) are taken by the EU Council of Ministers. For the eastern and western cod stocks, decisions on TAC have been above the annual catch limits recommended by ICES for many years (Figure 3). For a number of years, TAC for herring and sprat was set at considerably higher levels than those recommended by ICES.

Figure 3 Comparison between ICES’ recommended TAC for western and eastern cod stocks and maximum values of decided TAC and landings. The difference between the two is expressed as a percentage of recommended TAC.
The bodies responsible for the management of the sea’s living resources have committed to act in accordance with the Precautionary Approach. The Precautionary Approach emphasises that, in order to ensure sustainable development, it is necessary to apply prudent foresight, taking into account the uncertainty within the systems (fisheries).

**The ecosystem approach**

Future management of marine resources is to be based on the ecosystem approach. This is a management strategy based on the premise that management of resources should not only take into account the impact of activities on specific target species, but also the impact on the ecosystem as a whole. The transition to management according to the ecosystem approach must take place gradually and through cooperation between the relevant actors. So far, no serious attempts have been taken to apply this strategy in fisheries management. One reason for this may be that the complexity of the marine ecosystem means that our understanding of processes is still very limited. It is therefore important to improve our knowledge of the interactions between fish and other components in the ecosystem. Current fisheries management has also been inefficient, because the focus has mainly been on trying to save stocks of the most common food fish from collapse. Taking bottom-dwelling animals and by-catch species into account in this context has not been realistic. A major step towards ecosystem-based management would be to restore all fish stocks that are currently depleted, which can only be achieved by decreased fishing pressure. When or if this is achieved, a further reduction of fishing mortality would probably be required in order to fully take into account all other ecosystem components.
Green paper – a basis for reform of the Common Fisheries Policy

Ahead of the planned reform of the Common Fisheries Policy (CFP) in 2013, the European Commission has produced a Green paper which is intended to serve as a basis for discussions starting in 2009. The Green paper notes that the outcome of the reform in 2002 has been modest and that the overall aim (achieving sustainable fisheries) is far from having been achieved. Long-term plans have, however, been adopted for a number of stocks, and the creation of regional advisory councils has considerably increased commitment and communication between fishermen and other stakeholders.

In its Green paper, the European Commission lists five structural failings (in italics) of the current CFP, as well as a number of related issues and possible amendments to the forthcoming CFP:

– **Fleet overcapacity.** Are one-off scrapping schemes more efficient than multiyear scrapping programmes? Could rights-based systems such as individual transferable quotas (ITQ) be a cheaper and more efficient means of eliminating overcapacity?

– **Imprecise policy objectives resulting in insufficient guidance for decisions and implementation.** The lack of any priorities for objectives regarding ecological, economic and social sustainability needs to be dealt with. Ecological sustainability must be the point of departure.

– **A decision-making system that encourages short-term decisions.** Less detailed regulation by the Council and Parliament, which should instead focus on principles: the Commission and/or the industry should be responsible for implementation. Increased regional decision-making, the Advisory Committee on Fisheries and Aquaculture and the Regional Advisory Councils should be further developed.
– A framework that does not give sufficient responsibility to the industry. The fishing industry should be given more responsibility and rights. The burden of proof should be changed so that the industry has to show that it acts in a responsible manner in return for access to fishing.

– Deep-rooted disregard for the regulations. What should be done to increase the general willingness to comply with the regulations?

The Committee on the Environment and Agriculture of the Swedish Parliament agrees with most of the Commission’s opinions on failings of the fisheries policy. The Committee highlights a few points that it considers especially important, for example, that subsidies are abolished and that regional decision-making is made possible.³

International experience

Experiences of fisheries management in three countries – Canada, the USA and Norway – show that in order to succeed, fisheries management must be adapted to the conditions and area in which it is to be applied.⁴ Control of and compliance with the regulations are crucial, but factors such as trust, dialogue and transparency in decision-making processes are also important for well-functioning and efficient management. It is important that the various actors involved in management share an interest in maintaining an ongoing dialogue. Another condition is that the actors share information with each other and have a good understanding of their commitments. Decisions are often taken far from the actual fishing activities, which is why regionalisation could be a key to more successful management.

⁴ “Best practices” for fisheries management, Baltic Sea 2020.
The Baltic Sea seems a highly suitable area for working on a more regional basis with fisheries management. There is a long tradition of multilateral dialogue in the region, and thanks to the Baltic Sea Regional Advisory Council (BS RAC), dialogue between fishermen and other actors has already been initiated. The improvements in the status of eastern cod stocks that are currently taking place provide a good opportunity for introducing regional management. As regards Baltic cod and its management, it is primarily important that the existing recovery plan is followed.

**Trust and cooperation**

A questionnaire revealed that fishermen had low levels of trust in those who have the main responsibility for information about the status of the sea. This affects the legitimacy of the decisions and, in the longer term, compliance with regulations. There is a need for greater openness, transparency and opportunities to exert an influence when decisions are taken. The users need to be able to feel confidence and trust in the agencies and institutions that take the decisions, and thus affect their existence. This will lead to greater understanding and acceptance of regulations. In order to bring about a common view of the problems associated with the fishing industry, all the relevant actors need to be made aware of the risk that stocks may be depleted to such a level that continued fishing is no longer economically or ecologically sustainable. Trust and a common view of the problems, where fishermen, researchers and those responsible for management agree, is therefore necessary.

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5 Sverker Jagers, ”Svenska Fiskbestånd – hur ska de förvaltas” [Swedish fish stocks – how should they be managed?], seminar at the Swedish Parliament, 14 April 2008.
**Shrimp-fishing in the Gullmarn fjord – a successful management experiment**

Shrimp trawling in the Gullmarn fjord was prohibited in 1989 after claims that it caused great damage to the ecosystem. Examinations showed that there had been some impact, but that this could be reduced by limiting the size of the gear. From 1999, fishing in some parts of the fjord was permitted with lighter trawl doors and with smaller trawls equipped with a sorting grid. A maximum fishing limit of 100 days per year was introduced and between five and eight trawlers participated. The small gear and the absence of by-catches helped to increase the quality of the shrimps and thus the price. The fishermen decided to use a larger mesh in their trawls (45 mm) in order to increase long-term profit. Access to this attractive fishing was limited in 2004. Six boats now share the 100 fishing days. They feel a responsibility for “their” stocks and plan to test a further increase of the mesh size and to introduce a fishing ban in the spring, when the shrimp hatch their roe and moult. The fishermen expect thereby to get larger shrimps of better quality and higher prices.

**Scenarios for some of our commercially important species**

A one-day scenario workshop was held in June 2009, with the purpose of highlighting possible future scenarios for commercially important fish stocks. Six experts\(^6\) took part in discussions on central issues for a handful of commercially important fish stocks: cod, herring and

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\(^6\) Michele Casini, The Swedish Board of Fisheries, Anna Gårdmark, The Swedish Board of Fisheries, Olle Hjerne, Stockholm University, Christian Moellmann, Institute for Hydrobiology and Fisheries Science, Hamburg, Stefan Neuenfeldt, Technical University of Denmark, Bengt Sjöstrand, The Swedish Board of Fisheries.
sprat. Materials on vendace were submitted after the workshop. Below follows the conclusions of the discussions (discussions as a whole are found in 2009/10:RFR2, in Swedish).

**How can the economic yield be optimised?**
- If the direct economic yield alone is taken into consideration, cod stocks should be as large as possible, but socio-economic values of different fisheries e.g. sprat/herring should also be taken into account.
- A number of factors may affect the profitability of future fishing: the price of fish (in Sweden and in other countries), the price of fuel, management of stocks and changes in patterns of fish distribution due to policy decisions and environmental factors.

**A growing seal population and its impact on fish populations**
- With a larger seal population, size-selective predation on herring, sprat and cod will have a potential impact on these stocks.
- If we manage fish stocks we can afford larger seal stocks.
- The management of seal and cod stocks should be coordinated.

**How will the cod population be affected by increased sprat fishing?**
- Our current knowledge of the central Baltic ecosystem indicates that reduced sprat stocks may affect cod in a number of positive ways.
- Model simulations predict however that increased sprat fishing alone is not sufficient to shift the food-web from the current cod-depleted state, because cod fishing mortality is still too high.

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7 Written by Johan Modin, *The Swedish Board of Fisheries.*
These simulations show that cod stocks will only be able to recover if increased sprat fishing is combined with a reduction in cod fishing mortality compared to the high levels of 1996-2005.

Reduced fishing pressure on cod, leading to larger stocks, may be enough to reduce sprat stocks (see also discussion below on sprat).

**How will the cod population be affected if trawling is replaced by gillnets/hooks?**

In Öresund, trawling has been prohibited since around 1930, due to reasons of maritime security. The length distribution of cod in Öresund shows that stocks have considerably better size class distribution than in the Skagerrak and the Kattegat (Figure 4).

**Figure 4** Number of cod caught per trawled hour distributed between different size classes in Öresund, the Skagerrak and the Kattegat (data from RV Argos, March 2009). A total of 44 cod per trawling hour were caught in the Skagerrak, compared with 27 cod/hour in the Kattegat and 3,621 cod/hour in Öresund.
− Switching from trawling to gillnets would generate a more selective fishing mortality and entail positive effects for cod stocks.

− Due to the narrower selectivity range of gillnets and hooks, discards of juvenile cod are generally considered to be lower than in trawling.

− As an additional bonus, the use of longlines reduces the impact of fishing on species composition and habitats, incorporating the objective of preserving ecological functions and services. Similar effects can be expected using other gear where catchability is directly related to stock size, such as baited gear, e.g. baited cod traps.

− The main disadvantages of gillnets would be that they may be lost in bad weather yet continue to catch fish (“ghost fishing”).

**What effect will modified fishing gear and changed mesh size have on the cod population?**

− Increased mesh size can have a positive effect on a cod stock, but needs to be coordinated with other stipulations, such as minimum landing size, to generate the desired results.

− However, the potential negative effects of higher fishing pressure on large cod individuals need to be studied.

**Marine protected areas – what effect would they have on the cod population?**

− As Baltic cod are considered to be highly migratory, marine protected areas (MPAs) would need to be large and long-lasting for efficient protection, or to be accompanied by a decrease in TAC.

− Currently the effects of MPAs are uncertain and further study is needed if they are to become an effective instrument for fish stock preservation.
− The situation is different with regard to the closure recently implemented in the Kattegat to protect the local cod stock. In this case, a closed area may be an effective instrument for directing fishing effort away from the severely threatened Kattegat stock towards the part of the North Sea stock also found in the area.

**What are the effects of a growing cod population on herring and sprat stocks in the Baltic?**

− When cod stocks recover, predation pressure on sprat and herring will increase.

− Model calculations predict that changes in stocks will be both rapid (on a time scale of five years) and long-lasting.

− The effects on stocks will depend on the extent of overlap between the distribution of cod and clupeidae (herring and sprat).

− In general, it is difficult to predict how herring will be affected by an increase in eastern cod stocks.

− The management of cod, herring and sprat should be coordinated. Coordinated management would require advice including indications of the effect of one fish stock on another, for example how fishing of one stock affects other stocks (which is not included in the regular advice provided by ICES today).

**How are herring and sprat populations affected by increased fishing pressure on cod?**

− In the long term, sprat stocks will increase, which can reasonably be assumed to cause a decrease in herring stocks due to increased competition.

− Short-term effects (five years) depend on natural variability in seasonal conditions for cod recruitment.
Cod has a controlling role affecting the whole ecosystem - thus, successful management of cod is of crucial importance.

The effect on herring and sprat populations is dependent on the levels of mortality caused by the fishing of the Baltic cod stock, which is surrounded by uncertainty. The 2008 estimate of fishing mortality for cod is highly uncertain.

How will a probable climate change affect populations of cod, herring and sprat in the Baltic Sea?

- What has decisive impact on cod, herring and sprat up until 2020 is fishing, not climate change.
- In the long term, it is important to adapt fisheries management of cod to expected changes in environmental factors that can be expected as a result of climate change.
- A potential increase in temperature is not expected to have any direct effect on cod stocks. Water temperature is, however, an important factor for the recruitment of both herring and sprat.
- It must however be kept in mind that the three fish species have a significant effect on each other and in order to be able to draw conclusions on climate change a large number of simulations of future climate scenarios are required.

How will a probable climate change affect vendace populations in the Baltic?

- Potential climate change may affect vendace in the northern Baltic in several ways:
- As a result of earlier break-up of ice, the production of food will begin earlier. It is therefore possible that the time when the larvae hatch will be less well synchronised with the production of food, which will result in new year-classes of vendace possibly being smaller in the future, as compared to today.
- Increased precipitation and run-off will result in lower salinity. Lower salinity will affect species composition of organisms that constitute potential food. It is unclear today how this scenario will affect vendace populations.

- Lower salinity and increased winter temperatures will favour species such as perch, which eat vendace larvae and juveniles, which may result in fewer larvae surviving to maturity.
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