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The EU Concerted Action on **S**tock **A**ssessment and **P**rediction (SAP): Aim, Procedure, Results

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Abstract

From 01 January, 1998 to 30 April 2001 scientists from 18 European fisheries research institutions worked on the tasks of the EU Concerted Action "Sustainable Fisheries: How can the scientific basis for fish stock assessment and prediction be improved? (SAP)".

Aiming at utilizing existing and potential knowledge for such an improvement, the participating scientists from different disciplines

- identified sources of errors and main causes for shortcomings in present fish stock assessments and time horizon limits of the predictions,
- discussed physical and biological processes including their possibilities of prediction which set limits via the parameter's influences on predictabilities in fish abundances,
- looked for existing scientific knowledge of the physical and biological environment, of the population dynamics and multi-species effects which is potentially useful for fish stock predictions,
- conducted case studies on the knowledge and the gaps for selected fish stocks in the major geographical areas of the European waters,
- evaluated, tested, and compared used assessment models.

The published literature was scrutinized, long time series of physical and biological data identified, own investigations were made. The implications for fisheries management were part of the discussions.

From these results future research towards the main goal of the concerted action are proposed. Suggestions are given to minimize or to overcome the identified shortcomings in the cooperation and communication between the "northern" and "southern" European fisheries institutions.

The concerted action was ended by an international symposium with contributions to all its tasks. A few examples of these are given here.

Even if they are only demonstrating the gaps in the knowledge about life history of fish species, all contributions aim at improving the scientific basis for stock assessment and prediction by taking into account e.g. environmental parameters and thus give a better advice to the fisheries administration in the cycle of an adaptive management for sustainable fisheries.

Background

In 1902 ICES was found *to be prepared for a rational exploitation of the sea on a scientific basis*. That means: International cooperation in sciences relevant for fisheries should establish the basis and procedures for maximum catches from fish species in optimum stock conditions in the fishing areas of the ICES member countries.

Through about 10 decades scientists edited volume-rich sequences of journals and lots of monographs as well as established databases of different kinds to provide fisheries administration and fishermen with useful advice and information within the periodical cycles of adaptive fisheries (Fig. 1). However, all the exchanges of advice, management actions, and data collecting and integrating did not lead to more or less continuously good stock conditions. Thus, more precise assessments basically for the scientific advice were and are urgently necessary.

In the European countries actually growing together there are quite different situations in the fishery research institutions on behalf of data bases for stock assessment: Generally speaking, there is a North-South-Gradient in data availability and quality.

Additionally, lots of measured but unused parameters in fish stock dynamic and environment exist in European marine institutes and fisheries research centers. Further on, up to recent times none of the stock assessment models directly used environmental parameters for calculations. The data mentioned as well as the methods hidden in the mountains of literature perhaps may help to solve the problems in insufficient stock estimation and may help to flatten the North-South-Gradient when they are used in improved stock assessment models.

Thus, inside "The European Community Specific Programme for Research, Technical Development and Demonstration in the Field of Agriculture and Fisheries 1994-1998" the Commission of the European Community financed a Concerted Action titled: "Sustainable fisheries. How can the scientific basis for fish stock assessment and prediction be improved? (SAP)". Coordinated by Prof. Øyvind Ulltang, assisted by Dr. Geir Blom, from the Department of Fisheries and Marine Biology of the University of Bergen (Norway) the Concerted Action lasted for the period from 01.01.1998 to 30.04.2001. The total costs were 550 thousand Euros, which in total were contributed by the EU.

The participants of the Concerted Action were from larger university and governmental fisheries research institutions in the EU, Norway and Iceland (Table 1) to cover all the European waters (Fig. 2), to have access to the state of the art in the different marine disciplines and to data sources, and to work inside national benevolence. Special experts from Canada and USA were invited to participate (Table 1).

The aim of SAP

An EU Concerted Action differs conceptually from a "project": It is not to bring up primarily basic scientific result, but to prepare the fundaments for potential future projects by data path finding and evaluating, method comparing and/or literature scrutinizing.

Thus, the participants of the EU Concerted Action SAP had to:

- examine how existing scientific knowledge can be better utilized for reducing the uncertainties of fish stock assessments and for increasing the time horizon of these assessments carried out by ICES and other stock assessment agencies/institutions. This includes the evaluation of the implications of the improved assessments and predictions for the fisheries management.
- investigate whether existing oceanographic and biological time series, or other available data – meteorological, river runoff, nutrients etc. – can be used for testing theories which would expand the scientific knowledge relevant for fish stock assessments.
- propose future coordinated research on stocks in all EU and adjacent waters.

The proceeding of SAP

Related to the different disciplines and geographical areas they came from, the SAP participants worked in thematic groups called Topic Working Groups as well as in geographical area groups, the Area Working Groups (Table 2).

The detailed investigation program contained the following tasks and subtasks (Table 3) as formulated in the Working Program of the contract.

In **Task 1**: *Shortcomings in fish stock assessments*, the sources of errors in the present stock assessments and the limits on time horizon of predictions from the ICES Assessment Working Group Reports and other assessment reports were to identify.

Dealing with **Task 2:** *Limits on predictability*, the working groups had to consider e.g. the limits set by nature on predictability of fish stock development by critical review of published literature and, by chance, by own complementary simulations from the fields of the sub-tasks.

Task 3: *Scientific knowledge potentially useful in fish stock predictions* was one of the main parts of the Concerted Action. By scrutinizing the published literature in the fields of physical and biological environment, population dynamics and their modeling, multi-species effects, and the implications for fishery management, it was to identify that part of already existing knowledge which is not effectively used at present for fish stock assessment and prediction. From these discussions future coordinated research topics were to propose.

Within **Task 4**: *Case studies* the participants had to summarize the substantial research which has been done up to now, and was to demonstrate the potential for improvements in quality and time horizon of stock predictions for key fish stocks or fish stock complexes in the SAP-areas.

Task 5: *Scientific communication and cooperation* was to propose how the communication and cooperation between fish stock assessment experts and experts of other marine sciences can be improved, and how communications between experts working in the different geographical regions may improve understanding and quality of their work.

This schedule was to work off during six SAP meetings, each in one of the member countries (Table 4) and paid by the EU contribution. During the periods between the meetings the literature reviewing, the evaluation of the different kinds of time series, the assessment tests etc. in the institutes at home were done without special pay.

The last SAP-meeting was followed by an International Symposium on *Fish Stock Assessments and Predictions: Integrating Relevant Knowledge* in December last year in Bergen (Table 4). It was supported by NAFO, ICES, and the city and the university of Bergen.

The final SAP-report will be available soon. The symposium contributions are in a reviewing process to be published as a special issue of "Scientia Marina". By means of very few glances this paper will address to these voluminous printings.

On the results

Task 1

To get hold of the *shortcomings in fish stock assessments* for the main important stocks of the SAP-areas (Fig. 2) the available data, conceptual models, stock-dependent processes, multi-species processes, and environmental effects were tabled and evaluated on importance and error sources, respectively. Summarizing, main shortcomings were as follows:

In **Area 1** (Norwegian Sea, Barents Sea, and Icelandic Waters), the lack of data for the real catch including the discards, as well as gaps in weight-, maturity- and natural mortality-at-age have led to errors of unknown sizes in the time series of recruitment and spawning stock biomass for **Northeast Arctic Cod**.

The **Icelandic cod stock** has been studied extensively with regards to assessment methods, multi-species effects, stock structure, population dynamics and long-term utilization. No larger shortcomings were found for this species.

At the moment, the assessments of the reduced **Northern cod stock** are only based on research surveys. Due to the recovery still standing out prediction is not able. An improved understanding of the effects of climatic variation is valuable.

For **Norwegian spring spawning herring,** the large stock variations during recent years caused problems in the assessments. Short and incomplete data time series generate wide ranges of uncertainties of the abundant year-classes and in predictions.

In **Area 2** (North Sea, Skagerrak/Kattegat, and Baltic Sea) the main problem of many species is the low quality of the catch data: Misreporting, variable discards; mixtures of species in industrial fisheries are the reasons.

Data from environmental parameters even with heavy influences to the stocks were not taken into account in assessments until now: E.g. the increased mortality of sole due to very cold winter is not quantified sufficiently. However, the calculations for “spawning volume” of Baltic cod will be included in standard assessment in future.

The reaction time of the management due to scientific advice causes problems in this area: E.g. the closure of areas to protect juveniles takes too long time while passing the administration.

In **Area 3** (Mediterranean Sea), there are no regularly stock assessments for the different species with few exceptions. Main sources of error are the quality of official statistics of the commercial catches, un-quantified discards, lack of appropriate size-at-age data, problems of inter-calibration between the research vessels and countries. Environmental effects are not included in assessments of this area.

In **Area 4** (West of the Iberian Peninsula) the main sources of error are the lack of knowledge of the stock units, stock structure and migration pattern, as well as unknown biological data.

Environmental effects are not included in assessments of this area.

All the uncertainties limit the time **horizon of prediction**:

For the coming year a stock prediction is more or less possible for all species in all areas.

Stock sizes of some species, e.g. NE-cod, are predictable for more than 1 year. However, for a period of more than 3 years a prediction is impossible for all the species at the moment.

Task 2

The variability of the marine physical environment and its effects on fish stocks is part of the reasons for the variability of fish catches and abundances. Thus, these effects are **limits on predictability** whilst the dominant phenomena are different in the SAP-areas (Table 5):

Water temperature was found to be a key parameter with a large influence through all trophic levels in the regions of the North Atlantic ecosystems. The strongest response of fish stocks to temperature changes has been documented in the Barents Sea. Reasons may be that the changes in vital rates per degree Celsius for most fish stocks is much larger at the lower temperature ranges, or that the interannual fluctuations of temperatures are weaker in the southernmost part of the SAP area, i.e. the Mediterranean Sea.

Advection of specific water masses from outside influences ecosystem features, thermal structure, and fish stocks productivity. E.g., in the Barents Sea and in the northern North Sea, inflows of Atlantic water masses have been observed to effect plankton production. Via this, the temperatures along the Norwegian Coast are in use for estimations of next cod, herring and capelin recruitments. In the northern North Sea, the Norwegian catches of horse mackerel depend on the Atlantic inflow into this area (Fig. 3). The inflow of more saline water into the Baltic Sea strongly influences the vertical salinity structure and oxygen conditions, and, hence, the habitat extent and survival of cod and herring eggs and larvae.

In the southern North Sea the ecosystem is less influenced by the Atlantic inflow, but **tidal mixing** and **winter cooling** play more important roles. E.g. very cold winters have a double influence on the sole stock: Firstly, with increasing cooling the adults migrate and concentrate in larger depths. This causes large catches and high fishery mortality. Additional mortality increase results from skin vulnerability by the cold water. Secondly, the ice in the Wadden Seas, the later sole nursery areas, diminishes the predators on sole causing good survival rates of the juveniles. Both influences result in good recruitment of a reduced stock.

The near surface **inflow of less saline Atlantic water** into the Mediterranean Sea has a lower nutrient concentration than the more saline deeper water flowing out of the Mediterranean. The vertical nutrient difference is a major responsible factor for the oligotrophy of the Mediterranean Sea.

The area west of the Iberian Peninsula differs from the other regions with its direct contact to the Atlantic Ocean. The **upwelling** induced vertical transport of nutrient-rich water masses from lower layers provides the strongest influence on production in this area and reduced sardine recruitment.

The atmospheric **North Atlantic Oscillation** (NAO) influences ecosystems in all regions of the North Atlantic, but in varying degree. The most obvious climatic effects on the ocean during periods of high positive NAO index are increased wind mixing in the Northeast Atlantic, increased advection of Atlantical water masses, increased winter sea temperature, and anomalous wet conditions in the northern and anomalous dry conditions in the southern European areas.

Thus, at least larger parts of the physical influences mentioned above origin in the documented ecosystem effects of the NAO: In the Barents Sea and in the North Sea strong positive NAO seems to increase the inflow of Atlantic water with influences on the advection of copepods and subsequent influences on fish production; in the Baltic Sea there is an inverse correlation between the NAO and the ice cover with effects on egg and larvae survival; in the Northwest Mediterranean Sea, the NAO is negatively correlated with river runoff in some of the European rivers which influences the local phytoplankton production and in turn influences growth in small pelagic fish; off the Iberian Coast a strong NAO+ results in increased coastal upwelling and in reduced sardine recruitment.

Task 2 and Task 3

The extensive discussions on the *Variability of fish catches/abundance*, on the *influences of environmental parameters on fish population dynamics* including the species interaction and the *scientific knowledge potentially useful in fish stock prediction* may be characterized by the following basically parameters (Table 6):

The influences of temperature, food quality and availability, and environmental heterogeneity on **growth** in fishes are high. These factors have an important and significant effect on the assessment and the dynamics of fish populations. Density-dependent influences on growth are probably important and can have significant considerations for the assessment process.

Patterns of **maturity** are primarily influenced by variations in growth rates and hence by temperature, food, and environmental heterogeneity. The influence of condition on maturity is strongly apparent in some populations. However, in many cases dedicated studies of the process underlying do not exist.

The direct link between **feeding,** growth, and maturity is evident.

Concerning **recruitment**, predation, feeding, and transport or advection have an influence on the dynamics of pre-recruits. The question of how such information can be collected and implemented into routine population evaluations represents an area of future critical research.

In **mortality**, fishing, predation and in some cases cannibalism play important roles. Episodic events, such as those associated with disease or parasites, can also have a dramatic influence on population abundance and the assessment process. Extreme environmental conditions, e.g. the severe winters in the southern North Sea, intensify stock reductions.

Task 4

On the basis of these results, case studies connected the present knowledge and the gaps in this knowledge as well as the literature corresponding for selected species from the SAP areas (Table 7). Some examples from the study on North Sea plaice may outline the type of information combined:

- Among the current information used in ICES stock assessments (ICES 2001) the proportions of fishing and natural mortality before spawning is considered as annually unchanged. In future, this has to be altered to more realistic values.
- In plaice assessments 50% maturity is assumed for ages 2 and 3 and full maturity thereafter. At least for females, this is not realistic (ICES 1999). This parameter has to be changed into sample-based maturity values.

- Comparison of VPA-output versus survey-results as used by assessment working groups reveals that the various surveys represent the recruitment fluctuations fairly well (Fig. 4).
- For explaining the variability in the SRR for North Sea plaice only a few surveys covering the early life stages are available from earlier years. Egg and larval mortality gives a good predictor of future year-class strength. Thus, egg and larvae surveys have to be reactivated or other methods may be used for describing the SRR variability, e.g. drift modeling.

Proposals for future research and prediction in terms of time scale

The shortcomings identified in task 3 and during preparing the case studies resulted in proposals for future research.

- E.g., for improving predictability, the processes behind the relationships used for predictions must be understood better. Thus, relevant meteorological time series should be analyzed with respect to governing periods or pressure field variability like NAO. Time series, which include data of air-sea interaction on the thermal regime of the regions, should be generated.
- Models are to be used to produce sets of variables valuable for prediction. E.g., current measurements from the southern North Sea from different periods, at different positions could be enlarged to long-term 3-dim transport data for use in egg and larvae transport prediction. Feeding and survival of eggs and larvae should be investigated further by field experiments and models. Further models should be used to estimate zooplankton production on the basis of survey results.
- For better understanding and prediction of the processes that affect the recruitment dynamics, comparative approaches and model simulation are recommended for key species.
- Simulations based on realistic structural relationships should be used to assess how environmental and regional specific information can be used to predict the impact of management actions.
- On behalf of improving the assessment modeling, it was recommended to evaluate the utility of ad-hoc management procedures against analytical assessments for TACs and effort management regimes in different areas, to evaluate the use of ecological models in fisheries management context, and to develop operational models which predict the effects of management actions on the biological, economical and social goals of fisheries.

Three types of predictions in terms of time scale were defined:

1. Short-term (e.g. TACs, catch),	1 - 3 years
2. Medium-term (e.g. SSB, weights-at-age, catch)	5 - 10 years
3. Long-term (e.g. SSB)	10 - 30 years

Task 5

Due to the differing research and data situations as well as the regional competence in investigation, coordination, and stock assessment in Europe, there is need to improve the scientific communication and cooperation. It is suggested to install a ***S**ustainable **F**isheries **R**esearch **O**rganization* (SFRO) similar to an organization model discussed in the ICES Bureau in 1998. This might develop and co-ordinate research in the fields of:

- Fisheries biology
- Environmental interactions
- Models and statistical methods
- Economics, social, legal and political science
- New methods of sustainable management.

As a first step and paid by special funds, scientists of natural sciences and mathematical modeling could be "bought" from their home institutions for a limited period of time (e.g. some months); experts for economic, social, legal and political sciences could be added on necessity. The specific investigations are to be specified by this organization in close cooperation with ICES and the national research centers.

Additionally, there is a particular marine science problem inside Europe while growing together: ICES is the center for investing the northern and middle European waters and their fish stocks. ICES exclude the Mediterranean areas. Cooperation across subjects and regions may be like this:

- Mediterranean fish stock will be included in assessment and advisory work of ICES (if the Mediterranean countries do wish so).
- The General Fisheries Council for the Mediterranean (GFCM) and ICES establish joint working and study groups; the groups of both, GFCM and ICES, invite the members corresponding to their meetings.

Further on, the understanding of modern stock assessment models is mostly limited to a small priesthood of experts. They have to devote more effort to explain what they and their models are doing besides the "number crunching" supposed by the atheist. And an increased number of biologists in the assessment working groups have to improve the biological understanding of all the members in these groups.

Symposium

The contributions inside the structuring sessions of the Symposium on *Integrating Relevant Knowledge for Fish Stock Assessments and Predictions* (Table 8) mirrored the topics of the Concerted Action.

In his review on the *State of the Art of Stock Assessment* the keynote speaker Ray Hilborn (USA) pointed to the necessity of high data quality and the understanding of the biological processes as the base of sophisticated assessments.

One of the existing *Shortcomings in Fish Stock Assessment* was addressed by Jordi Lleonart in his *Mediterranean perspective*. The Mediterranean fisheries are characterized by fragmented fleets of usually small vessels, large number of landing sites, multi-species catches, low CPUEs. There are problems with market sampling. No TACs exist. The stocks on the narrow shelf are shared by more countries; no sufficient international management exists; regularly assessments were made only during recent years. Thus, at the moment, in the Mediterranean Fisheries there is no real advice from science to management, no effective management actions exit, and scientists get only few data from the fisheries. That means in contrast to the aim given in Fig. 1: For most stocks of the Mediterranean Sea there exists no yearly adaptation of the fishery to the stock situation. Lleonart called it Sustainable *Over-fishing*, which is to change during the next years.

In the sessions on *scientific knowledge potentially useful in fish stock predictions* recent improvements were presented. E.g., Rainer Oeberst and Martina Bleil asked: *Can we be faster with the estimating of the recruitment than the Belt Sea cod stock with the spawning?*

During the last years, this cod stock produced very different year-classes. Up to now the first estimates of the new year-class strength come from trawl surveys: In November for the age group 0 and from February for assessing the age group 1. The estimated data are available about one year before the year-class enters the commercial fishery.

The year-class strength of this stock is mainly determined by the highly variable portion of female cod of a maturity stage more than 2 in March. Analyses of the temporal development of the Belt Sea cod maturity showed that a trawl survey in March for estimating the portion of the active female spawners and the amount of eggs produced, can be used for a first estimate of the coming year-class strength with acceptable accuracy. These data are available before the spawning period of the Belt Sea cod ends, roughly two years before the year-class will enter fisheries.

Environmental influences to the stock support the early year-class estimation: The large variations in the portion of active female spawners appear to be influenced directly by the seasonal temperature decrease as well as by inflow events during the pre-spawning period and indirectly by the distribution of the age-1-group herring. Additionally, the inflow events cause stronger year-classes by increased development conditions of eggs and larvae.

An *Improvement in the scientific basis of fish stock assessment and prediction* seems to be the development of *FLEKSIBEST – an age-length structured model* by Kristin Guldbrandsen Frøysa and Bjarte Bogstad.

FLEXIBEST is a single species model. It is fitted to the data quality: The reported catch numbers are assumed to be not exact. The model addresses year-to-year variations in mean length-at-age for Northeast-Atlantic cod and other boreal stocks. The biological processes are modeled as functions of length, not of age as, e.g., in XSA. The comparison of the results from FLEXIBEST and XSA reveals (Fig. 5): The new model seems to give a more dynamic stock development and its results are in better accordance with survey results.

As an example from the *Case studies on improvements in quality and time horizon of fish stock prediction* is the review in literature *Physical influences on the stock dynamics of plaice and sole in the North Sea* by Gerd Wegner, Ulrich Damm, and Martin Purps.

E.g., for plaice, the first estimations of recruitment may be taken from surveys on the larvae drifting with the residual current in the southern North Sea and/or from the momentary SST. However, this gives only a coarse estimate, the fine-tuning of the recruitment occurs in the nursery areas, in the Wadden Sea. May be, modeling the larvae drift could give less coarse recruitment information. First attempts with a two-dimensional drift model reveal correlations between tracer particle amount drifted from one of the spawning places to one of the nursery places and the investigated larval concentrations off these nursery areas (Fig. 6). Three-dimensional multi-layer models may improve these estimations.

Or: The growth of the juveniles of plaice inside their shallow nursery areas is highly influenced by the variable meteorological situations. In cases of rapidly increasing temperatures due to high irradiation, the age-0-group tries to escape from the shallowest parts and thus occurs in the brown shrimp fisheries. A long time series of regularly by-catch sample give information of the variability of these occurrences. Comparisons with the variation in sky cover (Fig. 7) as a NAO-coupled approximation for irradiation do not show the expected correlations. Thus, there must be further – unknown – influences that cause the young plaice to leave their nursery areas.

Final remark

During preparing the figures for the SAP-case studies on sole and plaice, the sole catches per age group were to illustrate. Figure 8 gives the time series 1957 –1999, corresponding, and reveals that in former periods at least some parts of stronger year-classes reached ages of more than 10 years. From the recent larger year-classes nominal catches were made up to age group seven. Generally, the year-classes are nearly perfectly cleared away by the fisheries after first or second spawning (or earlier).

More confident stock numbers by improvements from SAP will not change this phenomenon. However, by improved stock assessment and predictions resulting from SAP, a more adaptive fisheries management hopefully will give enlarged quantities of older sole – and other species – a chance to spawn different times inside a sustainable European fishery.

References

FAIR-CT 97-3805: Sustainable fisheries. How can the scientific basis for fish stock assessment and prediction be improved? (SAP).

Technical Progress Report for the period 1 January 1998 to 31 December 1998.
…
Technical Progress Report for the period 1 January 1999 to 31 December 1999.
…
Technical Progress Report for the period 1 January 2000 to 31 December 2000.
…
Minutes of the 1. SAP-meeting, Bergen, 16-20 February 1998.
…
Minutes of the 2. SAP-meeting, Barcelona, 13-17 October 1998.
…
Minutes of the 3. SAP-meeting, Hamburg, 6-10 April 1999.
…
Minutes of the 4. SAP-meeting, Santorini, 31 Aug. – 04 Sept. 1999.
…
Minutes of the 5. SAP-meeting, Mazara del Vallo, 2-6 May 2000.
…
Minutes of the 6. SAP-meeting, Bergen, 28 Nov. – 2 Dec. 2000.
Unpublished Documents.

Guldbrandsen Frøysa, K., and B. Bogstad. 2000. Fleksibest – an age-length structured assessment model. Lecture, Bergen, 6 Dec. 2000.

ICES 1999: Report of the Working group on the assessment of demersal stocks in the North Sea and Skagerrak. ICES CM 1999/ACFM:8

ICES 2001: Report of the Working group on the assessment of demersal stocks in the North Sea and Skagerrak. ICES C.M.2001/ACFM:Y

Iversen, S.A., M.D. Skogen, and E. Svendsen. 1998. Influx of Atlantic water and feeding migration of horse mackerel. ICES C.M. 1998/R:18 (mimeo).

Lleonard, J.. 2000: Shortcomings in fish stock assessment: a Mediterranean perspective. Lecture, Bergen, 4 Dec. 2000.

Oeberst, R., and M. Bleil. 2000. Can we be faster with the estimation of the recruitment than the Belt Sea cod stock with the spawning? Lecture, Bergen, 5 Dec. 2000.

Van der Veer, H.W., P. Ruardij, A.J. van den Berg, and H. Ridderinkhof. 1998. Impact of interannual variability in hydrodynamic circulation on egg and larval transport of plaice (*Pleuronectes platessa* L.) in the southern North Sea. J. Sea Res., 39: 29-40.

Wegner, G., U. Damm, and M. Purps. 2000. Physical Influences on the stock dynamics of plaice and sole in the North Sea. Lecture, Bergen, 5 Dec. 2000.

Table 1: Participants in SAP

No.	Associated contractors	Country	Contact persons
1	Department of Fisheries and Marine Biology, University of Bergen (co-ordinator), Bergen	Norway	Øyvind Ulltang
2	Finnish Game and Fisheries Research Institute, Helsinki	Finland	Eero Aro
3	Universidade do Algarve, Faro	Portugal	Pedro de Barros
4	CEFAS Lowestoft Laboratory, Lowestoft	United Kingdom	R.R. Dickson
5	Instituto de Investigação das Pescas e do Mar, Lisboa	Portugal	Maria de Fatima Borges
6	Institut für Meereskunde, Kiel	Germany	Dietrich Schnack
7	Instituto di Technologia della Pesca e del Pescato, Mazara del Vallo /Sicily	Italy	Dino Levi
8	Instituto de Investigaciones Pesqueras de Barcelona	Spain	Jordi Lleonart
9	Institute of Marine Research, Bergen	Norway	Harald Loeng
10	Science Institute University of Iceland, Reykjavik	Iceland	Kjartan G. Magnússon
12	National Board of Fisheries Institute of Marine Research, Lysekil	Sweden	Bengt Sjøstrand
13	Marine Research Institute, Reykjavik	Iceland	Gunnar Stefánsson
14	Aristotle University of Thessaloniki	Greece	Konstantinos I. Stergiou
15	Departamento de Oceanografia e Pescas Universidade dos Acores, Horta	Portugal	Gui Menezes
16	Danish Institute for Fisheries Research, Charlottenlund	Denmark	Brian R. MacKenzie
17	BFAFI, Sea Fisheries Institute, Hamburg	Germany	Gerd Hubold
18	Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Vigo	Spain	Carmela Porteiro
	Sub-contractors		
1	Keith Brander – ICES, Kopenhagen	Denmark	
2	Jean-Marc Fromentin, Séte	France	
3	Richard D. M. Nash, Port Erin	United Kingdom	
4	Timothy Wyatt, Vigo	Spain	
	Invited experts		
1	Pierre Pepin, St. John’s, NF	Canada	
2	Brian Rothschild, New Bedford, MA	U.S.A.	

Table 2: SAP research and geographical areas

SAP Research Areas:

Topic 1: **Variability of the marine physical environment and its effects on fish stocks**

Topic 2: Population dynamics including species interactions

Topic 3: Population dynamics/stock assessment models, including multispecies models

SAP Geographical Areas:

Area 1: Norwegian Sea, Barents Sea, and Icelandic waters

Area 2: North Sea, Skagerrak/Kattegat, and Baltic Sea

Area 3: Mediterranean Sea

Area 4: Waters west of the Iberian Peninsula

Table 3: SAP Investigation program

Task 1: Shortcomings in fish stock assessments.

Sub-task 1.1: Sources of errors.
Sub-task 1.2: Limits on time horizon of predictions

Task 2: Limits on predictability.

Sub-task 2.1: Variability of fish catches/abundance
Sub-task 2.2: Probabilistic character of physical and biological processes.
Sub-task 2.3: Role of deterministic predictions.
Sub-task 2.4: Probabilistic predictions.

Task 3: Scientific knowledge potentially useful in fish stock predictions.

Sub-task 3.1: Physical environment - plankton and fish.
Sub-task 3.2: Fish population dynamics.
Sub-task 3.3: Multispecies effects.
Sub-task 3.4: Population dynamics models.
Sub-task 3.5: Fishery management.
Sub-task 3.6: Future research.

Task 4: Case studies.

Sub-task 4.1: Barents/Norwegian Sea and Icelandic waters.
Sub-task 4.2: North Sea, Skagerrak/Kattegat and Baltic.
Sub-task 4.3: Areas west of the Iberian Peninsula and the Mediterranean.

Task 5: Scientific communication/co-operation.

Sub-task 5.1: Research Agency
Sub-task 5.2: Cooperation across subjects and regions.

Table 4: SAP-Meetings

SAP-Meetings:		
1.	Bergen, Norway	16 – 20 February 1998
2.	Barcelona, Spain	13 – 17 October 1998
3.	Hamburg, Germany	06 – 10 April 1999
4.	Santorini, Greece	31 August – 04 September 1999
5.	Mazara del Valo / Sicily, Italy	02 – 06 May 2000
6.	Solstrand / Os, Norway	28 November – 02 December 2000
SAP-Symposium:		
	Bergen, Norway	04 – 06 December 2000

Table 5: Larger influences of the physical environment to fish stocks

Temperature:	Everywhere (especially in the Barents Sea)
Advection:	Barents Sea, Northern North Sea, Baltic Sea
Tidal mixing:	Southern North Sea, Irish Sea
Winter cooling:	Southern North Sea
Upwelling:	West of the Iberian Peninsula
Inflow of Atlantic Water into the Mediterranean Sea	
Atmospheric NAO:	In all areas

Table 6: Environmental variability with influences on:

Growth:	Temperature; food availability and quality; environmental heterogeneity; density-dependence; parasites; pollutants; life history; the impact of perceived predation pressure; fishing.
Maturation:	Growth; condition; fishing.
Feeding:	Temperature; food availability; environmental heterogeneity; density-dependence; migration/movement; ontogenetic changes; light regime; water column stability; likelihood of being eaten (predation pressure); fishery discards; pollution.
Recruitment:	Temperature; food availability; predation (including cannibalism); wind stress; egg production (quality and quantity); transport and advection; fishing.
Mortality:	Starvation; fishing; disease; predation; cannibalism; extreme environmental conditions; habitat quality.

Table 7: Species of the case studies:

Norwegian and Barents Seas, Icelandic Waters:	Cod, herring, capelin
North Sea , Skagerrak:	Herring, plaice, sole
Kattegat, Baltic Sea:	Cod, sprat
Mediterranean Sea:	Tuna, hake
Areas west of the Iberian Peninsula:	Sardine, hake

Table 8: Sessions of the SAP-Symposium

Fish Stock Assessments and predictions: Integrating Relevant Knowledge

I: *Assessment of marine fish stocks: state of the art*

II. *Shortcomings in fish stock assessments*

III: *Scientific knowledge potentially useful in fish stock prediction*

IV: *Case studies on improvements in quality and time horizon of fish stock predictions*

V: *Improvements in the scientific basis of fish stock assessments and predictions*

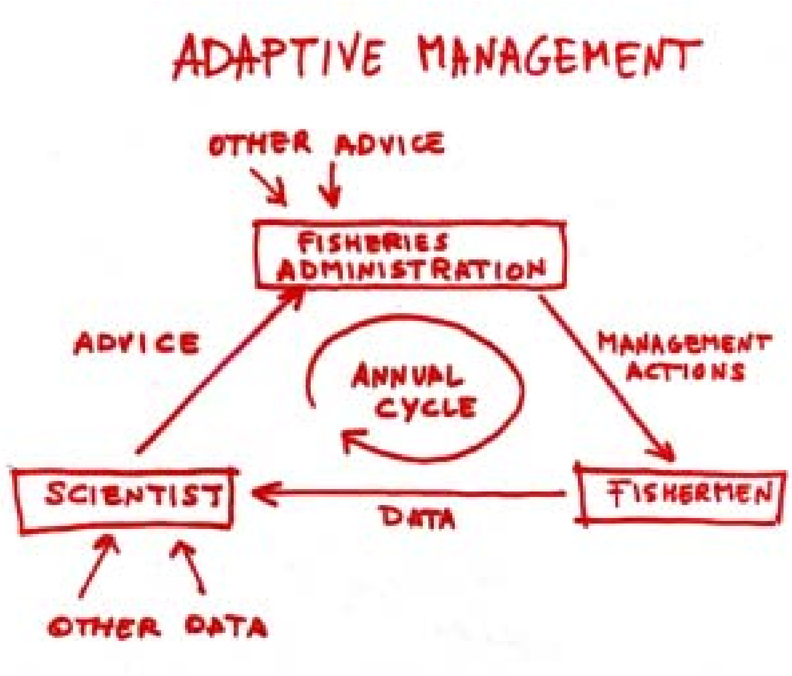

Fig. 1: Adaptive fisheries (from: Lleonard 2000)

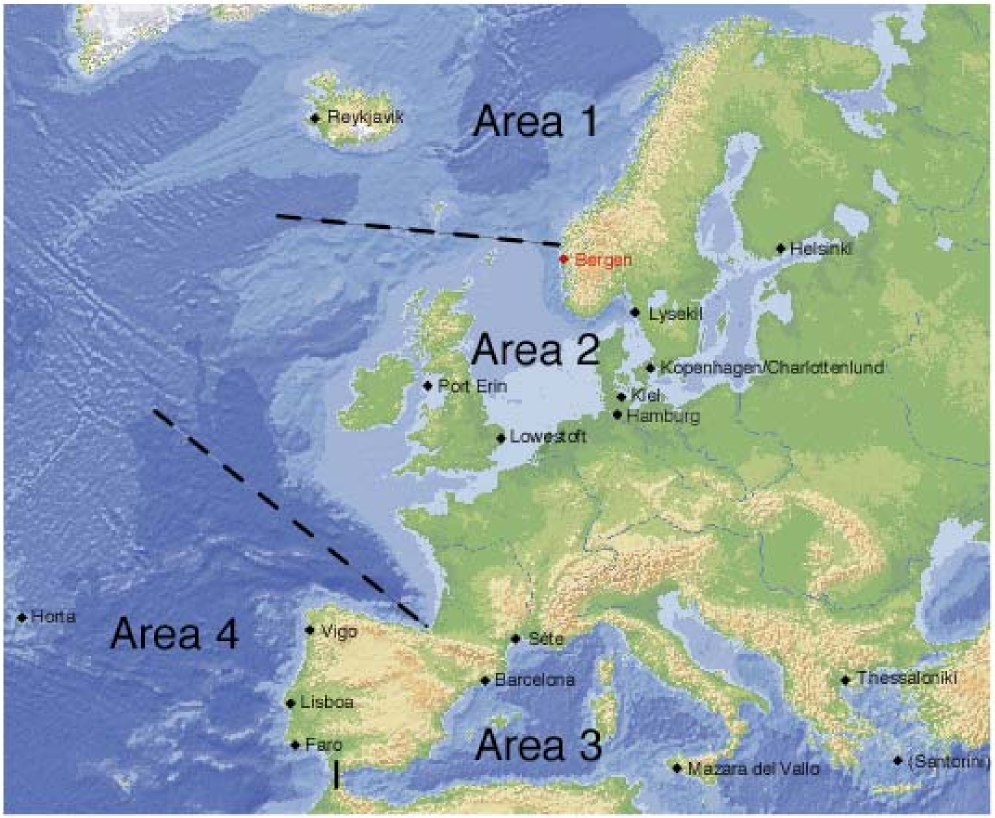

Fig. 2: Regional distribution of SAP-participants and geographical areas

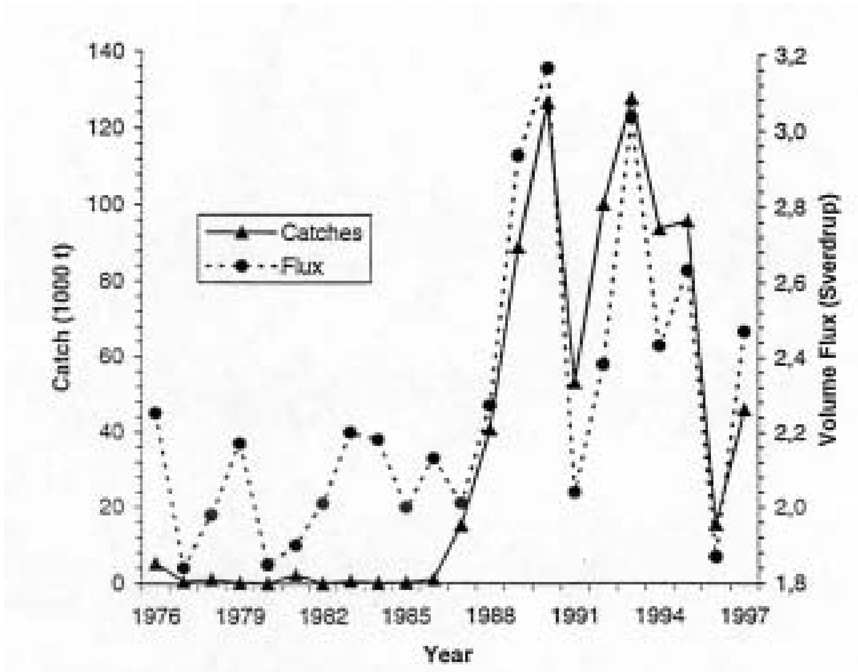

Fig. 3: Norwegian horse mackerel catches and winter volume fluxes of Atlantic Water for the period 1976-1997 (from: Iversen et al. 1998).

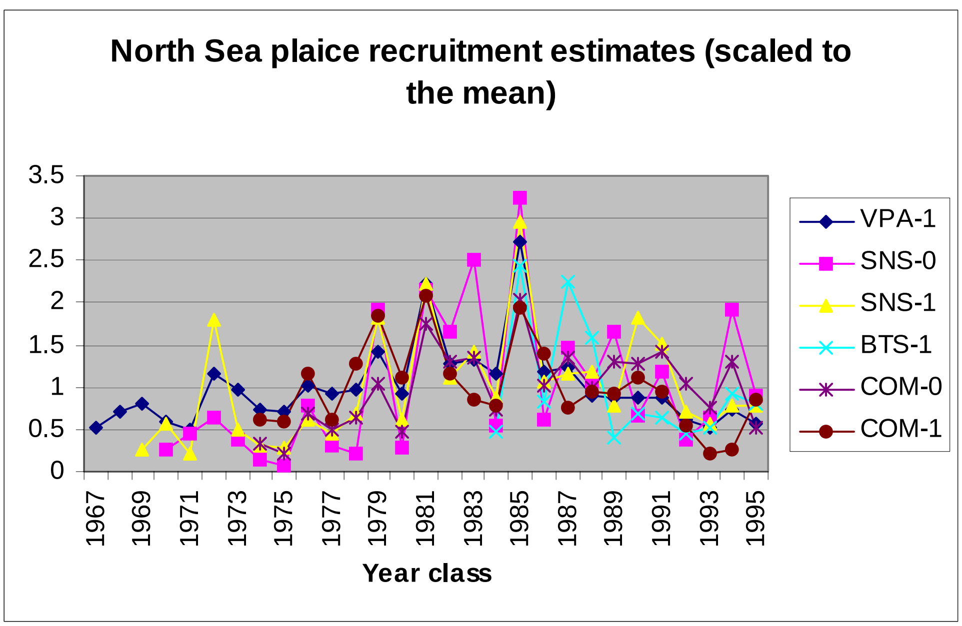

Fig. 4: VPA of North Sea plaice and recruitment estimates based on surveys (source ICES 2001).

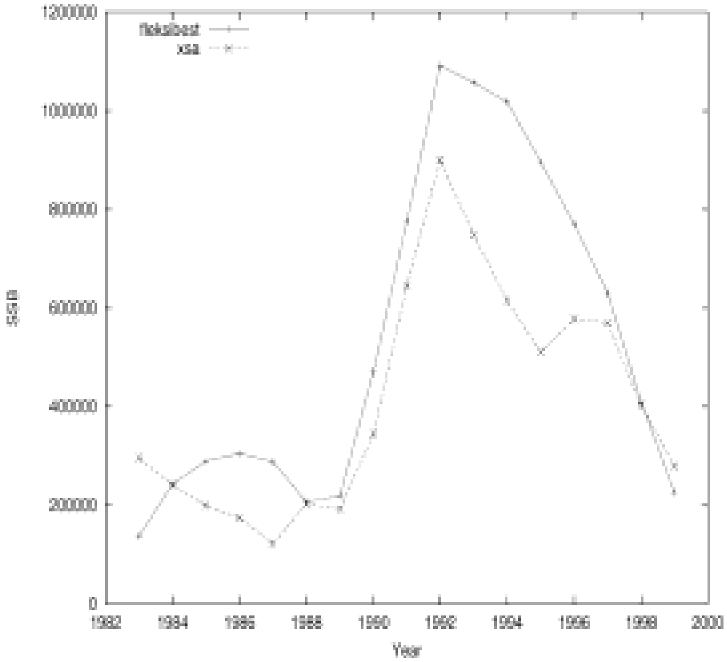

Fig. 5: The spawning stock biomass (in tons) of NEA cod, estimated by XSA and FLEXIBEST (from: Guldbrandsen Frøysa and Bogstad 2000).

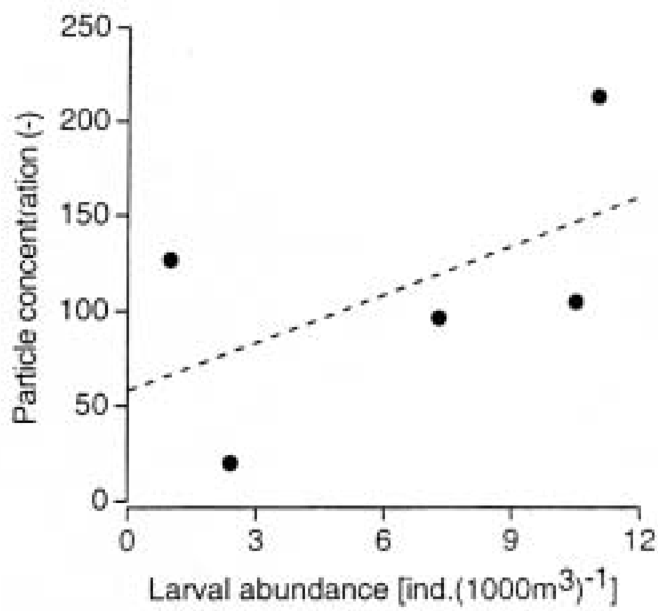

Fig. 6: Theoretical particle concentration and larvae abundance observed (from: Van der Veer et al. 1998)

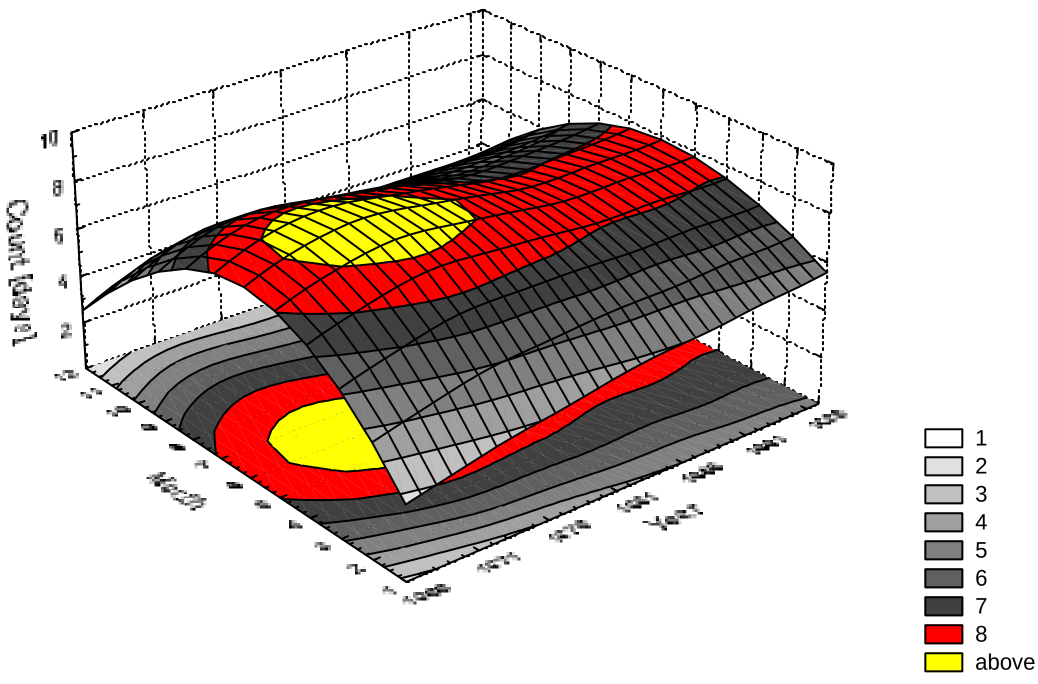

Fig. 7: Number of days with sky cover below 4/8 at Helgoland, 1966-1997.

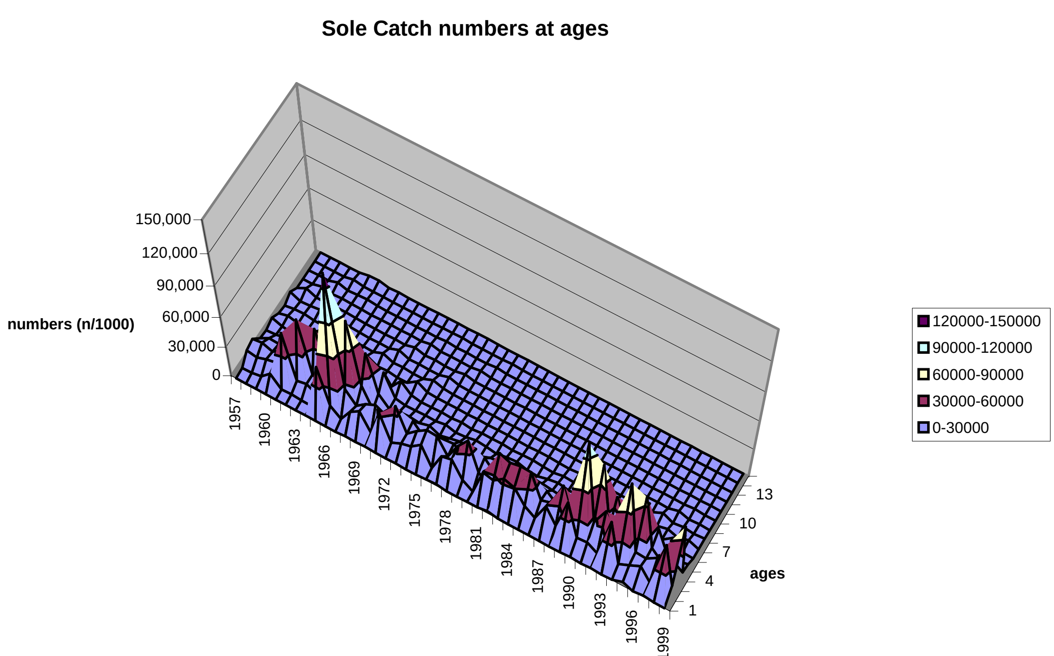

Fig. 8: North Sea sole catch numbers at age, 1956-1999.