Sustainable Aquatic Food Supply

Guidelines for an Interdisciplinary Research Program

Photo: Bruno de Giusti, Wikimedia Commons

Final version,

compilation date: 24.06.2013

Klaus Lucas, Peter Roosen

Generation process
supported by the
Volkswagen Foundation

PREAMBLE

For any major field of future research interdisciplinarity is constitutive for a sustainable approach that is directed to the advance and benefit to the people of Europe. To aid this groundwork process the involvement of organisations focusing on these aspects by their self-conception is most favourable. National and international academies of science and humanities are reasonable entities in this respect.

The notion of interdisciplinarity is not clearly defined. While problem-oriented research generally involves a multitude of disciplines, it is normally characterized by the major part of the work being carried out within the paradigms of each discipline with essentially no challenge of the disciplinary boundaries. This type of approach will be referred to here as multidisciplinarity. Quite frequently such multidisciplinary research cooperation can be observed among natural and technical sciences and also among various branches of the humanities and social sciences, respectively.

Interdisciplinarity in the sense of this initiative, and indeed in the sense of the intellectual profile of academies, reaches farther. It designates cooperation of MINT-disciplines (mathematics, information technology, natural and technical sciences) on one side and SSH-disciplines (social sciences and humanities) on the other. Different from a multidisciplinary research approach it is based on an integration of the various disciplines into a coherent framework of understanding. None of them is hegemonic with the rest being merely auxiliary and advisory, and integration takes place in all phases of the research process. For most societal problems even an enlargement of the group of disciplinary scientists by external stakeholders, from politics, administration, economy and civil society suggests itself. The approach then opens to one that is referred to here as transdisciplinary.

On the basis of extensive experience with this type of research the Berlin-Brandenburg Academy of Sciences and Humanities has started a new initiative with the goal of stimulating interdisciplinarity in European research programs. The guiding idea on which this initiative is based is the conviction that even in technically oriented research programs dealing with sustainable future development such as energy provision, climate change, world nutrition, digital futures and many others knowledge beyond the specialized one of experts is required. In particular, knowledge of organization and guidance as generated in the social and economic sciences and in the humanities should be considered and integrated in an interconnected manner right from the start. Work-sharing specialization, as omnipresent in all branches of the society, has clearly also penetrated the science system, with the consequence of fragmenting it into a manifold of autonomous disciplines and specialized research domains with their individual community cultures. This has produced a considerable increase of expert knowledge. These gains in rationality due to specialization must be conserved while at the same time avoiding a narrowing of the focus that causes high costs and losses of friction associated with the application of pure domain-specific knowledge to the scope of societies.

Unavoidable contradictions in goals and side effects have to be made visible and to be taken into account at an early stage of a research program direction definition by considering a plurality of perspectives. Decisions on the practical implementation of technical research results invariably lead to processes of value weighting and only a broad and critical reflection will allow a constructive handling of them and improve the capability of political acting. Finding optimal solutions to societal problems thus requires a multi-target research initiative in which technical solutions are optimized together with economic, social and ethical considerations in the sense of a Pareto procedure. This is the genuine added value of interdisciplinarity.

Interdisciplinarity in the broad sense referred to here, while generally regarded as a desirable objective, is only rarely put into practice. Unfortunately, it can generally be observed that both widely recognized as well as young scientists are rather reserved with respect to an engagement in interdisciplinary research projects because their reputational and career chances are much more furthered by recognition in their own narrow communities. So there is a need of generating realization strategies towards interdisciplinarity in European research programs and at the same time engaging young scientists in this endeavor in an effort to meet the frequently identified demand for executive scientists, in a way comparable to the coach in a football team or the conductor of an orchestra.

The strategy proposed in this initiative is based on a particular workshop format to be organized as a two-day meeting, embedded by goal-oriented preparation and postprocessing phases under the governance of a steering committee. This committee is composed of members of high authority from various disciplines of sciences and humanities relevant to the chosen topic. Participants of the workshop are limited to about 40 (including members of the steering committee), from which 20 are established experts and the rest young scientists on the post-doctorate level, both from various European countries and with consideration of the full spectrum of sciences and humanities.

The workshop procedure is organized in three phases: the preparation phase, the presentation and discussion phase, and the final compilation phase. In the **preparation phase** established European senior scientists of various disciplines working in the field of the chosen topic are identified and invited to submit short abstracts (about one page) of research suggestions with objectives deemed to be not satisfactorily solvable by exclusively disciplinary approaches. They are evaluated and condensed into a first guidelines draft by the initiative leader and the coordinator with particular emphasis on possible interconnections with other disciplines. This draft is redistributed to a steering committee consisting of established experts in their respective fields. In parallel, invitations for participation in the workshop are sent out, especially oriented at awareness raising in the community of young post-doc scientists in order to encourage an interdisciplinary look on research at an early stage of the career. Participation requires prior elaboration of a research proposal in more detail (about 3 pages) in consideration of the recommendations of the steering committee. The submitted research proposals are evaluated once again, their suggestions incorporated in the guidelines draft, and the result redistributed among the participants before the meeting, representing a multidisciplinary basis of the interdisciplinary research program to be developed.

In the **presentation and discussion phase** the various disciplinary research proposals are discussed, partially flanked by oral presentations during the actual convention. Here the goal is the interdisciplinary analysis and conjunction by the prepared audience, and the identification of discipline-spanning objectives for research. In the **final compilation phase** a manifest is assembled containing coherent research proposals in the field of the chosen topic with strong interdisciplinary aspects.

Contents

1. Introduction

Throughout history oceans have been important to human civilization. They are important factors in the earth's weather and climate systems, serve as a major route of human dispersion, trade and transport, provide important natural resources and represent a significant contribution to recreation and tourism in our days. In modern times, the overall effect of man's interaction with the oceans, although becoming more and more important economically, is clearly non-sustainable. While utilizing the oceans in a variety of ways, mankind affects the marine environment by introducing harmful substances of various origins and by activities that negatively impact ecosystems. As a result valuable natural resources are under threat, among other things, due to over-exploitation.

A particularly important human-ocean interface is represented by the utilization of oceanic bio-resources for human nutrition, such as fish, crustacea, seaweed and a range of others. Global seafood production, by wild catch or mariculture, is the world's biggest single source of protein: presently about 20 % of the total animal proteins used in human nutrition stem from fish. The demand for fish and seafood in general increases at a considerably faster rate than is to be expected from the world's population increase. To match the ever incrasing demand for proteins, the global crisis of overfishing needs to be resolved. The historic assumption of an unexhaustible richness of marine resources (as a precondition of the historic Law of the Sea) has proven to be a fatal misinterpretation of reality in the light of modern fishing techniques. The fishing intensity led to an extreme selection pressure on certain species with the consequence of evolutionary changes and severe impacts on marine food webs, leading to imbalances which may be irreversible.

The earth system is based on cycles, which are overlapping and dependent from each other. It must be clearly stated that any major human intrusion into the sea changes the interdependencies and hence the formerly established ecological feedback control loops, regardless which exploitation domain is to be held accountable for. We *are* already changing "nature" significantly with our many different ways of utilization. The picture gets even more complicated if the already proven but not yet completely understood long-term climatic fluctuations are taken into account as well.

Similar to mankind's early step from hunting and gathering to farming, a paradigm shift is currently taking place in the utilization of aquatic food resources. World-wide aquaculture/mariculture is developing at a breath-taking pace, leading to a growth rate of aquatic food supply of about 8 %/a in spite of the increasingly depleting returns from marine based fisheries. Similar to intensive farming, high animal population densities requiring extensive animal health care precautions are found in aquaculture as well. Mariculture is also looked upon critically in terms of health risks due to (over)extensive use of antibiotics and other conditions threatening both animal and human welfare.

Oceans are not only a source of food for mankind. With increasing depletion of fossil energy resources on land the technically more demanding and environmentally dangerous offshore oil and gas drilling is increasingly expanded to deeper regions of the continental shelves. On

April 22th 2010 millions of barrels of crude oil were spilled into the Gulf of Mexico after an accident on just one oil rig, seriously affecting the ecosystems and marine life of this region to an extent that is still under scientific investigation. Only recently monitoring results showed a surprising significant reduction of oil spill residues in this region that seems to be attributed to micro-organisms specialized in crude oil assimilation. Upon further scrutiny the existence of such organisms appears less surprising if the proven existence of natural fossil oil leakages into the Gulf of Mexico is being taken as a long-lasting but local potential food niche for organisms to feed on. In other parts of the world the temporal development of oil spill effects may be completely different, rendering cause-and-effect relations as strongly regional.

Even the deep sea floor is not spared from technical exploitation. In search of placer deposits and rare mineral sources like manganese nodules, depths of 5000 m and below are charged for economic exploitation. A very sensitive marine ecosystem may be affected on tens of thousands of square kilometers of deep sea floors if future scarcity ”demands” the exploitation, e.g. of the manganese modules, estimated to some hundred billion tons.

Compared to those activities heavily interfering with the environment the novel off-shore (mostly wind) energy harvesting is of minor anticipated impact — at least as soon as the infrastructure is set up and the construction area quietens down again. By creating zones of protection against fishing activities it might even be positive for marine life. Up to this point the civil engineering impact on the sea ground may become heavy, though.

While shipping by itself does not interfere with marine life too strongly, its side effects may nevertheless be malicious. Similar to accidents of oil rigs, leakages from oil and chemicals tankers due to accidents may pollute large areas of oceans and shores. Even under normal operation conditions ships are known to release harmful substances from compartment flushing and cleansing into the oceans since this is mostly unobservable as of today, economically very attractive compared to controlled disposal as official waste, and the chances of being called to account are rather low, bringing the discussion to the areas of law and jurisdiction, as well as politics.

A variety of international, multilateral and bilateral negotiations on matters of ocean utilization, especially with respect to fisheries exploitation, has resulted in a multitude of respective treaties to bar non-sustainable over-exploitation and unregulated access to the oceanic commons. The sheer existence of these treaties indicates that a general political will of cooperation, an attitude of environmental conservation and a basic support of the notion of sustainability does exist world-wide. Accordingly, there are international, agreed-upon rules like United Nations Conference on the Law of the Sea (UNCLOS) 1994, the United Nations Fish Stocks Agreement (UNFSA) 2001, the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct, as well as regional and species specific treaties. But they do not seem to have a measurable effect on over-expoitation. The causes are manifold, partially related to the physical and ecologic properties of the oceans, partially originating in the subsequent behaviour of the parties that negotiated those treaties.

A major scientific factor is the fact that there are striking deficits with respect to the understanding of the interdependence of individual factors connecting ecological effects. This leads to inconsistent assumptions and implications that are shaped into partially contradicting legal regulations. Moreover, the legally determined zones in which coastal states are entitled to manage fishing activities do not relate to the exigencies of marine ecosystems, defined by continuous exchanges of water systems and biological networks.

While these scientific factors and still existing uncertainties may be objectively resolved at least to a major extent by respective research, the human factor is even much more problematic in the melioration of the situation of oceanic food production. There is a strong linkage between risk perception/attribution and a traditional trade-off of benefits and risks on the one hand, and the cultural heritage of a society on the other. Accordingly, treaties that are phrased in a mostly qualitative manner may be interpreted quite differently, depending on the perspective of the interpreter. Even though the political culture in Europe is comparatively high it cannot be ruled out that agreed treaties are deliberately broken, or at least strained to the utmost, for short-term political advantages. As a collection of actors we are confronted with a classical Prisoner's Dilemma: Even though we would all benefit from collaborating towards the common good of preserving the oceans as a sustainable habitat, the open system of a free market, weak global politics, cultural distrust, and imperfect communication help any defector to benefit from this situation and get away with cheating.

Returning to ethically sound political conduct, subsidies are a measure of political targeting to encourage a desired direction of development. They are quite common in the furtherance of aquatic food generation if this is regarded favourable for the population of the subsidizing country. Even if the foundation of a certain subsidy definition is based on scientific and ecological findings broadly accepted at a certain point in history, new scientific advances may change or negate the assumptions on which the subsidy was based. In such a case it is not easy to withdraw or significantly reduce it since the flow of money has created economic structures of their own that would seriously be affected and tear down parts of the sociological structures that rely on them. Even though the perpetuation of the evolved status quo is counterproductive for ecological or scientific reasons, it cannot be helped being kept up for humanitarian reasons. Even though some 2010 agreements of paradigm shifts in exploiting fisheries made several existing subsidies void from the ecological perspective there have been no agreements on respective reductions even in 2011.

In a generally well-intended effort of interest balancing, treaties tend to be fixed on objective considerations without considering the social situation of fishers and operators of aquacultures. This may well lead to a mismatch considering locally differing social, cultural or even religious heritage of the affected societies or social groups within one society that are indirectly interacting on the grounds of utilizing the same ecological resources like fisheries or secluded estuaries.

With this multitude of interdepending effects and interests at play the marine resource sciences are a perfect example of an area in which international and interdisciplinary collaboration in research programs is of crucial importance. International research structures already exist at the European level. However, they are essentially organized along the classical scientific disciplines with little interdisciplinary interaction. For optimum benefit of the societies and a broad consideration of the full spectrum of concerns it is, however, essential to go beyond the existing structures and expand them to an interdisciplinary level. For this purpose it is essential that findings from disciplines such as engineering, biology, physical oceanography interact with insights developed in the social sciences and the humanities, such as sociology, economics, law, history and philosophy. Even art and literature may contribute as there are lots of works related to marine affairs, reporting the attitude of people towards the sea. Together these and other disciplines provide sources of knowledge for organization and guidance of fishing and mariculturing activities. At this time it is not clear how multidisciplinarity or even interdisciplinarity in this sense can effectively be integrated in the research programs.

There is an urgent need to improve understanding of the processes at work, balancing risks and benefits, and provide policy-makers with sound scientific advice on how to operationalize the nutrition from the sea best and ensure its sustainable availability for the future. The evaluation of historic examples may assist this process. There are examples of historic over-exploitation of geographically mostly secluded marine regions like the Baltic Sea or the Black Sea that can be evaluated in this respect. But it has to be kept in mind that the premises under which former developments and agreements have developed considerably differ from the present state of affairs, especially with respect to the available technology of exploiting and interfering with aquatic systems.

This shift of contemporary perspectives relative to historic ones is also fueled by the fact that economic requirements and gains drive the technical innovation in food production. The necessity of obtaining proteins from aquatic sources to feed a growing population, or the prospect to obtain monetary returns even for significantly more expensive food gaining technology in the light of raised market values, will promote and encourage technical innovation that may pose a stress on the affected ecological systems too heavy to bear. On the other hand this encouraged innovation may as well serve to preserve aquatic ecosystems if a respective consensus on the directions to take and to allow is found.

Accepting this very complex interconnection framework as basis for an improved interdisciplinary approach to the target objective "sustainable aquatic food supply" two possible paths are viable:

i) to define research suggestions in a more abstract and general fashion by a smaller set of circumspanning questions. This approach has been taken and elaborated by the participants of the workshop and the steering committee members, discussing numerous individual approaches to the various areas concerned. The outcome of this work is ordered along the workshop structuring session topics and summarized in section 3.2.

ii) to evaluate the individual research propositions that were collected prior to the actual workshop from every prospective participant, and extract interlinking thematic suggestions in a much more detailed manner, leading to a multitude of area-specific but interdisciplinary research suggestions. This path has been taken by the organizers of the workshop, with its result to be found in section 3.4.

Depending on the perspective of the reader these approaches serve different needs. If interdisciplinarity in the area of sustainable aquatic food generation is the primordial objective of a new research program the big questions may create a skeleton of suggestions to be filled by research applicants with their own individual contributions. If, on the other hand, a more specialized research program with a strong disciplinary backbone should be enhanced and completed by interdisciplinary objectives to be treated in context, the significantly more detailed and more area-specific extracts from the written research proposals of the participants may well serve as a basis.

2. Multidisciplinary Research Aspects

As already discussed in the introduction a larger number of disciplines is engaged with the description and modelling of aquatic systems with the intention of securing an adequate and favourably sustainable food production. In the broad public discussion the topic is generally perceived as principally an ecological one, with secondary contributions stemming from economy, the social sciences, humanities, and politics. Taking all relevant disciplines into account complicates things considerably, but neglecting them will certainly cause any future-oriented approach to fall short of achieving sustainability goals. The following sections highlight some disciplinary objectives that transgress the main public notion, but contribute important partial aspects to an adequate treatment of matters.

The main issue of ecology is certainly the interdependence and direct or indirect interaction of the various marine species living in the same habitat. External disturbances, like species-selective fishing, discharge of pollutants into the marine eco-system, or the change of climatic conditions are quantitatively considered. Nevertheless there is a striking ignorance about the deeper linkages between different effects still since the physical object of scrutiny is extremely complex, and the means of detailed investigation have not been available since long. A wide field of current research is the assessment of the ecological footprint of deliberate, human induced changes in nature. An important further area is the investigation of the impact of rare or comparatively recent events, like the influence of large submarine oil spills or the over-exploitation of one species on the bio-diversity of a whole eco-system and the related food chain. A multitude of individualized interdependencies have been identified and described, but the broader picture on larger scales is still mostly missing, or at best coarsely qualitative.

Economics, as a part of the description of human interaction and utilization of resources, can provide a detailed modelling of markets and their influences on the activities of natural rescources exploitation. With an appropriate scale of a system in observance, results of (macro-) economic investigation and modelling are mostly independent of any individualized interest and can be considered objective to a certain grade of exactness. Economic reasoning may well treat the effects of future availability developments of scarce goods, e.g. by scenario analyses. At the present state of the professional art there are limitations in the description of non-reasonable and unlogical decisions taken by individual actors. But such are frequently observed as soon as political appreciations of differing interests of stakeholders are in play.

With increasing penetrative power and impact of the technical exploitation of marine resources the importance of political interactions of the affected stakeholders increases. While in historic times the non-exhaustibility of most fisheries was a pragmatic fact modern fishing methods can very well cause the extinction of species if pursued in a very obtrusive manner[1]. Only international, or at least multi-national, treaties can avert the exploitation of fisheries beyond sustainable limits — if the adverse behaviour is practically incriminated and persecuted. Political decisions and directions depend on many factors that do, and should, not necessarily rely on purely ecological considerations. Being representatives of larger or smaller population groups

[1] As an example of man-caused extinction of a maritime species the disappearance of the giant auk (pinguinus impennis) may be taken.

that have different and differing interests in the economization of the marine resources in general politicians have to perform a weighing of objectives and mutual expectations, frequently without in-depth knowledge of stringent quantitative cause-and-effect relationships and objective limits with respect to the objectives that are being negotiated. In this respect a more stringent (and honest) communication between politics and objective sciences is required, as well as a politically more continuous adaption to new scientific findings as part of the ongoing political processes in itself. There is an important implication for a frequently employed means of political direction definition: setting up and persevering subsidies. Originally subsidies in the fishing domain were intended to promote a socially desirable activity (fishing to secure food and employment) that would otherwise not be economically attractive enough to engage in. However, a subsidy that is continued over a longer time period can create social and economic structures of its own that develop their own impetus and resist their elimination even if the direction of development has been shown to be counterproductive in the light of newer scientific findings. Relevant in the case of marine fisheries are the findings that many marine fisheries are both economically and ecologically unsustainable. The social sciences may help us understand the socio-economic structures that keep such conditions alive and how these structures may be adapted so as to become more sustainable.

Politics is closely connected to law: Political decisions must be cast into legislative procedures, and resulting individual laws must at least be formulated in a manner that is not in conflict to other areas and enables practical enforcement. Similar to the politically induced subsidies, legal structures have the tendency to persist once they have been adopted, even if the basis for their justification changes or erodes. Legal frameworks, on the one hand, are intended to create long-term security for individuals and institutions that depend on the constancy of boundary conditions when defining investments and development paths of their own. Without questioning this special and crucial aspect the general possibility of changing jurisdiction as an adaptation to changed scientific reasoning remains to be developed. As a change of a legal settingsy may strongly influence the social and economic implications for affected persons, law acting in concert with politics must develop a means of taking such effects into consideration e.g. by explicitly honouring the developmental time constants of other disciplinary fields — both on the scientific and the sociological side.

Aquatic food generation is also a matter of sociological scrutiny since a large number of people draw their living directly or indirectly from fishing or aquaculture. They do so in quite different societies in respective contexts, as those societies relate to the maritime vicinity in differing ways. In some societies, like the Icelandic, the Norwegian or the Greek, fishing is an important and integral part of everyday life. In other countries, like in Germany or those without a coastline, there is, if at all, only some local relation to sea in a geographically small area. The majority of people there, dominating the local discussion, judges maritime affairs only as far-away bystanders or aquatic food customers and honors the alimentary perspective in a much more balancing manner compared to the other aspects of marine utilization and the perceived importance for the world-spanning ecology. Sociology is the discipline of choice if the impact of changed aquatic food conditions on (parts of) the involved societies and their structures is to be assessed, mostly in a descriptive manner. It needs external input, though, when it comes to estimate inevitable changes of society imposed by changes in boundary conditions as availability of fish, population increase, increase in pollution, etc.

An interesting topic at the interface of sociology, cultural heritage and ethics is the gender-wise attribution of aquatic food production. In practically all societies world-wide there has been a quite sharp distinction of hunting and farming: Hunting, and in a figurative sense fishing, was and is almost always the domain of the males while farming and cultivation, comparable to aquaculturing, lies at least on the gender-neutral if not even more on the female side. This effect implies the prevalence of respectively differing mindsets for fishing and aquacultivation. The maritime food post-processing is, if not gender-neutral, frequently performed by women. But the respective practitioners are usually not in the position of the deciding stakeholders.

Apart from the human-centered ethics the ethical implications of changing sea-born species genetically is another discipline-spanning objective. Modern genome scanning provides a powerful toolbox for changing the performance, breeding efficiency, social interactions within a swarm, predisposition for diseases and more. But there are many unknowns that may affect the species outside the controlled areas as well. Due to the sheer abundance of genetic information for any species an application of any genetic manipulation will have to be closely monitored for side effects up to the point where the food chain may result in medical implications on human beings as well.

Another utterly multidisciplinary issue is the definition of risks and their management. Risks in aquatic food harvesting are manifold: Risk of stock depletion, risk of acute food under-provision, risk of irrevocable changes in ecological settings by different causes, risk of human health impairment by exalted usage of antibiotics and the like, risk of social disintegration of human cultures based on fishing, market risks, and many more. The management of those risks can be based on very different approaches. The scientific, not to say mathematical approach is the objective arbitration of risk extent times occurrence probability, but this is not necessarily the manner human beings outside the scientific domain perceive as adequate. There may be a deeper wisdom in this deviating public notion of risk, as it relates to a deemed non-linearity of awkwardness for larger accidents or catastrophes.

As an example directly related to fishing the definition of the safety margin for the so-called maximum sustainable yield (MSY) and, immediately in relation with this, the catch limits imposed on fisheries may be taken. Depending on provenience and cultural heritage the MSY of a certain area of the ocean is regarded quite differently, as reflected in respective statements on provisionary limits in multi-national exploitation negotiations. Again, only a dialogue of the disciplines can mediate and conciliate in the multi-target valuation of aquatic affairs. This differentiating consideration is touching the disciplinary domains of ethics, or even religion as well: it is the question on how to treat and operate with the historically grown concept of the "commons", i.e. a property that must not be allocated to an individual user but is available to a community. As long as a commons is (near to) unexhaustible due to its sheer abundance there is no need to regulate the access and the individual share being claimed.

If this inexhaustibility does not hold any more rules for equipartitioning have to be formulated. Historic comparisons may help to understand how this process has been dealt with in other practical fields, like the willow or village pond utilization in former rural and agricultural communities. Ethics and rules of communal life, if the interacting people know each other individually, may lead to a quite different utilization handling compared to those originating in economical and political considerations mediated by representative anonymous organizations. As an example the debate is open whether it is ethically justifiable that about two thirds of the aquatic food consumed in Europe stems from non-European sources, even though significant hunger and starvation prevails in countries close by the fisheries that provide this food. Even if the sale of aquatic goods is economically favourable for those countries and may even not over-exploit the local ecologies: Under which ethical and sociological premises this nutritional export can be regarded as sustainable?

While directly history-related experiences of marine resources exploitation, due to the former frugal technical equipment in relation to the size of the aquatic "commons", frequently fall short if transferred to modern situation interpretation, there are some cases where historic information combined with geological and archeologic information may help to draw conclusions on long-term developments of ecological development of co-existing species. This is especially the case if respective research can be focused on mostly secluded maritime subsystems like the Baltic Sea or the the Black Sea.

So far mainly the scopes and limitations of individual disciplines have been discussed together with their shortcomings with only a few indications on potential cooperation, shedding a somewhat negative light on the respective scientific results in their disciplinary limitedness, and defining the needs and perspectives of multidisciplinary cooperation only as a means of finding additional restrictions to be obeyed. This impression is wrong. Synergetic effects may be identified as well if two or more disciplines cooperate by utilizing structures created by the pursuit of one target for the benefit of another one. Two examples of anticipated potential future synergetic effects shall be given: i) Genetic research may point to more illness-resistant species of aquacultured fish necesitating less usage of veterinary treatment, and ii) structures set up for wind energy harvesting in coastal regions may support larger than usual aquaculture net cages that at the same time, due to their size, relieve the dense population stress on the domesticated species, support an ethically more adequate living of the creatures, and reduce the need of intensive proactive veterinary care. If such cooperations can be converted to business cases needs further predominantly multidisciplinary investigation.

Another already successful example of a multidisciplinary approach, although predominantly remaining in the scientific/technical domains, may be given as well: North American small volume tuna fishers obtained a chance to sell their catches to international markets only after development of commercially viable smaller ice boxes that enabled them to meet the US legal standards.

Creative configuration of aquacultures, e.g. by integrating vegetables and food chain effects offensively in their setup, may also improve the independence of the individual culture from very intense human interaction like expensive feeding, and contribute to a reduced eutrophication by a better filtering of waste substances like nitrogen and phosphor containing agraric fertilizers that are washed in large abundancies into coastal water bodies.

One further aspect should be mentioned: The position of aquacultured species in the food chain.

While European aquacultures tend to prefer top-most predator fish like salmon, East-Asian aquacultures raise larger amounts of low food chain positioned fish and crustaceans, reducing significantly the need of high-value feeding. There is a certain preference of European tastes to the predator fish species, though, thus necessitating accompanying social and or cultural intervention if consumer attitudes should be adapted.

3. The Challenge of Interdisciplinarity

3.1. Interdisciplinarity in the Scope of Aquatic Food Research

Interdisciplinarity in the research on *Sustainable Aquatic Food Supply* designates intensive reflection and cooperation of MINT-disciplines (especially biology, ecology, control science, information technology, and some further natural and technical sciences) on one side and SSH-disciplines (especially politics, law, history, sociology, ethics, art, and some further humanities) on the other. Those very different disciplines must be combined into a coherent framework of mutual understanding and contentual recognition, with cooperations taking place in all phases of the initiated research processes.

The omnipresent work-sharing specialization has created specialized research domains with their individual community cultures, producing a considerable increase of expert knowledge. These gains in rationality due to specialization must be conserved while at the same time avoiding the high costs and losses of friction associated with the application of such knowledge to the scope of societal problems.

The guiding idea on which this research program proposal is based is the conviction that there *is* a true interoperation possible across the larger realms of sciences and humanities at work. Dealing with the development of sustainable future aquatic food generation on the basis of the natural and technical sciences, not only the specialized expert knowledge on the more or less mechanical interdependencies of naturalistic cause-and-effect relationships of each scientific discipline is required. Instead and in particular, knowledge of organization and guidance, as generated in the social and economic sciences and in the humanities, is required to focus on special technical and scientific regimes of ecological and economic system designs and potentially change the status quo of the recent situation, representing distinct sectors of the possible scientific scenario settings that just obey the boundary conditions defined by ecological, biological and geophysical laws. Accordingly, an integrated approach in the topic of sustainable aquatic food supply is mandatory right from the start.

3.2. The Interdisciplinary Objective — Global Perspectives

The subsequent sections comprise the aggregated discussion results of interdisciplinary research suggestions of the *Sustainable Aquatic Food Supply* workshop participants. The ordering of the research suggestions does not indicate any order of ranking or importance. It originates in the structuring of the workshop into 4 topic-centered and discussion-oriented sessions that were flanked by an antecedent introductory session, consisting of overview presentations of the steering committee members, and a finalizing/summarizing one. The session topics had been defined by an earlier meeting of the steering committee. The topic-centered headings try to approach the mesh of interwoven individual topics from perspectives that are aligned in an intentionally non-disciplinary fashion.

3.2.1 Economic Optimization and Ethical Considerations

During this workshop discussion session two major themes were identified. The first thematic block addresses interdisciplinary research questions related to sustainability. There was a broad agreement that sustainability means justice: Justice between generations of humans, between different peoples and cultures, and eventually also between humans and other forms of life and nature. A need of definition arises how sustainability can be defined in research on aquatic living resources. Are there differences in understanding between different cultures, between aquaculture and fisheries, but also between the different natural and social science disciplines involved in this kind of research? Along some individual contributions the subsequent research questions are suggested:

> How does culture and ethics influence the perception of sustainability? What technical means can be applied to improve the sustainability of the fisheries and the aquaculture sector?

The second major theme dealt with the economical pespective and the related market influence on sustainability. The discussion contributions grouped around the central question whether and how economics can help to solve problems of sustainability in aquatic food supply generation. In this context the interrelation of a global supply and market demand for aquatic food, tradable fishing rights, bio-economic modeling tools, and consumer behavior in view of an intended increase in sustainability was addressed as worthwhile for deeper investigation. The subsequent paragraphs hightlight the interdisciplinary questions identified during the workshop discussions.

Forms of sustainable aquatic food sequestration and production under conditions of cultural plurality, universal/global obligation and conditions of uncertainties. Not only on a global scale between cultures, but also locally between different actors like governments, NGOs, industry and science we are having a general plurality of values. On top we have to cope with a great deal of uncertainty about our predictions. For example, predictions about fish stock development and sustainable levels of exploitation, upon which we base management decisions, rely on extremely small samples and snapshots of information in space and time leading to extremely large uncertainties in these predictions and projections. Things we would not eat in Europe like jellyfish or sea cucumbers are a delicacy in China and Japan. Such differences in values will also cause differences in the perception of sustainability. For example, developments we consider sustainable in the western world might be judged differently in the Far East, and similarly. For NGOs the maximum sustainable yield concept might be insufficient, for the European Union it is a great step forward towards sustainability of fisheries. Despite these well known differences in values and perceptions of sustainability, we, nevertheless, seem to have a general consensus on judgment about state of affairs in aquatic food supply in past decades, which was and is considered plus/minus unsustainable. There is a strong necessity to align these diverse perspectives of view operationally in a fruitful way.

As local demands, influenced by global developments and global markets, determine the demand for and thus pressure on local aquatic food systems, we need to identify how the natural-social-cultural system “aquatic food” works on a global scale to address the general problem of unsustainable exploitation of aquatic resources:

> What are the cultural dimensions of aquatic foods? What counts (not) as food in different national, regional cultural contexts? What about the shift from tradition and aesthetics to ethics when people choose (not) to accept certain products or production measures? What could be strategies to address those differences and conflicts (examples: whaling, genetic engineering, fairtrade etc.)? What are the underlying values, how could they be explicated and negotiated? What does make the difference in different views on sustainability? Are cultural, religious, national differences the (only) major issue, or are differences within societies like social and economic groups to be found in many countries around the globe also (or even more) important?

On the normative side of things important questions to be addressed are:

> Which developments can be identified as (un)sustainable on which (universal) grounds? What can be accepted also across social groups and/or cultures; Where are possible limits of plurality – especially when relating to international law and governance? What are the value dimensions and the need for a value-informed governance?

Only if we understand the normative, cultural ethical and social differences and commonalities next to functioning of the biological systems, we will be able to understand how global markets and thus the demand for aquatic food functions and what needs to be done to secure global food security in terms of aquatic food.

Addressing the problem of open and interacting systems, how do we deal with different scales and nonlinear dependencies and resolve use and user conflicts? Aquatic food production relies on catch fishery and aquaculture. Production happens at local scales in a large number of very different ecological and social systems. However, we do have interactions between the different sectors and systems at various scales and have specific interaction knots, like global markets. Moreover, fisheries and aquaculture compete with other marine and maritime sectors for ecosystem goods and services. Yet, governance and management systems work at best on local scales - in most cases even on local scales governance and management is sectorial.

Interdisciplinary research questions relate to interaction between different actors and sectors — how can we balance interests? Risk-cost-benefit-analyses as disciplinary approach might be jumping too short especially when values change over space and time as the actual definition of value is related to a whole value landscape depending e.g. on whom we trust, changes over time etc. Also, relevant scales differ considerably between ecosystems, ecosystem components, decision making layers, sectors and even scientific disciplines and our perception of truth depends an the scale we working with.

> In order to achieve sustainable aquatic food production we need to understand the interactions between the systems we are working with. We need to understand the nonlinearity between causes and effects of interacting systems and acknowledge that processes happen on different scales depending on the nature of the problem we are addressing.

Improved understanding of demand and markets. Capture fisheries are limited by productivity of the oceans and market demand. Contrary, aquaculture is limited by technology and space and other input, e.g. from capture fisheries and market demand. Market demand determines what can be marketed profitably. Market demand is determined by the price of the product, the price of competing products, income, population size, taste and preferences of the consumers. As income, population size and taste can be assumed constant over shorter time periods, the price of the product and competing products determines the short term demand for aquatic food. Over longer periods the latter variables will also be changing and market demand will be fairly dynamic. If we want to understand how demand will change over short and longer time scales we need a better understanding of market demand and finally consumer behaviour. Also, if the goal is to achieve ecological sustainability of aquatic food production the demand and thus the consumers may need to change their behaviour. It is an important interdisciplinary research question what influences the consumer behaviour and how can we make use of that to achieve sustainability.

In that respect research questions related to best practise for participatory approaches must be addressed. What is good information, how can we include stakeholders into scientific approaches? Our kind of scientific knowledge may not only be the only knowledge and stakeholder knowledge may increase the robustness of our models. Participative stakeholder involvement is even a more fair way of decision-making and may link diffent social systems. When it comes to technology design, this is not linear from basic research to applied research to implementation, but there are value choices to be taken underway. Therefore, we need involvement of stakeholders with different value perceptions to design a widely acceptable product. This whole complex of research questions is also related to compliance. How can we establish a culture of compliance in fisheries and aquaculture? If we would introduce more flexibility into the static legal system, e.g. via participation, would that help? Still, the question is not fully resolved how we can organize participation so that people are also willing to involve themselves, and how would best practise look like.

Another issue related to better understanding market demand and consumer behaviour is related to transparency and trust. Can certification and ecolabelling help achieving transparency? Are there other means to achieve transparency? Ecolabelling might nicely link consumer preferences to production and management, but does certification really result in changes in management, and finally lead to more sustainability? There is some evidence that ecolabelling does only have a small effect on overall management practice and sustainability, but it might be an important puzzle piece in a larger framework for improving transparency and trust. Even though there is no dispute that full transparency will increase trust and compliance. The question on the consequences remains, though, as e.g. in how far especially the population of the rich western world would comply to measures that would limit their free choice about the quality and amount of seafood they consume, in order to secure globally fair sea food supply. Will it be possible that we accept to eat things that have been discarded before?

Application oriented ethics: Ethics of the ocean/s. Application-oriented ethics addresses specific fields of action and societal debate. Empirical expertise is of central importance and the approach is interdisciplinary. Valuations and judgments are based on both empirical (descriptive) and normative (prescriptive) premises leading to mixed judgements. Application-oriented ethics necessarily has to integrate knowledge from natural and social sciences as well as humanities and normative/evaluative knowledge. A philosophical approach in this respect does not mean a purely theoretical one. Instead it needs to relate among others to production, validity claims and implications of both empirical facts and moral norms.

3.2.2 Wicked Problems: Simulation and Participative Governance

Wicked problems are problems which by their nature defy complete solution. When we address one or more sides of an issue by active measures other aspects will be aggravated, new aspects that we did not foresee turn up, and we may face results that nobody wanted. Many food-related problems are wicked. Because of a globalising economy, resource constraints, weak global politics, diverse preference systems (and the list goes on), we as academic researchers may be skeptical of the ability of science to prescribe and indeed predict future "best practice" action. This leads to an intense debate of scenario-building and participative governance as a possible scaffolding for future research.

Two quotations inspire this discussion. The first one is by Helga Nowotny, present chair of the ERC, who states: "The quest for relevance in the social sciences triumphed during the mid-twentieth century, celebrating planning, social engineering and foresight. Its latest embodiment is the belief in evidence-based policy. Yet, it is often difficult to discern which kind of evidence counts in a given situation, whose evidence is to be used, and for what purpose... Shifting from relevant knowledge to socially robust knowledge includes multiple, even contradictory, perspectives." (World Social Science Report, 2011, pp 320-1). The second quotation is from the UNDP Text Book on Foresight methodologies: "most authors discussing scenario analysis recommend the use of multiple scenarios. The future is uncertain, and analysis of just one scenario does little to communicate much about the range of opportunities and challenges liable to confront us." (p.72)

In the interdisciplinary discussion it was noted that it may be helpful to try to redefine wicked problems as technical problems as this will empower us to seek "objective" solutions, and food problems are often better understood as technical problems. On the other hand, it was noted that technical solutions are bound within a certain context, which will only exacerbate the problem, if it is indeed a wicked one. This leads to a research theme:

> Democratising the process of scenario-building by empowering society to put forward alternative 'visions' of sustainable aquatic food, alongside scientific scenarios: How can transdisciplinarity be used to enhance the capacity of communities for collective decision-making?

In predicting future scenarios and trajectories of change, science also prescriptively defines the social choices that society 'ought to make' along these trajectories. However, this shift from a descriptive to a normative mode may alienate citizens from the political process of collective decision-making that should precede decisions on future action. As a critical challenge to the prescriptive nature of scientifically defined scenarios, it is important that non-scientific actors be empowered to put forward their own visions for what sustainable aquatic food scenarios may look like, to be discussed in a political forum.

There is, therefore, a need for research into decision-making in food systems based on participatory models. Such democratisation implicates any number of disciplines in a transdisciplinary mode. Decision-making will address a huge variety of desired outcomes such as resource abundance and management, human food preferences, and desired aquatic and terrestrial landscapes. The research undertaken should therefore draw on the full knowledge base provided by academic disciplines, such as natural resource science, social sciences like sociology and political science, science and technology studies, and humanities like history, literary studies and rhetorical studies.

There are a number of approaches for putting such democratisation into action. We see scenario-building according to 'narratives', or creative methods like asking people to 'draw their future scenario', participatory film-making, whereby each actor participating is given the resources to make their own short film that presents their future vision/scenario, before using these films as a basis for a discussion of desirable future scenarios. Less creative, but also exciting are innovations in qualitative modelling, or participatory modelling like 'mediated modelling.'

These future scenarios must be based on the identification of different knowledge systems/experiences, as well as explicit regard for values and aspirations for the future. Importantly, not all of these visions/scenarios will be of the same 'quality'; but this presents an opportunity to negotiate the merits and demerits of each scenario within a group, and root scenario-building in its political context.

A special problem is how to develop such participatory research and practice in countries with weak institutions and capacities as participation only works with full transparency and trust. Also issues of priorities in resource utilization and economic development are highly contentious and need further research.

> Fishery and Aquaculture — insufficient action despite sufficient (scientific) knowledge: What steps are needed to adjust the research system?

Current environmental and societal problems call for more interdisciplinary research. Inter- (and trans-) disciplinarity are difficult and pose challenges, but the benefits from overcoming present fragmentation are potentially huge. The benefits relate to legitimacy, saliency (contextualisation of technological and environmental constraints in their social and economic settings) and accountability.

Sustained aquatic food supply calls for inter-linked studies of capture and aquacultured supplies. Presently fishery and aquaculture seem to be investigated quite often as single and non-linked resource uses. However, they are strongly interacting. There is a need for an appreciation of both fields in order to optimize resource use. The research system and the funding of research must be adjusted to the need of both areas. Research must aim at potential, positive (beneficial) interactions between aquaculture and fishery.

The earth system is based on cycles, which are overlapping and dependent from each other. Both aquaculture and fisheries are beneficiaries of the earth system. They are overlapping, and must be operated accordingly. If aquaculture and fisheries are not investigated, treated, and controlled as an entity, research results, management, and control remain fragmented. The risk of failures is extreme.

The earth system is not independent from stakeholders and opportunistic politicking. Aquaculture and fisheries are open to external pressure because products derived from both are bounded by economic rationality. The weakness in the scientific advice on aquatic food supply is the incoherent scientific approach, which appears often driven by individual research interests. Research results are, therefore, fragmented and neglect important interdependencies between fisheries and aquaculture. Future aquatic food supply needs a combined management of aquaculture and fisheries in order to avoid further damage to the earth system and to sustain the aquatic food supply.

The proposed research should analyse fisheries and aquaculture as inter- or transdisciplinary science:

> Where have we been good, i.e. we have lessons to offer to other areas, and where have we been poor?

The proposed research may also benefit from looking into other research practices such as medicine practices, to evaluate science in a systematic way and to learn from both positive and negative examples.

3.2.3 Global Cooperation: Knowledge and Uncertainty

The general topic reflects on food as a global issue, where production sites, processing factories, retailers and consumers may be located in very different parts of the world. Even though productions for local consumption are still important, particularly in the poorer parts of the world, the trend towards a global food value chain seems to continue, and thereby the ideal of providing a global food security as well. Yet it is also the complexity and to some extent the relative opaqueness of this value chain which presents a particular challenge for governance. Behind this, one can certainly detect something like a global consensus on common goals for development, as e.g. in the Millennium goals or in the goal of sustainable development. Turning from these general commitments towards the identification of the main drivers who can assure global cooperation and the enforcement of regulatory practices remains a much more complicated task.

In this picture research is not necessarily the main driver, not even perhaps one of the most powerful drivers. This raises the question of the necessity to seek alliances so that research results can be translated into practices. But does that imply that scientific researchers cross the borders towards becoming campaigners, associating themselves with more powerful actors? Given the traditional ethos of science this is at least problematic. Aquaculture is a good case in this respect.

> If aquaculture is really a promising way forward to ensure global food security, then how can researchers effectively prepare the ground for such a development?

One may favour a top-down approach and look for powerful global players: examples would be the European Union (mainly looking for market security and economy), or big industries (feed industries, retailers, etc mainly looking for profitable markets), or NGOs (often advocating criticisms of industry). Or one may favour a bottom-up approach and look for local producers (e.g. in developing countries, engaging them in sustainable ways out of poverty) or consumer or citizen groups (mainly formulating a holistic sustainable life style). All of these alliances raise their particular problems, and none should be entered without a good reflection of the role of scientific research in it.

The conceptualisation of risks and uncertainties raises particular concerns about ethical responsibilities on the part of science, and prepares much of the ground for communications between users of scientific knowledge and indeed wider parts of society. Given the complexities of the global value chain of our food supply, this part becomes even more challenging. It is perhaps this challenge which in particular calls for interdisciplinary research. Different contributors and participants hold quite different views about risks and uncertainty. How do these affect the research and the communication of research results? Apparently there are some fundamental differences in the conceptualization of risk and uncertainty which would indicate the need of a more thorough dialogue between different disciplines, and, indeed, different views of the scientific enterprise.

This leads over to one of the central claims which should characterize interdisciplinary research about sustainable aquatic food supply:

> Interdisciplinary research about sustainable aquatic food supply should be granted the 'luxury' of being 'slow science', i.e. one should calculate sufficient time and resources for the participants in this research to get to know each other's viewpoints and develop a common language.

One of the most common hindrances to engage more in interdisciplinary research seems not the lack of will among researchers, but the pressures to produce outcomes in relatively short times versus the effort it takes to get acquainted with methods, viewpoints and concepts from other participating disciplines. It must be stressed that one should have enough time to build small interdisciplinary communities of researchers who truly can benefit from and supplement to each other's approaches to the common problems. New fora and formats for these common learning processes are required, and any effort to promote interdisciplinary research into this area should include adequate resources and time for this learning to take place.

How deeply these difficulties affect the current research was reflected in repeated claims about the clash of different notions of sustainability during the preparatory discussion of this research suggestion. There is clearly a multitude of different understandings. Any interdisciplinary group of researchers needs to come to a shared and inclusive understanding, since this is providing the guidance for the objectives a joint research aims at.

Problems lie not only with the intended outcome of the research. They also have to do with the acceptable input into the research. While natural science favours quantitative data, the humanities and partly the social sciences embrace also a variety of qualitative data. Among the latter the importance of narratives was stressed, since it is whole and all-encompassing narratives which assumedly have the greatest impact on decision makers and indeed on society at large. Here history has an important part to play; experiences from the Black Sea management may serve as an example.

While practising scientists from the natural sciences typically focus on the status quo of technology and research, including the prospects for further future development, history and social science can and should supplement this picture with historical and social accounts which do not shy away from previous failures and failed predictions. From insiders from e.g. aquaculture or fisheries it may indeed be experienced as unfair that earlier failures may receive such prominence in these narratives when they are about to change things for the better. Nevertheless such narratives may serve two important objectives. First, they provide the necessary background for mutual learning in and especially between different disciplines: one has to learn from the failures of the past so not to repeat them in the future, e.g. through unfounded expectations in the benefit of research. Second, they are the backbone of the communication with society: unless we are open about earlier performances and unless we manage to connect to public perceptions of the issue, we fail to generate the necessary trust in the research that lies ahead of us. As an instrument to achieve good narratives the interaction with a wide variety of stakeholders and civil society may be part of the research.

> Interdisciplinary research on sustainable aquatic food supply should seek to integrate quantitative and qualitative data to the largest possible extent, and the inclusion of holistic and truthful narratives (perhaps also in the form of films etc) generated through the cooperation between the participating disciplines should be an explicit aim.

With this backdrop of more general features for the envisaged interdisciplinary research, some more specific suggestions emerge which deserve a wider attention.

One issue is the need to set up more integrated approaches. Basically this has to do with the fact that most of the systems for aquatic food productions, certainly aquaculture and fisheries, deal with open or half-open systems, i.e. they interact with the environment in countless ways. They also interact with social systems, and we interact with them e.g. in regulations, technological interventions and management. Marine spatial planning for marine wind energy parks can serve as a good example. Some practices like feeding in aquaculture pens may have unintended outcomes for the food safety of wild fish in the surrounding. The issue of escapees from aquaculture, and the transmission of fish diseases, has been a long standing headache concerning the environmental and ecological impacts of the industry. All of these issues typically relate to imminent decisions, i.e. decisions that cannot wait until we have reached sufficient positive knowledge about the systems and sub-systems involved. This bespeaks the necessity to use models to capture essential features of the problem. Yet, modelling is known to be partial and imperfect. Again, interdisciplinary research can have an important task in this respect. First, one may look for a more integrated approach crossing all the areas for which modelling is done. Second, one may look for new ways to take account of parameters which so far typically have been treated as intangible parameters, such as e.g. social values. Third, one may increase the resilience of the process by slower step-by-step assessments tied to rigorous monitoring of outcomes. One should perhaps take note of the fact that in such an effort philosophy of science and practical ethics may have important insights to contribute.

> Interdisciplinary research on sustainable aquatic food supply should aim at more integrated approaches of the overall assessment of fisheries and aquaculture systems, taking due note of their nature as open or half-open systems in interaction with other environmental and social systems.

A further concern is the scope of the research. So far, most research projects concentrate on narrow sectors and geographical regions. This is most often also a consequence of the funding systems where money "keeps its colour", i.e. where specialised funding agencies concentrate on their narrow sector. However, with interdisciplinary research one may reach for higher goals, reflecting some basic insights. First and foremost one should acknowledge that fisheries and aquaculture provide food, mainly (though not exclusively) for human consumption, as do agriculture producers. Thus the relative sustainability performance of various products from all these sectors becomes an important issue. This also applies to some sub-themes, as nutrition. While there is a lot of talk about feed for aquaculture systems, one needs to widen the scope of investigation in the sense of realizing basic insights in the nutritional needs of living organisms as such. From this it is but a small step to our ethical responsibilities, namely that malnutrition in any form (and basically for any species, not only humans) is ethically unacceptable. Thus there emerges a need of embedding the interdisciplinary research within wider and more general issues.

> Interdisciplinary research on sustainable aquatic food supply should integrate a wider scope of problem formulations, allowing comparative analyses between sectors which so far are dealt with separately, while still balancing this wide scope with a focus on concrete problems of further development.

Lastly, the issue of best practice models and / or performance indexes and / or certification systems is of great concern. There is a general consensus that best performance models do not travel easily. There is indeed a danger that some regions or countries repeat failures from areas which since have improved considerably. There is also a danger that viable new production modes, technologies, regulatory systems, and governance systems are not sufficiently known in areas or regions of the world which are about to invest in new technology and productions. Seaweed production as part of an integrated aquaculture shrimp production as already practiced in parts of Thailand should be of considerable interest for efforts in Indonesia to build up seaweed production systems. The same applies mutatis mutandis to new organic shrimp production in Bangladesh, to various modes of poly-culture in Asia, to semi-intensive or even extensive alternatives to intensive aquaculture productions systems, or to governance models of fisheries from Europe. Similarly, while there exists already a wealth of standards, e.g. in the form of the FAO Code of Conduct for Responsible Fisheries, the Bangkok Declaration (2000), The Holmenkollen Guidelines for Sustainable Aquaculture (1998), or certification systems like Global GAP, the FAO/NACA certification systems, MSC certifications, or GAA standards, the impact of these standards and certifications is still restricted. First, they typically implement minimal standards, not necessarily providing best standards examples, and second, their implementation requires governance capacities which often are absent in those areas where they are most needed.

> Interdisciplinary research on sustainable aquatic food supply should make a concerted effort to contribute to capacity building in the various sectors of aquatic food production and governance of the sector, concentrating on effective instruments and media to convey up-to-date examples of best practice and providing viable options of sustainable development of the sectors.

In conclusion, efforts to promote wide interdisciplinary research on sustainable aquatic food supply will be a promising way to realize socially responsible research and innovation, and offer new opportunities for a constructive dialogue between science and society, as well as addressing the global challenges of food security.

3.2.4 Managing Societal Impacts of Fishing and Aquaculture

During the workshop the topic was introduced from the perspective of scales and the linkages between scales, informed by social-ecological thinking and nested circles as well as ideas about polycentric systems[2]. Both conceptualizations emphasize the importance of and possibility for experimentation at the more local and flexible levels and the importance of the links between the various levels, which allow for experimentation to have impacts beyond the local level. It was suggested that the links between the various levels of organization and between social and ecological organization require further interdisciplinary study in order to better understand how sustainable aquatic food production and thus sustainable change may be fostered in times of Europeanization and globalization.

[2] For further information on social-ecological resilience, see Stockholm Resilience Center at http://www.stockholmresilience.org/21/about-us.html on polycentric systems see Elinor Ostrom, Beyond Markets and States: Polycentric Governance of Complex Economic Systems, Nobel Prize Economics) Lecture, December 8, 2009, available at http://www.nobelprize.org/nobel_prizes/economics/laureates/2009/ostrom_lecture.pdf.

One of the (time) scales that was discussed was the archeological/historical dimension of fisheries management and aquaculture and lessons that may be learned. Archeological research, for example, may be relevant for determining how fish stocks have reacted to past instances of climate change. Or, to understand consumption patterns and how they were linked to traditions and ethical considerations. Furthermore, historical research can serve to understand changes in consumption patterns in response to ethical considerations or marketing efforts. In other words:

> How have various narratives and perspectives constructed our understanding of the relationship between food preferences and aquatic food and and how do they still today?

It was also pointed out that, on another scale, scientific communities, for example fisheries scientists, construct their own narratives thereby influencing policy choices and our understanding of aquatic food sources, often over long periods of time. The Beverton/Holt fisheries management model was mentioned as an example for the trust that the European Union's fisheries management policy places in modeling. How are narratives of this nature sustained and how might they be dispelled? Once such narratives find their way into law they are perceived as particularly difficult to dispel even if proven wrong by newer insights and developments.

The topic of narratives was also explored with respect to aquaculture and the difficulty of introducing aquaculture in some societies, where ownership of livestock is regarded as a sign of social prestige, whereas 'managing a pond' is not. Thus, introducing certain technologies, such as aquaculture, may run counter to accepted social relations and therefore fail. This finding points to the need for knowledge about social relations and the need for integrating that knowledge into projects that seek to promote aquaculture. In addition, our own social narratives, for example regarding the role of women, may predispose us to forget about the role of women in aquaculture. Understanding these social narratives operating at different scales, their impacts and linking them to fisheries and aquaculture management and thus integrating the knowledge, including qualitative information, generated by various disciplines was regarded crucial. This applies also for a potential adaption of Asian aquaculture practices to European conditions: In this case we need to translate the local narratives into our own.

Aquaculture and narratives were also linked in terms of the role that the media play in portraying the products resulting from aquaculture. It was pointed out that aquaculture on the one hand could play a significant role in addressing the world food crisis, on the other hand fish and fish products originating in aquaculture are often portrayed as 'second-best', despite the fact that aquaculture has a long tradition and needs not be environmentally harmful. Media studies thus need to be integrated into an interdisciplinary knowledge gathering agenda.

The role of scientific knowledge, learning, participation and the need for self-reflection needs to be scrutinized, too. Social network analysis facilitates the latter, it enables reflection on the role of knowledge producers of various disciplinary backgrounds in fisheries management. Knowledge producers, including the participants in the meeting, have been and mostly are part of the fisheries management system.

> To what extent has inter-disciplinary research been integrated into fisheries management, what went wrong and what went well? Besides self-reflection, the need to focus on social learning was emphasized, bringing the focus back to the importance of narratives.

The dominant narrative in fisheries management has been one of modeling and planning dominated by the hard sciences and the values associated with these sciences. It was suggested that a much wider variety of stakeholders should be involved in fisheries management in order to generate socially robust knowledge that recognizes that there are values and interests beyond the basic food production at stake and that objective knowledge is not readily available in all touched fields. Fisheries management linked to socially robust knowledge is more likely to be sustainable and perceived as legitimate.

Participation was also regarded as important because of the role that traditions play in shaping fisheries management. Some traditions may be valuable for achieving social-ecological resilience in that domain, others may need to change. Understanding the role of traditions in societal processes, such as fisheries management, and how traditions may change requires input from the humanities.

A more general point was made regarding best-practices in the context of several case studies. While best practices manifest themselves in specific, localized contexts (one scale), these contexts are often impacted by processes that originate in levels above the local ones, such as European Union regulations or international policies and laws, global markets for fish products or the introduction of farmed species into the natural environment (creating a set of different scales). This finding suggests a particular set of challenges. First, in order to identify best-practices localized case studies need to be performed, with a need to take into account and incorporate impacts that originate in other scales but surface at the local level. Secondly, in order to identify best practices, the findings of these localized case studies need to be linked into analyses of European and global processes, like global supply chains for fish and fish products and their impacts on the local levels.

3.2.5 Subsuming Central Interdisciplinary Questions

During the concluding and collating session of the workshop the participants identfied a number of principal questions or directions to be approached in an interdisciplinary fashion, derived from the various realms treated in the anteceding more topic-centered sessions.

1. Production, consumption and discourse — create tools to improve communication that will inform producers and consumers of sustainable seafood. Research on how consumers make choices. How is this coupled to production decisions in seafood generating firms? This topic can be coupled to the next one,

2. Research into spatial, biological, technical, and socioeconomic aspects of sustainable local food supply through combined aquaculture and fisheries activities. In how far must locally restricted aquaculture be related to more global attitudes, e.g. by questioning the procurement of fish collected for fish feeding.

3. How can final seafood products be compared and how can they be backtracked through the whole value chain to establish assessment standards for the different processes of the products? This question domain includes an analysis of what kind of labelling is sensible to inform the consumers so that they will be able to make educated choices from their own values perspectives.

4. What are the drivers of technological development in aquaculture and fisheries, and how do they comply to, as well as alter, the ethical, legal and social implications of taking food from the sea?

5. How can fisheries be adaptively managed balancing indispensable tradeoffs between ecosystem benefits and service provisions?

6. How can legitimacy be built through communication with stakeholders? Including the issue of fairness between all involved parties into the discussion, how can the dialogue with stakeholders be organized to facilitate planning security of intrusive investments with changing boundary conditions of the systems that the investments will affect?

7. Does the perspective on sustainable aquatic food production change with scope of the stakeholders, concomitant to a change of economic incentives? How does this change affect the answers given in an interdisciplinary context?

8. How can the prioritisation of scarce resources, namely aquatic food production areas, coastlines, inland and marine space, be organized in a fair manner by its management and governance? Topics to be included are the criteria of scarcity, and of use and non-use values.

9. How can globally oriented EU regulations both find an expression in the context of local-scale fisheries and aquaculture governance, and allow for local-scale historically evolved structures?

10. How can scientific models be operationalised in a way that render them adaptable and dynamic in order to integrate new findings and the interests of all relevant stakeholders? Depending on the prevalent lineage of a scientific field the modelling approaches differ significantly. How can they and their different types of underlying data be linked in a canonical, circumspanning way? Being a truly interdisciplinary topic, aquatic food supply might be a very well suited test case for the development of new methodologies.

11. How can the communicative connections among the different disciplines be improved, and how can disciplinary arguing habits be opened to other points of view in order to develop or find a common language connecting different methodologies?

12. Develop a methodology to improve the capacity of scientists and communities for supporting decision making, with scientists as story tellers alongside other storytellers. From the scientific perspective it must be borne in mind that there is already lots of knowledge in other domains on which reasonable decision making has been made and can be made.

3.3. Multidisciplinary Target Definition Leading to Fine-Grained Interdisciplinary Research

As long as people are involved in a decision process on how to act in future there is no such thing as objectivity. Different persons or groups of persons are interested (and live from) differing directions of development that are contradictive in their effects, e.g. on the purely objective ecological conditions of the oceans. Nevertheless a partially objective support of the various involved disciplines can be provided on the grounds of pareto optimality if commonly agreeable "target definitions" can be separated from such targets that involved decision takers disagree on basically. There are other concepts of reaching multi-stakeholder agreements, but from a systematic point of view the pareto concept seems very fit in discerning objective and subjective contributions to a required decision-taking.

The basic idea of this approach is that it is comparatively simple to reach broad accordance on an isolated normativity of a certain goal if there is no inherent necessity to trade it against another one. As an example, there is hardly any objection to the isolated goal to have as much fish stock as possible in the seas. The same holds true for the isolated goal to obtain as much food as possible per time for human alimentation, or to generate as much income from fishing or aquaculturing as possible. For any such goal objectively derivable boundary conditions or procedures can be identified that are interlinked though: Depending on what measures are taken either of the defined goals will be better or less satisfied, but the general procedures to calculate or guess the resultant target values in a scientifically educated fashion will be communicable regardless of the individual preferences of any person engaged in the discussion process.

The human factor of necessary arbitration and valuation enters the scene as soon as it comes to the weighing process of the relative importance of goals. At this point it is important that whatever development path is negotiated to be taken in the end, it should at least be one that is not dominated by any known other one at that time: there should not be a feasible setting of boundaries that supersedes the discussed one in all expectable goal fulfilments.

Fig. 1 shows an illustrative example of this approach: In this example the definition of two individual target functions "ecological quality" and "economic gains" is assumed that are quantifiable each in their own value defining respects. The only thing known, and must be basically accepted in a circle of differently oriented stakeholders, is that both targets should be maximized. Depending on any assumed set of boundary condition settings (like number of fishery ships available, maximum landings of different fish species allowed, subsidized income for small fishing enterprises, etc.) simulated or practically realized systems deliver respective target function values (grey asterisks in fig. 1). Some of the systems, defining an individual boundary condition & management scenario each, will lead to inferior results, i.e. there are other configurations that will lead to better values for both targets considered. Nevertheless a whole set of system settings can be identified where one target can only be meliorated if the other one is slackened. This set is called the Pareto set or “Pareto front” (blue line) of the problem and defines the solutions from which to chose in the subjective arbitration process.

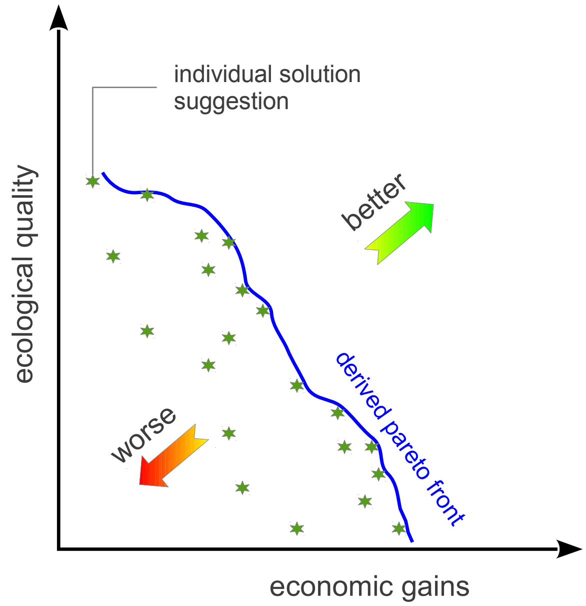


Figure 1: *Resultant pareto front of a set of individual solution suggestions, trading off an assumed ecological and economical performance as exemplary targets.*

The charm of this approach is the fact that it systematically avoids the definition of a “one and only” and thereby pseudo-objective, normative target function definition that everyone involved in decision making should adhere to, and that would lead indeed to an indicative single set of boundary and governance conditions. It thereby eliminates the need to weigh the individual and typically non-comparable targets against each other at a too early state of the weighing process. The selection of a final development direction to be taken remains rather a matter of subjective trade-offs between negotiating stakeholders or interest groups. But they can rest assured in this process that under given and accepted circumstances for the individual target functions no “generally better” solutions will be available. Adhering to this procedure of separating individual objective target function determination as a basis of subsequent decision taking by subjective negotiating of stakeholder group interests, even the individual mono-criterial compromises are quantifiable for any pareto-optimal solution in view of any other, thus yielding an immediate feedback for the involved parties. The methodology is immediately transferrable to an arbitrary number of dimensions, but becomes less intuitively accessible and graphically representable if an appropriate set of individual goals in the realm of aquatic food generation is to be reflected.

Without a systematic search for such pareto-optimal solutions the manifold suggestions derived from disciplinary optimality considerations, agreements of small numbers of lobby groups, or persecution of political tactics may well render sub-optimal in the sense that another solution with better performance in all those decision dimensions may be identified that have not explicitly dealt with, without deteriorating the focused solution quality for the lobbied dimensions.

This has an important implication for the disciplinary approaches. While their typical direction of disciplinary research is directed to scrutinizing the so far identified optimal solutions in order to meliorate them even further, a true interdisciplinary approach may require a focus on a mediocre solution from a purely disciplinary point of view. But this mediocre solution may be one in the vicinity of the pareto points of the underlying problem and therefore a very interesting one for the final tradeoff of different subjective and objective targets. It is therefore very important that the representatives of the involved disciplines start talking to each other as early as possible in the process of “optimal” solution identification. Any research program with the intention of a pragmatic melioration of the aquatic food supply situation will have to take this effect explicitly into account.

It should be kept in mind that each target point as shown in Fig. 1 represents a multi-dimensional assessment of either simulative system calculations, or target values actually observed in fishing or aquaculturing reality for a certain set of realized boundary conditions. The observation of existing facts will be mostly objective, but it can only provide a very limited amount of scenario settings for comparison. Simulation models, on the other hand, can deliver a vast number of scenarios and their respective target value outcomes. But their value depends strongly on the correctness of the implemented causal relations which are manifold and always associated with modelling errors and fuzziness. As sciences and humanities improve their descriptions of causal interactions, simulated outcomes for identical settings of boundary conditions tend to change over time. So any determined pareto front, as a result of a multiple scenario evaluation, will only represent the knowledge of that point in time and is subject to change in future evaluations. Nevertheless the creation of scenarios, however they are constructed, and their preemptive evalution is the only method to shape the future in a structured manner.

The aspiration of the research program will reach even further, though. Even if a mostly stable set of pareto-optimal solutions is found on the long run there is no objective indication towards which of the competing solutions should be taken. As already pointed out this practically most decisive step is a intrinsically subjective one, even though additional objectives relating to the imperfection of the objective knowledge at any point in time should be taken into consideration as well.

Back to the actual subjective decision taking of just one solution, humanities will play an important rule in this process. Differing choices represent different subjective valuations of the considered partial targets and will certainly reflect the sociologic, historic, and ethical background of the groups and/or individuals in interaction. At this point it is necessary i) to understand the underlying reasoning of the groups, ii) to find possibilities to communicate the different point of views between them, and iii) to resolve potential arising conflicts by pointing to respective strategies of mutual understanding and respecting.

3.4. The Interdisciplinary Objective — Fine Resolution

While the discussions during the workshop led to the more circumspanning and global research topic definitions the in-depth analysis of the contributed individual research topic suggestions yielded further interdisciplinary aspects that appear quite specialized and should require a more intense fathoming. Nevertheless these topics may render as valuable in the light of thematically confined calls for research tenders where interdisciplinarity is sought but not the only perspective in question. For alignment reasons with respect to the workshop session topics these individualized topic extracts are ordered in the same way as the global ones, re-iterating the workshop session structure for mapping reasons.

3.4.1 Economic Optimization and Ethical Considerations

The open water body bearing the constituents of aquatic food is by no means homogeneous from an ecological or biological perspective. In fact it is highly structured, separating the body e.g. into spawning, nursery and adult age regions of the species we finally withdraw from the seas as food. Each region needs respective care in human interaction, far beyond the pure fishing activity. The localization of these regions, both spatially and temporally, is not well understood as of today for the rather large variety of oceanic waters adjacent to Europe and the creatures living therein, reaching from the Mediterranian Sea to the Polar Waters. Accordingly the requirements of always locally oriented means of protection are unclear as well[3].

In this context ‘protection’ comprises the sheltering against undue fishing[4] as well as limitation or exclusion of activities not directly related to the food aspect, as oil drilling, transport activities in shallow waters, tourism and similar[5]. Especially the aspect of non-disturbance necessitates a close cooperation with disciplines outside maritime ecology as the dimensions of relevant intrusion can be very diverse[6]. Just as examples, oil drilling activities may induce both heavy noise that fades away only in rather large distances, and spill and distribute poisonous material into the water that may affect too delicate local ecological balances. Intense touristic activities may endanger benthic plants and breeding grounds of near-coast animals, etc. On the other hand it is not wise, or even adverse, to restrict non-food activities in a too aggressive, proactive way as this will produce respective negative economic side effects, potentially combined with social resistance against restrictions perceived as penal. As a consequence a close cooperation between engineering and social sciences with ecology must be sought that assesses potential disturbances and researches ways to reduce them to ecologically sensible levels in an economically, technically, and politically feasible fashion[7]. Some non-food activities may even prove beneficial: base fortifications of wind turbines, together with the restricted access area for ships around them, seem to act as artifical reefs that serve as additional refuge areas for all stages of marine life.[8]

Most European marine aquacultures are hedging predator fish way up in the food chains. They are confronted with increasing aggression and spread of diseases in the populations in high-density intensive cultures, resulting in increased amounts of proactive medication and losses of economic return. Some negative effects can probably be remedied by advanced genetic manipulations[9], but scepticism prevails especially in the later seafood customer community[10]. Without anticipation of a later customer attitude the topic of genetic manipulation potential for improving species properties, at least but not exclusively with respect to aggression, disease disposition[11] and body mass increase is one of rising importance if increased output of aquacultures in general is intended. In this field a close cooperation of genetic engineers with ecologists is requested to relate successfully implemented genetic alterations not only to the intended target value (like speed of body mass increase) but also in a more holistic view to a larger variety of individual fish life quality determining parameters[12].

An alternative development direction for European aquacultures may be derived from compar-

[3] Holm, Mikkelsen, Tzanatos [4] Froese [5] Vidas [6] Alexander, Moren [7] Bjorndal [8] Alexander [9] Lie, Myhr [10] Arcuri, Bacher [11] Baruah [12] Bacher, Potthast, Waller

isons with East-Asian approaches, featuring a multi-species setup of aquacultures, potentially also including the plant life[13]. Beyond the more or less intradisciplinary ecosystem researches on which species would be combinable and create a synergetic community, truly interdisciplinary cooperation should be installed between ecosystem research and economic considerations: Considering more than one target species complicates management procedures and reduces the density of each single species. A major topic of research is the identification of robust constellations of the artificial ecosystem and its control[14].

Also still unknown on a European scale is the consumer attitude towards targeted genetic changes especially of cultured fish species. It may be anticipated that the attitude varies significantly across Europe, but the amount of vigorousness has not yet been quantified, so conclusions with respect to ethically accepted and economically attractive intensity can not yet be drawn and needs further research[15]. Stress should be laid both on the objective medical implications on human welfare and the ethical perception across the European societies of altering existing species just for increased servicing of human expectations[16].

Striving to reduce the ecological impacts of aquacultures an alternative approach in the line of the multi-species approach may be reasonable: Creating very large, extensively operated aquacultures, e.g. by cutting off a whole estuary that is, as a culture, not ‘operated’ in a high population density fashion — comparing it to land-born animal handling methods: recreating the difference between cowshed rearing and herds freely roaming a larger parcel of land. As such extensively operated aquacultures are mostly new on the European market the economic reasoning will have to be scrutinized in parallel to the ecological settings and effects but closely relating to and in reverse defining the ecological settings that are possible[17]. Both in the ecological and the economic balances additional synergistic effects should be considered, as respective structures may even fuel tourism or the settlement of related secondary enterprises[18].

In most of the suggested issues the topic ‘sustainable aquatic food’ is considered from the producer perspective and related effects on the ecosystem and the economy. But with respect to the sustainability the consumer of aquatic food plays an important role as well that partially originates in historic developments[19]. With his buying behaviour he determines what products are economically placeable. Today and in the foreseeable future there is a definitive tradeoff between economization of the production of aquatic food and the ecological and social side effects. It is an important matter of concern how far the consumers honor sustainability properties by their buying behaviour, e.g. by watching out for eco-labels[20]. The general tendency to do so is observable from the consumer inclination in the major consumption nations towards biologically valuable agricultural products, at least within a certain share of the total number of consumers. There has been no investigation performed so far on the strength of this movement, especially so with respect to the economic-ecological tradeoff[21].

It is therefore supposed to investigate the consumer perceived economic value of improved environmental conditions in the generation of aquatic food. In this task the relations must be kept in order: Economists have to research this relationship under the condition that realistic

[13] Mulyati, Ott, Sorgeloos [14] Ott [15] Arcuri, Bacher, Myhr [16] Baruah, Potthast [17] Bacher, Ott, Potthast [18] Sorgeloos [19] Schwerdtner, da Silva [20] Almeida, Arcuri, Ekerhovd [21] Kaiser, Potthast

differences of boundary conditions derived from parallel work of ecologists are communicated to the consumers. Vice versa ecological research on increased effort of sustainable production has to take into account the limited surplus monetary effort that may be put into changing the production conditions, e.g. in aquacultures to keep them in an economically sustainable operation range. It is to be expected that consumer habits and expectations differ substantially across Europe, so the consumer related investigations should be locally diversified to be representative[22].

Within the range of researching the consumer backlash on the marine environment, a better understanding what consumers accept as palatable is required[23]. So far only a limited number of mostly traditional aquatic species have qualified as food within Europe. Even in this range the quality requirements have risen in the last decades, e.g. with respect to the amount and distribution of fish bone, the look and feel of the merchandise or the size of the marketed specimen, regardless of the ecotrophological value[24]. Only a few 'new' species have entered the mass market segment, as the East-Asian Pangasius, with specific sustainability and ethic problems by themselves. But there are lots of other ones yet unfamiliar to the standard European citizen, like the whitings (Cyprinidae), the smelt (Osmerus eperlanus), or the sea cucumber (Holothuroidea). In contrast to East-Asian eating habits appreciating quite a lot of mollusk species as food, the European dietary habits concentrate on 'real fish', with only a few exceptions like shrimps in the mass market. It is therefore desirable from a research point of view to investigate the willingness of consumers to change to other aquatic food species that can be assessed as more favourable from an ecological point of view[25] even if it may need increased industrial pre-processing (like appropriate de-boning, or removal of unpalatable parts). To address this research direction a close cooperation of market researchers, ecologists and food conditioning representatives is encouraged.

Last but not least, the research on sustainable aquatic food, creating an objective of an almost global scope, needs a broad public communication of its results in order to create a practical effect and a public involvement across Europe[26]. Accordingly, provisions should be taken in the later stages of the research initiative to publish *all* obtained results in a publicly accessible way without any procurement costs and with explicit and royalty-free permission for reproduction if the original source is cited. Since the preparation of respective research results will require a respective effort it must be made clear to any contributing researcher that this method of publication is part of his or her project and that it is not negotiable.

It is even suggested to create a publicly advertised topic oriented electronic publication & communication platform, or at least a sub-platform in a framework of related interactive sites, to induce a discussion on the outcomes of the research initiative, and motivate personal involvement[27] and further research progress beyond the limited time of research founding for this topic cloud.

[22] Almeida, Ekerhovd, Potthast [23] Ott [24] Almeida [25] Bjorndal, Ott, Quaas [26] Piccardi, Potthast. Proelss
[27] Almeida

3.4.2 Wicked Problems: Simulation and Participative Governance

As the discussion of the pareto principle (see also Fig. 1) implies there is no single 'optimal' solution to the underlying problem of cross-influencing and mutually curtailing maritime activities, even though only one solution, comprising development target definitions for a multitude of human action areas, can be chosen as the one to be agreed upon and realized in a multi-stakeholder context. Therefore the research activities can be split into two major aspects: i) to generate solution suggestions as close as possible to the pareto frontier, and ii) to develop an arbitration schema that is mediating between the involved stakeholders but resting them assured that there will be no 'really better', dominating solution at the time of discussion, rendering the subjective tradeoff as inevitable.

The comparison of a multitude of conceivable solutions[28], leads to relatively varying fulfillments of the individual target aspects. Since there is, by definition, no objective arbitration of target values against each other, this basic scenario system delivering any calculatable or at least rankable value of interest *individually* (e.g. population sizes, water quality, energy harvesting numbers, social product of related stakeholders, political viability of treaty agreement, gross monetary product numbers for the involved branches, ethical acceptance of induced changes in nature) has the best chance of being objectively acceptable beyond the limits of each disciplinary community. In this respect it will ideally support the first aspect, without arousing too early arbitrating stakeholder discussions[29]. Even beyond this purely objective solution alternatives sampling, decision makers of very different proveniences should come to terms in excluding very extreme solution sets (e.g. no fishing activities altogether, all fishing activities only by members of one country, etc.), thereby cutting the extreme regions of the pareto front to generally acceptable absolute maximum/minimum limits[30].

The scenario system should comprise some essential features, creating a framework for individual disciplinary contributions:

Multi-target. As already detailed out, the various simulated 'target' objectives should be determinable individually without the necessity of relative weighing as aggregation. This will motivate open discussion on the subjective relative perception of individual goals[31]. This should provide possibilities of nonlinear/cross-effects consideration also.

Open structure. The system should allow an inclusion of arbitrary "simulators" by input-output-relations that may be quantitative, fuzzy-like or qualitative, in order not to exclude non-numerical approaches of the humanities but present them for consideration in resultant multi-target discussions.

Modular. The system layout should facilitate inclusion of new, or removal of out-of-date modules without breaking its general functionality. This property will enable a continuous inclusion and refurbishment of the individual contributions according to most recent findings without the danger of compromising the system as such.

[28] Fylling-Jensen, Holm, Mikkelsen [29] Holm, Mikkelsen, Proelss, Reid, Vestergaard [30] Hey [31] Gee, Mikkelsen, Moren

Multi-Species. There is evidence that the interdependencies of species development in ecosystems are numerous and strongly non-linear. Many aquatic species create an extensive food network, rather than individual and isolated food 'chains', with a magnitude of interwoven cause-and-effect relationships and a history and memory of past states[32]. The simulation system should be able to model those effects on the habitat as well as on the resultant human conditions by explicitly considering the temporal evolution of changes in scenario case studies[33].

Explicit consideration of modeling limits and inherent uncertainties. Allow for a definition of explicit uncertainty ranges of input variables as well as of functional dependencies that will propagate in cause-and-effect relationships into respective and temporally changing target value probability distributions[34]. By this means the resultant error margin of derived and indirect conclusions will become appearent. As of today the complexity of the interwoven food nets in the aquatic regime challenge the respective modeling effort[35] and limit stringent causal interpretation, making the probabilistic and food obtainment security oriented approach including disease emergence and spreading[36] next to indispensable.

Disciplinary modeling. Due to the different habits of setting up models in the contributing disciplines each pragmatic cause-and-effect description is expected to provide interfaces for triggering custom disciplinary simulations and receiving 'calculated' results for inclusion into a multi-targeting display output.

In this modeling effort a great stress should be given to the aspect of explicit and quantified insecurity representation[37]. This will create the basis for future appreciation and reduction of lacks of knowledge, and bring a very important aspect to the front: the appropriate identification and management of risks[38]. Dealing properly with this major objective will help to identify robust system constellations[39] for a sustainable aquatic food provisioning on a European scale. It will also enable a comparison of fishing and aquaculturing[40] on a multi-criterial output basis.

One of the main purposes of the scenario simulation system will be the identification and stimulation of the trans-cultural and trans-disciplinary discussion of safety margins and their perception[41], especially so with a special communicated stress on the basic target objective of sustainability. Again this necessitates a close cooperation of social sciences field studies and members from the environmental sciences that need to define variation spans and margins in an objective and quantitative manner[42].

3.4.3 Managing Societal Impacts of Fishing and Aquaculture

The amount of contemporary fishing activities in conjunction with modern fishing gear shows a striking excess capacity and is the widely accepted reason for the almost ubiquitous fish population decline and a reduction of yields. As there is no reasonable way back to the

[32] Borme, Piccardi, Poudel, Reid [33] Reid [34] Kuikka, Poudel [35] Moren [36] Baruah [37] Gee, Kuikka, Poudel [38] Guillen, Kuikka, Moren [39] Froese, Mikkelsen, Poudel [40] Kraus & Döring, Reid, Vestergaard [41] Hey, Holm, Moren, Potthast [42] Fylling-Jensen, Guillen, Poudel

inefficient but fish population saving methods of former decades and centuries[43], aproaches must be found that will satisfy several targets at the same time without inducing too adverse social and economic side effects in a multi-national perspective[44]. The mere qualitative definition of this task directly implies a pareto-optimizing basic research approach on food yields, social care for involved persons, targeted support for the at least temporally superfluous engineering and ship construction industry, and a ‘fair’ distribution of aquatic food resources over fishing fleets of several nations. It may be anticipated that after some recuperation time for the fisheries a more intense fishing may be taken up again, thus rendering less of the present gear and manpower as excess capacity, but a decisive reduction will have to take place[45].

The existing models on the development of fisheries as a function of the fishing intensity indicate that a temporally limited interval of strongly decreased fishing would help most fisheries to recover from overfishing. But even a temporary reduction of fishing activities will create relevant opportunity costs for fishers and aquatic food post-processing industry branches, not exploiting the currently agreed legal limits, just to keep, at least partially, facilities functional for a resumed increase in production as soon as the fisheries have recovered. These opportunity costs will be distributed very disparately across European participants in the fishing business as this branch is contributing in very different shares to the national economies, affecting the societies and thereby the indiviual citizens in very differing ways[46].

On the other hand it must be taken into account that opportunity costs are not real costs, and a perseverance on the status quo featuring a pronounced overfishing will postpone the irrevocably looming negative effects on the same communities just for some years[47]. In order to promote a coordinated approval of the relevant stakeholders this issue of assessment and adequate consideration of reduced fishing opportunity costs into environmental, industrial and social strategies in a multi-national approach must be offensively addressed[48]. In a joint ecological, social sciences and economic approach the reduction of the fishing intensity, its distribution over the member states and the bearability effects for the immediately and indirectly affected population should be researched[49], considering the important difference of opportunity costs of individuals bearing the burden of their work and income being taken away, and the reduction/limitation of potential future yields in former expanding businesses.

Compared to sea fishing aquacultures are localized activities with respective impacts on mostly local environmental and socio-economic settings. Nevertheless farther reaching effects must be considered for several aspects like implications for epidemiologic considerations in human healthcare and bycatch utilization as fishmeal, originating in far-away fishery exploitation[50]. Aquacultures are by far more subject to deterministic handling and planning, as their respective settings are immediately resulting from human action. In practice this leads to an immediate and principal arbitration of economic payoff versus fulfilling necessary ecological, healthcare and potentially ethical obligations, at least partially counted in monetary effort for the operation of a culture[51].

Even without considering genetic manipulation there is a wide and yet unfathomed field of

[43] Bekker-Nielsen, Borme [44] Bjorndal, Froese, Stuart [45] Bjorndal, Borme, Hey [46] Bjorndal, Dankel, Piccardi, Potthast, Quaas, Stuart, Vestergaard, Vidas [47] Hey [48] Froese [49] Bjorndal, Proelss, Vidas [50] Jover, Myhr, Sorgeloos [51] Bacher, Baruah, Fylling-Jensen, Kaiser

adapting cultivating boundary conditions[52]. Most of these adaptations will remain in the realms of disciplinary treatment, or at least can be settled by closer cooperation of adjacent fields like marine ecology and biology[53]. These are not considered in broader detail in this research proposition outline, even though they play an important role in aquaculture innovation.

As in almost every intensive, industrialized utilisation of environmental resources aquacultures alter the conditions of the neighboring water body and its surfaces in a non-neglectable fashion. Promoting the raised environmental awareness of modern citizens, proactive political regulations for instantiating new or enlarging existing aquacultures tend to be very restrictive up to the point where economically motivated entrepreneurship becomes stifled. This leads to an aquaculture-specific but interdisciplinary research necessity of developing objective indicator numbers on the impact of human induced environmental alterations, together with research on the influence of an economically oriented operation of an aquaculture on these numbers[54]. In this context the economic perspective must be regarded as well. Medium to large scale aquacultures will produce food output quantities in industrial dimensions that may alter the economic and potentially the social balance of a regional market[55].

In forthcoming years larger numbers of artificial structures for wind energy harvesting are to be expected in not too deep open sea areas. Using this infrastructure dedicated to above-sealevel activity for creating aquaculture waterbody sectioning may yield synergetic reuse effects of alternative domain structures for food production activities[56]. It remains to be investigated whether such a reuse can create an economic bonus.

The generation of aquatic food by aquacultures is not limited to open marine water bodies. There is a long tradition of sweetwater aquacultures, producing trouts, perches and similar fish as human food. As the respective cultures are landborn and feature defined boundaries of the constituting water body they are subsumed here as closed water body systems. Some objectives of open water body aquacultures apply to them as well.

A major concern is the ecologically sound and economically sustainable acquirement of food for the typically intensively operated cultures as the majority of the cultivated species are carnivorous fish. Beside feeding on bycatch originating fishmeal alternative sources of nourishment should be investigated, like targeted breeding of larvae that feed themselves from decaying organic matter and thus do not compete with human food production[57].

In recent times the improvement of process engineering even suggests to set up landborn saltwater aquacultures that are more complicated in their operation control but may save transportation energy and cut substantially on the effort to keep the easily perishable fish meat fresh, especially when supplying inner-continental markets. To assess the feasibility of such approaches an assessment on both ecological footprint and economic sustainability of landborn saltwater aquacultures should be initiated that directly from its start compels the affected disciplinaric researchers to concentrate on the likely boundary conditions imposed by the cooperating faculties[58].

[52] Baruah, Sorgeloos [53] Jover [54] Bacher, Bjorndal, Jover, Kuikka [55] Fylling-Jensen, Kaiser, Mulyati, Ott, Sorgeloos [56] Alexander, Sorgeloos [57] von Büren [58] Waller

Regarding landborn aquacultures as mere providers of faunal protein, they are direct local competitors to standard terrestrial animal rearing. Accordingly both ecological and economic aquaculture assessment should also elaborate the direct comparison of fish vs. land animal meat products[59].

As water purification in Europe is predominantly organized quite near to the pollutant inputs, e.g. agricultural fertilizers or liquid urban waste, to keep the rivers as clean as possible, an extension of the aquaculture idea to in-land units may be considered. Based on the technical feasibility of arbitrary aquaculture vegetables and fish rearing in respective basins an economically feasible approach may arise to synergize protein production and wastewater cleaning[60]. Doing so, the socio-cultural effect must not be forgotten, though: The notion of potentially toxic organic waste being the foundation of a food-chain may not be very attractive to many Europeans, so the potential medical, ethical and ecologic by-effects of such an approach must be scrutinized very thoroughly[61].

Another viewpoint on sustainable aquatic food provision is the one looking from the end of the food chain back to its origin[62]. With other words, the generation of aquatic food and its ecotrophologically relevant content should be assessed with respect to different qualities (amounts of provided food, environmental impact, energetic requirements, ...) regardless of the method of procurement[63]. From this perspective an unbiased comparison of the different methods of fishing and culturing is possible with certain externally defined objectives[64], like a desired prospective increase in aquatic food production under the condition of a limited environmental change, the amount of international treaty reorganisation[65], the foreseeable fluctuation of amounts etc. It concentrates completely on the outputs of human aquatic food procurement and thus creates a circumspanning assessment perspective.

An interesting interdisciplinary aspect, although mostly within the regime of the social sciences, is the attribution of historically developed professional roles that dominate the socio-cultural integration of the aquatic food related professions into society[66] and gender-specific roles in aquatic food procurement along the fundamental schism of hunting in opposition to rearing. It is to be investigated by a joint effort of gender and sociology research if the paradigm change causes further social or cultural effects especially on those societies that incorporate the aquatic food production as one of their major and traditional areas of professional engagement[67].

On a second layer of evaluating the results of a unified multi-target scenario system, the tradeoff between identified pareto solutions must take place to finally identify the single solution that can be accepted and is prone to be realized by all stakeholders[68]. This layer is mostly occupied by political and legislative discussions on different scales[69]. On a small scale it may only involve the residents of an estuary, on a large one representatives of the whole of Europe[70]. Even though these arbitrating discussions and the resultant decision making will reflect the much larger scope of respective political affairs they will have to take into account some essential properties of the matters being treated[71]: i) Individual target values can only be given with a limited precision[72];

[59] Potthast, Pucher [60] Sorgeloos, Waller [61] Ott [62] Fylling-Jensen, Kraus & Döring [63] Almeida, Holm, Kraus & Döring [64] Arcuri, Kaiser [65] Hey, Potthast, Proelss, Vidas [66] Mylona, Nervi [67] Kaiser, Mylona [68] Fylling-Jensen [69] Proelss [70] Kaiser, Potthast [71] Hey, Proelss [72] Kuikka

ii) target values are subject to change in future, due to new insights and discoveries, but without knowing in advance into which directions new findings will point. This renders any weighing decision taken (in the sense of an entered treaty) as intrinsically provisional and subject to future changes to keep it aligned with its original intent[73]. Several international historic and existing treaties on open sea utilization showed that they were kept up in spite of more recent contradicting scientific or economic findings[74].

This aspect includes explicitly the research on how to manage internationally exploitable resources, the 'commons', adaptively[75]. Reiterating historic cases[76] — with explicit consideration of cases beyond the aquatic food harvesting domain — political and juridic research should scrutinize past treaties that turned out workable or impractical as a function of the magnitude of later-on occurring changes in boundary conditions they originally related to[77]. With the perspective of expectable objective boundary condition variations in the regime of aquatic food generation, to be intensively discussed with representatives of the respective research domains, the political and juridic research should point out likely success paths as well as looming trapholes[78], including the means of enforcing agreements that have been taken[79].

The adaptivity of stipulated treaties also has to deal with foreseeable transitional phases of inappropriate capacities in the aquatic food chain without lashing them up for prolonged periods of time[80]. Accordingly, respective means of setting up relaxating rulesets have to be juridically researched in close cooperation with social and communication scientists in order to mind and communicate the needs of the affected segments of the population, yielding comprehensible guideposts for individual and corporate planning security[81].

A closely related topic mostly located within the regime of humanities, but spread over various disciplines, is the disparity of attitudes exhibited by local or professional groups and their political representatives who enter international contracts[82]. Including the communication sciences, research should be performed how to align the self-understanding of regional organisations with the procedure of agreeing to rules on an international treaty level[83]. This research may even be exemplaric for many other communication domains as well that feature a larger vertical hierarchy from the affected individual to the treaty entering representative on an international level.

3.4.4 Global Cooperation: Knowledge and Uncertainty

Without any doubt, the fishery management in the open seas is the most difficult one: It involves many stakeholders with differing personal attitudes, many nations with differing cultural and historic backgrounds[84], and complex networks of biological, environmental, climatic and technical interactions on the long path from basic vegetable life forms to the 'fish on the dish'. Even in the 'objective' domains like biology, climatology and environmental sciences

[73] Hey [74] Bremer, Proelss, Vidas [75] Froese, Hey, Mikkelsen, Proelss, Schwerdtner [76] Bekker-Nielsen, Borme, Bremer, Kaiser, Schwerdtner, da Silva [77] Potthast, Proelss [78] Borme, Hey, Kaiser [79] Proelss [80] Vidas [81] Froese, Kaiser, Potthast [82] Bacher, Bremer, Proelss, Stuart [83] Bacher, Bremer, Fylling-Jensen, Hey, Stuart, Vidas [84] Borme, Schwerdtner

large realms of causal ignorance remain due to the non-resolvable interconnections of mutually depending causalities[85].

Without any human interference the aquatic systems will develop into certain states of equilibrium that must not be regarded as static, though, but rather as continuously evolving, depending on the changing natural boundary conditions. In this context the term ‘equilibrium’ is designating a comparatively slow global variation that seems to have had the ability to tackle environmentally imposed boundary condition changes in historic time dimensions. Observed over short terms is not a static one, as is appearent from effects of medium and long-term climatic variations like the El Niño oscillation in the Pacific. Similar, but less widely known oscillations as the North Atlantic and the Arctic oszillation affect immediately the aquatic bodies next to Europe. Their quantitative influence on the aquatic biology and environmental settings is not known in sufficient detail, thus leaving a large range of ignorance with respect to ‘natural’ variation of the assumed equilibrium[86]. Recent climatological research indicates that even the underlying oscillations may be subject to mankind induced global phenomena, like global warming or an increased direct absorption of CO_2 into the oceans causing a change of the acidity of the sea water[87].

This in turn defines a core topic of multidisciplinary research activities. The stress of these proposed activities is not so much the determination of maximal possible amplitudes, but rather the probability distributions of the basic effects and their propagation of uncertainties under likely variation spans[88]. Reflecting the activities of contributing disciplines this necessitates an earliest possible communication on likely impacts of one partial system on the other[89]. As the focal point of the research lies in the range of aquatic food generation the causal effect chain should be back-tracked to the point where induced likely changes either become infinitesimal or in their variation spans so large that further backtracking is in vain[90]. Here growing backtracking variation spans do not necessarily imply non-predictiveness since even large stochastic spans of a partial cause may only lead to small deviations in the target value. The predominant disciplinary boundary condition is, however, that the variational effects are to be scrutinized in value regions that apply to the encountered natural situations[91].

As boundary conditions in different water bodies like the Arctic Sea compared to the Mediterranean may differ significantly the approaches for result oriented comparison should explicitly consider respective differences as well[92].

Risk and ignorance assessment is tightly interwoven with international treaty fixing and vertical attitude alignment. It is addressing the fact that even objective cause-and-effect relations are subject to external stochastic disturbances and a non-disappearing amount of modeling fuzziness of expected future developments, e.g. the influences of climatic changes or the development of aquatic food related industry. Depending on the differing importance of the aquatic food generation branch for any individual European society, but also on its cultural roots and generally aquired views, these unknowns are valuated differently[93]. In international discussions, as well as in local discussions between representatives of different segments of the affected

[85] Kaiser, Mikkelsen [86] Moren, Vestergaard [87] Vidas [88] Mikkelsen, Potthast [89] Holm, Moren, Vestergaard, Vidas [90] Proelss [91] Kuikka [92] Tzanatos [93] Kuikka, Stuart, Vestergaard

population, these differing mindsets will need to come to agreeable conclusions by successful communication processes[94]. Here communication scientists are asked to research and propose viable procedures that are immediately mindful of and relate to the mindsets of people that need to come to terms in the aquatic food generation discussion. This relation should be consolidated by immediately taking into account researched socio-cultural investigations of the respective communicating groups[95].

Research on sustainable meliorating of the European aquatic food procurement must also take into account that a large part of aquatic food consumed in Europe is imported from other regions of the world. A larger number of developing countries is selling respective products in order to get strong currencies, while at the same time the sold food lacks on the local markets and leads to local protein-related malnutrition if not even to an encompanying overfishing of the respective fisheries far away from Europe[96]. On the other hand the trading of fishing products may enhance a local economy considerably and create economic resources for fruitful landborn development[97]. As a result the impact of international fish trade on local markets of developing countries must again be investigated in an interdisciplinary manner that includes ethics and health-care considerations, but touches world-wide fishery management and politics as well[98].

[94] Bremer, Fylling-Jensen, Mulyati, Stuart, Vidas [95] Kuikka, Moren, Potthast [96] Arcuri, Holm, Pucher [97] Ott, Piccardi, Pucher [98] Arcuri, Bjorndal, Dankel, Kaiser, Mylona, Potthast, Quaas, Vestergaard, Vidas

4. Conclusions

There are various aspects in drawing conclusions from the undertaking of creating interdisciplinary research suggestions in the limited area of *sustainable generation of aquatic food* that proved, on the other hand, very interconnected with respect to the involvement of a larger number of scientific disciplines and humanities, including various arts. Accordingly the conclusions will be split up into content-related and methodological ones. In the scope of the methodological aspects the limitations of the involved people will be taken into consideration as this is a general property certainly transferable to other larger problem sets as well.

4.1. Generated Interdisciplinary Suggestions

The practical introduction of true interdisciplinarity in a pragmatically defined area of action may be roughly differentiated into i) general implications and requested attitudes of participants in respective research undertakings, ii) general thematic interconnections that stem from perceived needs and shortcomings by disciplinary actors in former research efforts, and iii) specific opportunities of individualized actions that arise from detailed research suggestions.

4.1.1 General Implications

The melioration of the present state in the generation of aquatic food, as it is deemed unfavourable, requires the basic assumption that there are causal relationships between a multiplicity of scientific, technical, social, juridic, political, ethical, medical etc. system defining parameters and the various target values that are taken to describe and assess the state of the system in an equivalent number of dimensions. The causal relationships, as complicated and delicate as they are constituted, create the basis of purposeful interaction by creating appropriate models. These models may both be assessed in their adequacy of description and evaluated with respect to parameter change effects forecasting by defining scenarios and comparing their outcomes to the human expectation. Even the actual setting of real world boundary conditions is nothing else but a single scenario testing, but the one with an uncompromisable claim of correctly rendered causal effects even if we do not understand or like them as is the case in the presently observed depletion of oceans. If this basic assumption of causality is dropped, i.e. the assumption that the purposeful setting of parameters implies an influenced outcome is questioned, the general idea of the possibility of a targeted melioration is abandoned.

In this context it should be stressed, though, that pragmatically relevant models cannot be restricted to classical, mathematical ones but must include qualitative dependencies, common beliefs and traditional or historical observations without accountable interconnections. This leads to a principal interdisciplinary activity: the development of a circumspanning modelling framework for the pragmatic topic area, but with the essential understanding that such a modelling effort will need the participation of every involved discipline. Its general scope should integrate and interconnect maritime ecology and operations control, as well as traditions and political agreements. Since such interdependencies are by no means simple a respective model will be subject to an ongoing and long-term overhauling effort even on its basic assumptions and represented causal interconnections. Special care should be taken to explicitly address the usual shortcomings of scientific modelling efforts: the scrutiny of systematic errors and stochastic / fuzzy system responses, and the limitedness of extrapolation beyond well-known system constellations.

A major practical aspect of an interdisciplinary approach is the necessity to accept the loss of the primacy of one's own discipline. Every participant in an interdisciplinary action should be prepared to do research not only at disciplinary frontiers of a given problem but to accept limits imposed by other disciplines, leading to mediocre target qualities from one's own disciplinary point of view. Some examples from the heart of this research proposal are: What does it help to point to the beneficial reduced pollution effects of less dense/intensive aquacultures if the resultant economic balance for the aquaculture operators is so bad that their social position in society is no more maintainable? Can seal hunting or whaling be generally condemned due to ethical reservations if a whole society obtains most of its food from such a resource? Does it make sense to research increased fish swarm detection sensitivity if the applied detection technique is already leading to over-exploitation of fisheries?

Disciplinary actions envisioning the larger perspective can pragmatically be addressed only if interdisciplinary cooperations are sought immediately at the start of a research or development initiative in order to identify all required aspects to be considered and to prevent inappropriate targeting.

Interdisciplinary approaches towards sustainability of aquatic food generation need respective communication — not only within the small circles of highly educated scientists, humanity researchers, governance representatives and larger scale stake holders, but also including a much broader public as there is a vast amount of implicit knowledge acquired from practical experiences. Even if this knowledge is unreflected and instance-specific in many cases it must not be left aside but needs to be actively called by raising a broad willingness of civil participation in this process through abundant communication of activities. As a result, the definition of an interdisciplinary research program approach should, besides the objective of the research itself, immediately organize and fund an appropriate barrier-free multi-directional communication process.

It is suggested to create respective distributable media (brochures, films, ...) to disseminate research results. There should be no access limitation by fees or difficulty of availability. As this provision of synoptical and detailed results handling is creating significant workload by itself there should be a certain amount of means dedicated just for this purpose.

4.1.2 General Thematic Interconnections

The content related results of the immediate workshop discussions mostly pointed to general approach suggestions that should be born in mind in the process of including interdisciplinary objectives in future research programs. A strong aspect was the explicit inclusion of cultural diversity within the parties involved in a future research community, leading to quite different views on basic features of food generation and post-processing, up to the point where even the quality of the products with respect to a general acceptance as food remains to be researched. A general methodological perspective in this respect may be the turn to collective negative research topic selections as a mutual exclusion: What nourishment contents would no one accept as food? Which practical approaches to fishery or aquaculture operations would be supported by no one involved in the decision process of aquatic food generation? Starting at this point a subsequent question may be which remaining aspects may be subject to strong antipathetic feelings in part of the jointly researching, and aquatic food generating and devouring community. If such are identified the development process of a structured negotiation on tolerated, even though not welcomed practises could be a next step of interdisciplinary research. Here very concrete settings down to very technical and scientific details will be important factors, like the handling of by-catch the strategies of herding and similar.

As any locally implemented strategy concept always has effects on the mostly globalized markets and thereby on very distant alternative local implementations the investigation of the relation of scales is a further general aspect of research. Suggesting any strategy by means of a respective setting of boundary conditions (like quota, relative shares, occupation of geospatial resources, etc.), as well as keeping existing boundary conditions valid, will unavoidably lead to a certain path of development that is also influenced by historic developments, governance settings and climatic conditions. This in turn creates a wicked problem that manifests itself in the fact that even identical decisions on human settable boundary conditions may lead to quite different outcomes. In order not to drop the basic human attitude of an intendedly meliorating exertion of influence vast regions of yet unknown causal and stochastic relationships have to be mapped in a long-term effort, always re-questioning former relations taken as true. This is a major effort to which all involved disciplines have to contribute to, including those that usually operate on qualitative relations. The aspiration must be to align both quantitative and qualitative modelling approaches. In the design of a respective research effort it must be explicitly taken into account that this is not a one-time effort but a substantial and ongoing labour.

Aquatic food generation by itself is not dependent on increased research efforts — it exists and will develop anyway based on the practises and historical settings of today. So any research effort must integrate existing stakeholders and their specific restrictions as well as their expectations. If research agenda fail to do so they are likely to fail their purpose. Public opinion and common views play similar roles as individual stakeholders. There is a broad distributed knowledge about aquatic affairs that must be integrated, as qualitative and diffuse as it may be. Failing to do so will render research results noncommunicable and prone to become disregarded with respect to practical relevance.

The aspect of food generation efficiency is to be considered in an interdisciplinary way as well: So far research activities dedicated to fishing and aquaculturing activities have mostly been separated. Rather, it should be unified on the basis of the outcome of products and the various efforts that must be undertaken to generate it.

4.1.3 Differentiated Individual Research Suggestions

In addition to the general, abstracted research suggestions presented in the last section a plentitude of potential individual interdisciplinary objectives has been identified by scrutinizing and relating the initial research suggestions of the workshop participants delivered in written form. Section 3.4 presents them in detail, and by their very nature it is not sensible to reiterate them at this point. They are highly specific and reflect to a certain extent the disciplinary foundation and specialization of the respective contributor(s).

Nevertheless one example shall be taken out of this section that provides a certain comparison of the nature of global vs. detailed research suggestions: the design of an appropriate simulation based scenario system. While a more global approach (Sect. 4.1.1) predominantly describes the aim and the limitations of a respective interdisciplinary modelling enterprise the in-detail suggestions point towards concrete details of a potential implementation. Defining and explaining the mandatory objectives of a future modelling system (multi-target, open structure, modular, multi-species, explicit naming of limitations, explicit dealing with uncertainties, concurrent disciplinary modelling) the fine-grained research suggestions try to contour the scope of suggested research requirements that should be asked for in new transnational and at least partially interdisciplinary invitations for research tenders.

Even though concretized research suggestions are necessary if they are to be integrated into larger thematically oriented research programs they are always prone to attract objections and disagreement in the group of research objectives definers, so to say stakeholders in the research administration business. Each individual suggestion can be questioned with respect to its relevance to a larger encompassing research framework, but this touches the realm of subjective vs. objective importance trade-off on a higher level and cannot be the objective of the contents level discussed here. Instead, the demonstrated possibility to extract practical interdisciplinary research objectives from individually suggested proposals, together with the modified approach explained in the next section, should be taken as an indication that the general pursued method to derive relevant detail suggestions from a stimulated discussion between the disciplines is of practical use.

4.2. Methodological Conclusions

The present effort to generate interdisciplinary research suggestions in the field of sustainable aquatic food generation was organized as a mostly linear process:

Assembly of established disciplinary capacities in related scientific and humanities areas,

→ first collection of suggested interdisciplinary areas of activity,

→ definition of a first scope of ideas, to generate an invitation to young scientists to contribute,

→ collection of further suggestions from young scientists,

→ definition of a steering committee consisting of five established researchers chosen from different disciplines: economics, history, law, maritime ecology & fishery, philosophy,

→ composition of a contributions primer in consultation with the steering committee members; redistribution to the participants of the subsequent live workshop, to familiarize them with the gathered ideas and topics,

→ two days intensive live discussion with contributing capacities in a workshop at the BBAW; session structuring of the workshop and chairing of sessions performed by the steering committee members,

→ evaluation of discussion threads by steering committee members and organizers of the workshop; independently, evaluation of written suggestions with respect to emerging interdisciplinary research fields,

→ composition of summarizing documents.

By its definition it was strongly oriented towards the personages that could be enthused to participate, and their individual approaches to and their views on the topic of aquatic food sustainability. Keeping in mind that most of the numerous contributing disciplines are represented by one or two individuals only, while even each disciplinary discussion certainly comprises a facet of interpretations of respective results, the gathered research suggestions are subject to a certain amount of subjectivity and randomness even though they are sensible and logical by themselves if the arguments of the proposers are acknowledged.

Significantly increasing the number of involved individuals in an otherwise unchanged procedure may certainly reduce this randomness to a certain extent but will hit upon other limits that must be kept in mind:

- The organisational as well as the monetary effort to realise the fruitful live discussion increases significantly.
- As there is no immediate benefit for the participants the arising costs cannot be transferred to them or their institutions.
- Evaluation and abstraction of an even larger amount of individualized interdisciplinary research suggestions creates a pinch point for the individuals in charge of this process.
- There is no reflection loop implemented yet that would allow for the typical incremental development of the more difficult, complex and unfamiliar approaches.

Judging from the feedback of the participants an ongoing discussion on the various initiated topics would have been highly welcomed but could not be provided within the scope of this first approach to interdisciplinary research topics generation.

Evaluating the experiences of this project a changed procedure is suggested that tries to address the identified shortcomings. It includes means to realize a better systematic coverage of disciplinary approaches, creates reflection loops, and provides means to carry on discussions that are initiated throughout the process. The changed procedure at the same time tries to conserve the perceived benefits of the tested one. The subsequent bullet list contains exemplary clarifications from the sustainable aquatic food regime to facilitate the comprehension of the suggestions.

∘ As a starting point established capacities of the contributing fields in the sciences and humanities are identified. They are asked to identify and collect disciplinary sub-topics that may relate and contribute to the pragmatic interdisciplinary field in question. As a secondary task they should check that the initial scope of addressed disciplinary fields is exhausting, or indicate otherwise what they regard as lacking, potentially with naming experts in the lacking fields. *Revisiting the range of disciplines involved in the present effort the following ones seem lacking: human and veterinary medicine, mathematical modelling, operations control, sociology, fine arts. They have been partially represented by delegates of other disciplines but respective participants would have been welcome if stemming from the core fields.*

  This searching process is pursued until consensus is reached that the required fields are gathered.

→ If not already achieved, at least one established representative of every disciplinary field is motivated to participate in the interdisciplinary discourse.

→ Established disciplinary capacities collect important disciplinary core topics that are relevant to the pragmatic interdisciplinary objective. At this stage an in-depth individual topic definition is explicitly not desired. Instead, a short paragraph on the meaning or interpretation of the named core topics is requested that elucidate the topic to an interested bystander and/or disciplinary colleague. *Reversing the topic identification process of the current project one could, for example, identify the sub-topics 'international law', 'national legislative processes', 'local governance', and 'public participation in law-making' for the larger disciplinary area of 'law'.*

→ Collection and systematisation of identified disciplinary (sub-) topics by the organisers of the interdisciplinary research topic identification process. They take up the preparatory work of the the last step, edit the topics in an discipline-spanning intelligible manner to construct a multi-dimensional matrix of potentially interconnected issues. Categorically this leads to the identification of any topic constellation of the kind $\{$discipline$A$.topic$B$ $\times$ discipline$C$.topic$D$ $\times$ $\ldots\}$. The number of disciplines to connect can lie between two at least, and the total number of involved disciplines, leading to some thousand individual interdisciplinary cooperative topics as matrix elements. Even though such a large number is not even approximately allocable in terms of individual research suggestions this matrix representation will serve as an ordering schema that can be investigated with respect to a more or less dense occupation in regions. *This categorisation approach is lacking in* *the present approach so far, leading to a missing reflection on placement of individually identified interdisciplinary topics as well as the identification of mostly undiscussed potential collaboration fields.*

→ Redistribution of the potential topic matrix to interested discussion participants. The established connection matrix will be returned to the already identified disciplinary capacities together with the request to suggest interdisciplinary research topics and to categorize them into that matrix. The systematized introductory elaboration will be taken to raise interest in young scientists to participate in the topic finding process and to suggest categorized topics on their own. *This step was not envisaged in the present invitation methodology. Rather the young scientists were confronted with the same unstructured and not to be reflected freedom of topic definition that led to more or less disciplinary suggestions in many cases.*

→ The resultant topic suggestions from all participants are collected and categorized by the organizers of the interdisciplinary topic generation process. A part of this evaluation is a reordering of the order of disciplines and their sub-topics in order to identify densely populated regions of the interconnection matrix, as well as larger unfilled ranges. *Again, this component is lacking in the present approach. It will be, and would have been, helpful in structuring the subsequent workshop with respect to its required thematic structuring. The layout of the actually carried out workshop has been somewhat random and subject to personal preferences of the session chairs.*

→ Workshop with intensive discussion, both on thematic clouds and on individual suggested interdisciplinary topics. The workshop will be organized along the lines of identified densely populated topic ranges as well as void regions. The densely populated clusters will be checked if they can be interconnected even further by scrutinizing so far not mentioned but potentially obvious additional topic connectivities, to coagulate the suggestions to larger research fields prone to raise and maintain a lively discussion culture when being treated.

  The mostly void spaces of the interconnection matrix will be revisited to identify fields of interdisciplinary action that may have been forgotten or that just had not been the principal choices of mentioning for the comparatively few participants. The results of the discussions will be minuted and made up by the workshop organizing team. *The actually held workshop addressed a lot of individual topics that were discussed quite deeply. This did not lead to concretized research suggestions to be incorporated into later research tenders, though. Topic ranges not addressed by the former written suggestions were neither identified, nor reflected or revisited.*

→ Preparation of workshop discussion results for a subsequent internet forum discussion. Due to the plenitude of identified and discussed individual topics and the scarcity of time the fathoming of each of them is principally restricted. In addition, necessary iteration loops for reflection are not possible for a one-time event like a workshop. In order to facilitate such a reflection process leading to a more precise formulation of worthy research areas each individual topic will be entered as a single thread into an internet based bulletin board. Participants of the workshop and further interested people, e.g. colleagues of the participants, will have access to this moderated discussion forum. *This additional component to the general discussion process was already discussed by the workshop participants and regarded as supportive. It could not be realized in the current procedure due to restrictions in required manpower. Additionally it would have necessitated the subsequent step of post-processing that had to be dismissed for the same reasons.*

→ The internet based afterdiscussion of addressed topics in a bulletin board system provides the possibility for the participants to reflect exchanged views and derive new conclusions for stating the objective of individual interdisciplinary research suggestions more precisely. The topics will be open for discussion in individual threads for a certain time (assumed: two months) or until the discussion intensity subsides. Upon closing the threads the discussion results will be collected and evaluated by the organizers.

→ The resultant whitelist of interdisciplinary topics will be finally made up and assembled into a final report. This report will be make openly available without any access limitation.

It is expected that this improved procedure will address the shortcomings identified during the first approach of the generation of interdisciplinary research propositions for pragmatically defined topics like the ‘Sustainable Aquatic Food Supply’.

A. List of Participants and Suggestion Contributors

Due to time scheduling and health reasons some anticipated participants were not able to attend the workshop physically, even though they provided proposals as discussion basis. Accordingly they are included in the subsequent list and the subsequent submitted proposals appendix.

Karen Anne ALEXANDER

Post-Doctoral Research Associate

Scottish Association for Marine Science (SAMS)
Scottish Marine Institute
Oban, Argyll
United Kingdom

Cheila ALMEIDA

PhD student

CO, FC, Lisbon University
CENSE, FCT, New University of Lisbon
SIK – The Swedish Institute for Food and Biotechnology
Sweden

Alessandra ARCURI

Associate Professor

Rotterdam Institute of Law and Economics (RILE) and Department of International Law,
Erasmus School of Law
Erasmus University Rotterdam
Rotterdam
The Netherlands

Kathrin BACHER

PhD student

Centre of Advanced Studies (CEAB-CSIC)
University of Barcelona
Spain

Kartik BARUAH

Post doctoral researcher

Laboratory of Aquaculture & Artemia Reference Centre
Department of Animal Production

Faculty of Bioscience Engineering
Ghent University
Belgium.

Tønnes BEKKER-NIELSEN

Associate Professor

Institute of History
University of Southern Denmark
Denmark

Trond BJORNDAL (member of steering committee)

Professor
Director of CEMARE

Centre for the Economics and Management of Aquatic Resources
Portsmouth Business School
University of Portsmouth
Portsmouth, Great Britain

Diego BORME

Research Scientist

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
Trieste
Italy

Scott Ronald BREMER

Researcher

Centre for the Study of the Science and the Humanities (SVT)
University of Bergen
Norway

Daniela VON BUEREN

Master's student

Zurich University of Applied Sciences
Wädenswil
Switzerland

Dorothy Jane DANKEL

Researcher

Center for the Study of the Sciences and the Humanities
University of Bergen
Norway

Ralf DÖRING

Workgroup Leader

Institute of Sea Fisheries
Johann Heinrich von Thünen-Institute
Hamburg
Germany

Nils-Arne EKERHOVD

Research Fellow

Institute for Research in Economics and Business Administration
Bergen
Norway

Damian FERNANDEZ JOVER

Institute of Oceanography and Fisheries
Split
Croatia

Rainer FROESE

Senior scientist

Helmholtz-Centre for Ocean Research (GEOMAR)
Kiel
Germany

Øyvind FYLLING-JENSEN

Managing Director of Nofima AS

Nofima
Tromsø
Norway

Jennifer GEE

Senior Research Analyst

Seafood Ecology Research Group / GAPI Project
University of Victoria / University of Portsmouth
United Kingdom

Jordi GUILLEN

Post-Doctorate Researcher

IFREMER, Marine Economics Department
University of Brest
France

Ellen HEY (member of steering committee)

Head of the Department and Professor of Public International Law

Erasmus School of Law
Rotterdam
The Netherlands

Poul HOLM (member of steering committee)

Trinity Long Room Hub Professor of Humanities

Trinity College
Dublin
Ireland

Matthias KAISER (member of steering committee)

Head of the Centre for the Study of the Sciences and the Humanities

Faculty of Humanities
University of Bergen
Norway

Gerd KRAUS (member of steering committee)

Head of Institute

Institute of Sea Fisheries
Johann Heinrich von Thünen-Institute
Hamburg
Germany

Sakari KUIKKA

Professor of fisheries science

Head of the FEM research group
University of Helsinki
Finland

Øystein LIE

Professor at University of Oslo,
Executive Manager MareLife www.marelife.no

Project Manager Oslo Innovation Center
www.forskningsparken.no
Founder GenoMar AS, www.genomar.com
Norway

Eirik MIKKELSEN

Research Director

Social Science Research
Norut - Northern Research Institute
Tromsø
Norway

Mari MOREN

Head of Research

National Institute of Nutrition and Seafood Research,
Bergen
Norway.

Heti MULYATI

PhD Student

Chair for Production and Logistics
Faculty of Economics Sciences
Georg-August-Universität Göttingen
Germany

Anne I. MYHR

Senior Scientist

GenØk - Centre for Biosafety
Tromsø
Norway

Dimitra MYLONA

Post-doctoral Fellow

Institute for Aegean Prehistory,
INSTAP — Center fo East Crete
Greece

Cristina NERVI

PhD student

Archeology Department
University of Genoa, Italy

Konrad OTT

Professor for Environmental Ethics

Institut für Botanik und Landschaftsökologie,
Ernst-Moritz-Arndt-Universität Greifswald
Germany

Martin PASTOORS

Professor

Centre for Marine Policy
Wageningen University
The Netherlands

Eliana PICCARDI

PhD student

Université de Gênes & Université de Aix-Marseille
Gênes
Italy

Thomas POTTHAST

Associate professor

International Centre for Ethics in Science (IZEW)
University of Tübingen
Germany

Diwakar POUDEL

Assistant Professor

Norwegian School of Economics and Business Administration (NHH)
Bergen
Norway

Alexander PROELSS

Professor

Department of Law,
University of Trier
Germany

Johannes Gregor PUCHER

Research assistant, PhD student

Life Science Center,
University of Hohenheim
Germany

Martin QUAAS

Professor

Department of Economics
Christian-Albrechts-Universität zu Kiel
Germany

Chris REID

Principal Lecturer

Department of Economics and Finance
University of Portsmouth
United Kingdom

Christine RÖCKMANN

Scientific researcher

IMARES (Institute for Marine Resources and Ecosystem Studies)
IJmuiden, The Netherlands

Kathleen SCHWERDTNER MAÑEZ

Lecturer

History of Marine Animal Populations Project
Bremen University
Germany

Antonio José Marques DA SILVA

Post PhD Researcher

Histoire et Archéologie
Universités de Coimbra/Porto
Portugal

Patrick SORGELOOS

Associate professor

Laboratory of Aquaculture & Artemia Reference Center
Bio-Science Engineering
Ghent University
Belgium

Heather J. STEWART

Tutor at the University of Edinburgh

School of History, Classics and Archaeology
University of Edinburgh
United Kingdom

Evangelos TZANATOS

Lecturer for Marine Ecology-Fisheries Management

Department of Biology,
University of Patras
Greece

Niels VESTERGAARD

Professor in Resource Economics and Head of Centre for Fisheries & Aquaculture Management & Economics (FAME)

Department of Environmental and Business Economics
University of Southern Denmark

Davor VIDAS

Research Professor

Director of the Law of the Sea and Marine Affairs Programme
Fridtjof Nansen Institute
Lysaker, Norway

Uwe WALLER

Associate professor

Faculty for Mechanical Engineering
University of Applied Sciences Saarbruecken
Germany

B. Research Suggestions by Workshop Participants

The following sections contain the contributions of the workshop participants, both senior and young scientists, in alphabetical name order.

Due to time scheduling and health reasons some proposers were not able to attend the workshop physically, even though they provided proposals as discussion basis. Accordingly their suggestions are included in the subsequent sections.

Some of the contributions are slightly edited in order to make them conform to the general intention of the European research topic generation process, or comprise extracts of submitted original publications that point into respective directions suggested as desirable for a European interdisciplinary research program.

B.1. Karen A. Alexander: Offshore renewable energy development and sustainable aquatic food supply

Introduction

Humans depend on ocean ecosystems for food, climate regulation and transport. However human activity is having a detrimental impact on these very goods and services on which we all rely [1]. As our seas become more industrialised, increased competition for marine space will lead to further pressure upon existing users and potential conflict [2]. In particular, development of the offshore renewable energy sector will have implications for the fishing industry by limiting access and navigation [3] and potentially have impacts (positive and negative) upon commercially fished species [4]. For an industry already under substantial regulation including total allowable catches (TACs), minimum mesh sizes and limits to time spent at sea, fishers view expanding development in the marine space as a threat to their potential to fish and thus to sustain livelihoods [5]. This project will investigate the relationship between fishing and marine renewable energy, assist conflict resolution and contribute towards a decision-making framework for policymakers/planners regarding the sustainable availability of aquatic food.

MREDs and associated infrastructure will be placed on the seabed, affecting important sources of food for many species of commercial importance [6]. Two plausible beneficial consequences of MRED installations are the ‘artificial reef (AR) effect’ and the ‘exclusion zone effect’ (Figure 2), already used as management measures which contribute towards conservation and fisheries sustainability [7]. The placement of artificial structures (such as MREDs) on the seafloor will lead to altered habitat which may increase refuge and food availability and enhance recruitment and thus increase biomass [8, 9]. Additionally, it is likely that exclusion zones will be created around offshore installations which may turn the areas into no-fishing zones, potentially protecting spawning stock biomass and creating enhanced catches in adjacent areas [10, 11].

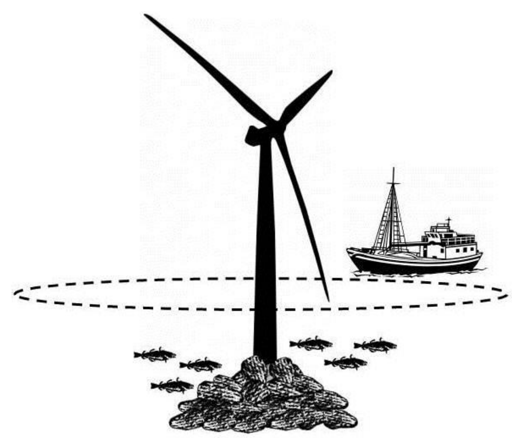


Figure 2: *Rock armouring (at base of turbine), used to prevent scour, will become an artificial reef. The turbine may also act as a fish aggregating device. The dotted line represents an area within which fishing (particularly mobile gears) may be excluded.)*

Research objectives

To date, few observational or experimental studies have been undertaken to assess the effects of MREDs on the fishing industry and the ecosystem upon which the industry relies. However, modelling (using a representation of a system) of the marine environment has been used to provide indications of how the ecosystem is likely to change in response to the cumulative effects of MRED installations and how this will subsequently affect the fishing industry [5]. However, the coarse spatial scale of this study (which attempted to model the entire west coast of Scotland) was a large simplification of reality. A key finding was that a higher resolution and more localised model would be more useful, where the differences in spatial extent between artificial reefs and exclusion zones may give a more realistic prediction of the amplitude of these effects [5].

The key objective of this study is to assess if, on a local scale (single installation site), MREDs can benefit the ecosystem, and provide benefits to the local fishing economy, by creating a) habitat through the 'reef-effect' and b) protection through the 'exclusion zone effect'. This research will also investigate differences and similarities between alternative installation sites.

Methodology

The study will use an integrated method, combining ecological, social and economic data in a modelling approach. Ecosystem modelling software Ecopath with Ecosim and Ecospace (www.ecopath.org) would be used to spatially model a number of single MRED installation sites. This would allow for artificial reef and exclusion zone scenarios to be tested, and the effects upon both the fishing industry and the ecosystem upon which they rely to be identified. The development of individual models for a number of installation sites will enable a cross-site comparison.

This study will engage with offshore renewable energy developers and the fishing industry (using a methodology such as the conflict resolution tool described in Alexander et al [12]). This will enable the collection and sharing of data such as bathymetry, seabed type and fishing ground locations, as well as bringing both sets of stakeholders together for a win-win approach.

The expected duration of this research project is 36 months.

References

[1] Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, et al. A Global Map of Human Impact on Marine Ecosystems. Science. 2008;319:948-52.

[2] Harte MJ, Campbell HV, Webster J. Coastal space use conflict and marine renewable energy development. Shifting Shorelines: Adapting to the Future,The 22nd International Conference of The Coastal Society. Wilmington, North Carolina2010.

[3] Mackinson S, Curtis H, Brown R, McTaggart K, Taylor N, Neville S, et al. A report on the perceptions of the fishing industry into the potential socio-economic impacts of offshore wind energy developments on their work patterns and income. Science Series Technical Report. Lowestoft: CEFAS; 2006. p. 99pp.

[4] Rodmell SD, Johnson ML. The development of marine-based wind energy generation and inshore fisheries in UK waters: are they compatible? In: Johnson MW, C, editor. Who owns the sea? Tjarno, Sweden: North Sea Commission, Aberdeen; 2002. p. 1 - 38.

[5] Alexander KA. Offshore power production and marine stakeholders: from understanding conflict to impact mitigation: University of Aberdeen/University of the Highlands and Islands; 2012.

[6] Tait RV, Dipper FA. Elements of Marine Ecology. 4th ed. Oxford: Butterworth-Heinemann; 1998.

[7] Claudet J, Pelletier D. Marine protected areas and artificial reefs: A review of the interactions between management and scientific studies. Aquatic Living Resources. 2004;17.

[8] Bohnsack JA. Are High Densities of Fishes at Artificial Reefs the Result of Habitat Limitation or Behavioral Preference? Bulletin of Marine Science. 1989;44:631-45.

[9] Powers SP, Grabowski JH, Peterson CH, Lindberg WJ. Estimating enhancement of fish production by offshore artificial reefs: uncertainty exhibited by divergent scenarios. Marine Ecology Progress Series. 2003;264:265 - 77.

[10] Roberts CM, Polunin NVC. Marine Reserves: Simple Solutions to Managing Complex Fisheries? Ambio. 1993;22:363-8.

[11] Sale PF, Cowen RK, Danilowicz BS, Jones GP, Kritzer JP, Lindeman KC, et al. Critical science gaps impede use of no-take fishery reserves. Trends in Ecology & Evolution. 2005;20:74-80.

[12] Alexander KA, Janssen R, Arciniegas G, O'Higgins TG, Eikelboom T, Wilding TA. Interactive Marine Spatial Planning: Siting Tidal Energy Arrays around the Mull of Kintyre. PLoS ONE. 2012;7:e30031.

B.2. C. Almeida: Analysis of Consumer Habits to Find Solutions for more Sustainable Fish Consumption

My proposal is to analyse consumer habits and find solutions for more sustainable fish consumption, relating it to both environment and socio-economic aspects. The approach strives to solve the problem through the consumers' point of view and to find in what extent food habits can be changed.

Portugal would be the case study since it has the highest seafood consumption per capita in Europe (Smith et al. 2010). It has a strong heritage culture, traditions, activities and also food supply from the sea. It should be interesting to study the environmental consequences of the seafood consumption and how food habits impact on the marine resources. Seafood consumption has direct consequences such as overfishing and damage to the marine ecosystems. A sustainable seafood movement has emerged and consumer-based campaigns have grown to help the way seafood production can be more sustainable. But very little change has occurred in Portugal.

There are three main topics to be considered in the individual consumption: (1) to reduce fish waste; (2) to reduce the fish intake proportion per meal; (3) and to choose sustainable fish sources.

1. The most important care that a consumer needs to take is not to waste food. One third of food produced for human purposes is wasted in the production chain between the sources and homes (Gustavsson et al. 2011). Fish is a natural resource and has a production cost. As consumers we are responsible for those costs even if we can't measure them.

2. Recommendations for protein intake per meal are around 1/3 of the ordinarily plate. In that way, people in the developed countries eat more meat/fish than they do need from the nutritioun point of view. To reduce fish proportion per meal is a small effort that can be beneficial for the health and for the environment at the same time (Oken et al. 2012).

3. The third topic, related to the consumer choices, aims at diminishing the lack of information when it relates to food production (Standal and Utne 2011). Modern life styles extended the gap between production and consumption food systems. Nowadays the supply chains are more complex and there is a lack of knowledge about where food does come from. Fish can come from many different sources and there is a variation between them both from an environmental and ethical point of view (Mitchell 2011). It also depends on the species, the stock, the country, the fishing gear, or the household preparation method (Pelletier & Tyedmers 2008). Without such knowledge it is difficult to make decisions and there is a need for transparent methods in the food production. Consumers need information, answers to compare different food, and food education programs. Certification is also an essential tool when it relates to communicate with the consumers (Jacquet et al. 2009). But depending on the country and on cultural traditions, different consumption habits can be adopted. There are countries where the

meat production is easier instead of fish and there are others where fish is the main protein source. Local food production and seasonality must be considered as well.

The project is only possible with the interdisciplinary work. Different research fields are necessary to promote a sustainable seafood supply, including sustainable consumption, biology, and sociology. Different groups of the society should be addressed to promote the implementation of measures. The work should be made together with NGOs to make possible to communicate in a broader way, companies from the supply chain, and schools, to spread the information through educational programs. Only with a broad work group it will be possible to achieve resolutions and to apply them to change the way we eat fish.

References

Gustavsson et al. 2011. Global Food Losses and Food Waste Report. FAO, 25 pp.

Jacquet et al. 2009. Conserving wild fish in a sea of market-based efforts. Oryx, 44: 45-56.

Mitchell 2011. Increasing fish consumption for better health - are we being advised to eat more of an inherently unsustainable protein. Nutrition Bulletin, 36: 438–442.

Oken et al. 2012. Which Fish Should I Eat? Perspectives Influencing Fish Consumption Choices. Environmental Health Perspectives. 120(6): 790–798.

Pelletier & Tyedmers 2008. Improving Sustainability Assessments in seafood awareness campaigns. Environmental Management. 42 (5): 918-931.

Smith et al. 2010. Sustainability and Global Seafood. Science, 327: 5967, 784-786 pp.

Standal, D.; Utne, I. 2011. The hard choices of sustainability. Marine Policy. 35(5): 19–527.

B.3. A. Arcuri: The Global Governance of the Aquatic Food Supply Chain: Legal Tools for Enhanding Sustainability

While the depletion and overexploitation of fish stocks are well-documented phenomena (FAO, 2012), the international instruments to remedy this situation are few and little effective (e.g. the United Nation Convention on the Law of the Seas (UNCLOS) and the FAO Code of Conduct for Responsible Fisheries). The lack of more effective international treaties may be ascribed to the fact that international agreements for the protection of global public goods are costly to achieve because of the 'collective action' problems and the uncertainties over the potential benefits involved (Houser et al. 2000). Given the underdeveloped international legal regime, this research proposal aims at investigating whether and in what ways other governance regimes could enhance the sustainability of world fisheries and aquaculture.

The global nature of the food supply chain demands solutions of transnational nature. In the absence of satisfactory international law, what legal means can be employed to achieve such types of solutions? In many fields, including fisheries, global supply chains starts to be governed by private regulatory regimes. What characterizes private regulation is that the actors establishing the regime are private and the authority of the regulatory regime is not granted by the state: 'under non-state-market-driven (NSMD) governance, the relatively narrow institution of the market and its supply chain provides the institutional setting within which governing authority is granted and through which broadly based political struggles occur' (Cashore, 2002, p. 506). For aquatic food supply, the Marine Stewardship Council (MSC) and Friends of the Sea (FOS) labels are representative examples of these schemes. Such schemes can also be seen as tools to amplify the effects of public international law. For instance the MSC certification and eco-labeling program are consistent with the United Nations FAO guidelines for fisheries certification. Given the growing importance of NSMD governance mechanisms, it is crucial to understand how these private regulatory regimes operate and to what extent they do/can contribute to the achievement of more sustainable aquatic food chain. Some recent research has brought to light vulnerabilities of these schemes by showing that some seafood stocks certified by the MSC or FOS are in fact overfished stocks (Froese and Proelss, 2012).

While important research has been conducted on how to improve private schemes in the field of sustainable fisheries (Oosterveer and Spaargaren, 2011), insufficient attention has been devoted to the 'interactional' dimension of these regimes. These private regimes, in fact, do not act in isolation but are often interacting with public laws. Thus, in order to investigate how they could be improved, it should be further researched, the mutual interplay of the private and public regulatory schemes dealing with the protection of fisheries.

In particular it will be investigated how existing public law already affects these system (e.g. EU regulations on fisheries; Regulation (EC) No 710/2009, on organic aquaculture, US Marine Mammal Protection Act, etc.). To what extent are the provisions of NSMD schemes going beyond the standards set by existing public law rules? To what extent are they developed following concepts, such as the one of Maximum Sustainable Yields, entrenched in much public international law?[99] Are there instances in which public regulation refer to private schemes? Are there cases of conflicts? Are the discourses promoted by different sets of regulatory schemes different, complementary or irreconcilable? In answering these questions, the research will try to map how different international, national and private regulatory schemes interact and, how, together they (may) form a regime for the global governance of a sustainable aquatic food chain.

This descriptive analysis will be complemented by the study of how public regulation could possibly enhance the effectiveness of private/voluntary regulatory schemes in reducing the depletion and overexploitation of fish stocks. For instance, it could be argued that disclosure of information relating to the sustainability of fishing practice should be made mandatory. In this case, reference can be done to existing schemes or national schemes for certification should be adopted. Even more strongly, governments could demand that all fish products are certified and may ban the imports of non-certified fish products.

Such possibly synergic interaction should in turn be studied against the background of international trade law. The laws of the World Trade Organization (WTO) in fact may influence this body of polycentric regulation in several ways (Young, 2011).[100] Firstly, environmental and technical regulation adopted by WTO Members should comply with WTO rules, most importantly with the so-called environmental exception (Article XX GATT) and with the Technical Barrier to Trade (TBT) Agreement (Roheim and Sutinen, 2006). The recent dispute over the US regulatory schemes for the labeling of dolphin-safe tuna (US – Tuna II) is an example of the types of issues that may arise in these cases (Arcuri, 2012). One interesting rule at the WTO is the one that establishes adherence to international standards as one of the benchmarks to test the compliance of standards and technical regulations with the TBT Agreement.[101] While international standards are not defined with precision, it seems that private regulatory schemes, complying with certain criteria, could qualify as international standards. This may mean that schemes, such as the MSC could possibly be considered as international standards, within the meaning of the TBT Agreement.[102] Thus, paradoxically, the compatibility of public law regimes with WTO law may be determined by private regulatory schemes. Finally, if private governance

[99] For an analysis of the concept of maximum sustainable yield in public international law, see Hey, 2012. Private regulatory schemes may prove more adaptive to change and thus more quickly be able to endorse and operate with concepts that may best address the problems affecting fish stocks. [100] Negotiations on the controversial question of fisheries subsidies have been undertaken at the WTO level. However, at the time of writing these negotiations are stalled. If those negotiations will be resumed it may be interesting to investigate how a WTO specific discipline of fisheries subsidies would affect the governance of sustainable aquatic food supply. An overview of these negotiations is available at the WTO website: http://www.wto.org/english/tratop_e/rulesneg_e/fish_e/fish_e.htm

[101] Cfr. Article 2.4 of the TBT Agreement which reads: Where technical regulations are required and relevant international standards exist or their completion is imminent, Members shall use them, or the relevant parts of them, as a basis for their technical regulations except when such international standards or relevant parts would be an ineffective or inappropriate means for the fulfilment of the legitimate objectives pursued, for instance because of fundamental climatic or geographical factors or fundamental technological problems (emphasis added).

[102] Yet standards, to qualify as international standards have to comply with a set of principles such as openness, transparency, impartiality and consensus, effectiveness and relevance, coherence and improving participation of developing countries. From this vantage point it can be argued that the WTO has a transformative power and in fact it can be seen as explicating global administrative law (GAL).

schemes have the potential of playing such influential role, it should be considered their possible impacts on developing and least-developed countries.

This research proposal aims at involving different disciplines. If lawyers are clearly necessary to understand the interactions of different existing regulatory frameworks and to judge the legal soundness of possible changes, social scientists and marine biologists are crucial in identifying vulnerabilities of the effects of the legal tools studied, and to assess what reforms may most effectively address the problems of depletion and overexploitation of fish stocks.

References:

Arcuri, A., 2012. 'Back to the Future: US-Tuna II and the New Environment-Trade Debate', European Journal of Risk Regulation, 2012.

Bush, S.R. and Oosterveer, P., 2007. 'The missing link: intersecting governance and trade in the space of place and the space of flows', 47 Sociologia Ruralis, 384.

Cashore, B., 2002. 'Legitimacy and the Privatization of Environmental Governance: How Non-State Market-Driven (NSMD) Governance System Gain Rule-Making Authority', 15 (4) Governance 502.

FAO, 2012, The State of World Fisheries and Aquaculture, Rome. Available at http://www.fao.org/docrep/016/i2727e/i2727e00.htm

Froese R, Proelss A., 2012. 'Evaluation and legal assessment of certified seafood', Mar. Policy http://dx.doi.org/10.1016/j.marpol.2012.03.017

Hey, E., 2012, The Persistence of a Concept: Maximum Sustainable Yield, The International Journal of Marine and Coastal Law (forthcoming).

Houser, D., Bial, J. R. and Libecap, G. D., 2000.Public Choice Issues in Collective Action: Constituent Group Pressures and International Global Warming Regulation (July 20,). Available at SSRN: http://ssrn.com/abstract=235285 or http://dx.doi.org/10.2139/ssrn.235285

Oosterveer P. and Spaargaren G., 2011. Organising consumer involvement in the greening of global food flows: the role of environmental NGOs in the case of marine fish, 20 (1), Environmental Politics , 97–114

Roheim and Sutinen, 2006. Trade and Marketplace Measures to Promote Sustainable Fishing Practices, ICTSD, Fisheries, Trade and Sustainable Development Series, Issue Paper 3.

Young, M. A. 2011. Trading Fish, Saving Fish: The Interaction between Regimes in International Law, Cambridge University Press.

B.4. Kathrin Bacher: Factors shaping the perception of aquaculture in Europe

In addressing costal management and aquaculture it is essential to strike a balance between the need for economic development and the need for natural resources conservation. The global growth of aquaculture involves the expansion of cultivated areas and a higher density of aquaculture installations potentially leading to negative impacts on the environment and portions of the society when unregulated and badly managed. A key aspect of developing a sustainable industry is to appreciate the range of opinions about aquaculture's economic, social and environmental benefits and costs. In the past insufficient effort has been devoted to understand the different ways that communities and officials perceive natural resource issues and to find ways to build mutual understanding and improve communication (Mazur & Curtis 2008). Insufficient participation and consultation of relevant stakeholder groups and members of the public could lead to mismanagement of resources and social conflict and/or decreased public support and confidence (Kaiser & Stead 2002). Including information on the range of views on aquaculture is therefore essential for governments and the aquaculture industry to develop a socially acceptable and sustainable industry.

Exploratory studies have shown that the social perception of aquaculture is influenced by the perceived risks of the activity, such as human health risks (Verbeke et al. 2007) and environmental impacts (Whitmarsh & Wattage 2006), the level of trust in the industry and government (Mazur & Curtis 2006), socio-economic benefits and costs (Katranidis et al. 2003), individual knowledge about aquaculture (Kole 2003), media representation of aquaculture (Schlag 2011), local circumstances (Whitmarsh & Palmieri 2009) and individuals' values and experiences (Verbeke et al. 2007). Whitmarsh & Palmieri (2009) reported marked differences in attitudes towards aquaculture between different actors of the aquaculture sector and the wider public revealing a complex web of interests and tradeoffs. However, to date it is not known which factors are most important in shaping social perception of aquaculture. There is a variety of individuals and groups who have a specific interest in aquaculture, such as consumers of farmed seafood, people that live close to farms, governments, scientists, NGOs, and other economic activities in the coastal zone (e.g. tourism, fishery) which will all be affected in different ways and whose opinions are most likely influenced by distinct aspects of aquaculture. The aquaculture sector in Europe is very diverse with many different cultivating systems; therefore opinions about this sector are likely to differ among different countries and regions.

To date there is a lack of a study that investigates all the above mentioned factors in an integrative approach to reveal which are the most important aspects affecting social perception of aquaculture among different stakeholder groups and among different European countries. This knowledge will serve the society as the different perspectives can be integrated in future aquaculture development, but will also help the industry by giving specific recommendations to reduce uncertainty about its products and farming practices in different areas in Europe.

I propose the following three main questions:

1. What are the different perspectives that communities and stakeholders have of aquaculture?
   - Which are the risks and benefits that people associate with aquaculture?
   - How much do people trust the aquaculture industry and policy-makers?
   - What do people know about aquaculture and what information do they rely on?
   - Are opinions about aquaculture based on knowledge or on values and emotions?
   - How do perceptions of different respondents compare and contrast?
2. How do perceptions on aquaculture differ among EU countries and regions?
   - How do the key social, economic and environmental features of an area shape the perception of aquaculture?
   - Which are the key factors shaping the perception of aquaculture in different regions?
   - How do perceptions on different sectors of the aquaculture industry differ?
3. How can the knowledge of perspectives on aquaculture help the industry and government to build a more sustainable and socially acceptable sector?
   - Which are the implications of the survey findings to improve industry communication, education and marketing?
   - Identify examples of successful integration of aquaculture in local communities and discuss how an exchange of experience and know-how can help to improve the situation in another area
   - Develop options and strategies for addressing negative perceptions of the aquaculture industry

This study requires an inter-disciplinary approach that combines the disciplines of environmental sciences, biology, social sciences and economics in order to gain a better understanding of the environmental, social and economic concerns of different sets of the society. Especially the experience of social scientists is needed in eliciting and understanding social perception.

A possible approach could include the focus group methodology (e.g. Kitzinger 1995) or the Q- Methodology (Stephenson 1953, Brown 1980) to gain an in-depth view of the perspectives, experiences and interests of selected sub-groups of the public. The detailed information gained from these exploratory investigations can then be used as a basis for a survey on a statistically representative sample of a larger population.

References

Brown SR (1980) Political subjectivity: applications of Q methodology in political science. Yale University Press, New Haven

Kaiser M, Stead SM (2002) Uncertainties and values in European aquaculture: communication, management and policy issues in times of "changing public perceptions". Aquaculture International 10:469-490

Katranidis S, Nitsi E, Vakrou A (2003) Social acceptability of aquaculture development in coastal areas: the case of two Greek islands. Coastal Management 31:37-53

Kitzinger J (1995) Qualitative Research: Introducing focus groups. BMJ 311:299-302

Kole APW (2003) Consumer opinions towards farmed fish, accounting for relevance and individual knowledge. In: Luten JB, Oehlenschläger J, Ólafsdóttir G (eds) Quality of fish from catch to consume Labelling, monitoring and traceability. Wageningen Academic Publishers, Wageningen

Mazur N, Curtis A (2008) Understanding community perceptions of aquaculture: lessons from Australia. Aquaculture International 16:601-621

Mazur NA, Curtis AL (2006) Risk perceptions, aquaculture, and issues of trust: lessons from Australia. Society & Natural Resources 19:791-808

Schlag AK (2011) Aquaculture in Europe: Media representations as a proxy for public opinion International Journal of Fisheries and Aquaculture 3:158-165

Stephenson W (1953) The study of behavior: q-technique and its methodology, Vol. University of Chicago Press, Chicago

Verbeke W, Sioen I, Brunsø K, De Henauw S, Van Camp J (2007) Consumer perception versus scientific evidence of farmed and wild fish: exploratory insights from Belgium. Aquaculture International 15:121-136

Whitmarsh D, Palmieri MG (2009) Social acceptability of marine aquaculture: The use of survey-based methods for eliciting public and stakeholder preferences. Marine Policy 33:452-457

Whitmarsh D, Wattage P (2006) Public attitudes towards the environmental impact of salmon aquaculture in Scotland. European Environment 16:108-121

B.5. Kartik Baruah: Interdisciplinary Approach to Understand the Emergence and Control of Disease in Aquaculture Production Systems

The aquaculture sector is the fastest-growing animal food-producing sector in the world, providing a significant supplement to, and substitute for, wild aquatic organisms as well as terrestrial animal protein. However, diseases, caused by bacteria, virus and/or parasites, are the primary constraint to the growth of many aquaculture species and pose a serious and continuing threat to food security, food safety, national economies, biodiversity and the rural environment. Despite this, the mechanisms underlying disease emergence are still not fully understood, and effective broad spectrum anti-infective measures are not developed. The aquatic environment is a complex ecosystem which makes the distinction between health, suboptimal performance and disease obscure. Incidents of disease in this complex system are not solely natural occurrences but are due to the direct or indirect effects of various drivers of disease emergence. These include ecological, political, and socioeconomic drivers, such as climate change, urbanization, globalization (rising volumes of trade within and between countries, potentially transporting disease organisms), agricultural intensification, and breakdown of public health measures. This indicates that there present several challenges in understanding the underlying causes of disease outbreak in the aquaculture system and accordingly developing effective eco-friendly preventive and treatment measures. To address these challenges, the different disciplinary or multidisciplinary approaches to infectious disease research and intervention design are proposed. The need of the hour is to bring together different academic disciplines like natural sciences (aquaculture nutritionist, microbiologist, immunologist, ecotoxicologist, physiologist, biochemist, molecular biologist), social sciences along with farmers and policy-makers to identify the underlying causes of disease outbreak as part of a broad strategy to prevent their emergence, to find answers to burning issues and developing strategies to implement science-based tools at the field and national levels to ensure sustainability of aquaculture. The multidisciplinary approach is used in a variety of different setting including human healthcare, education, mental health and criminal justice. The concept is that it is best to address an issue or problem from all angles. The multidisciplinary approach is typically used in difficult, multifaceted cases and situation where a comprehensive response has the best chance of accomplishing the goals.

Intensive aquaculture to meet increasing food demand together with diversity of the species cultured, varying culture methods employed and impact of climate changes has resulted in breakdown of the delicate balance between the host, the pathogen and the environment. This has caused disease problems due to newly emerging and reemerging pathogens resulting in colossal losses to the industry and consequent livelihood issues. Local disease problems have become global in certain instances due to the transportation of live aquatic animal across boundaries.

It is an established fact that aquaculture is expanding rapidly with Asia contributing substantially to the global food security and in turn serving as a major economic activity in several developing countries. Sustainable production calls for adoption of scientific aquaculture practices keeping in mind the environmental impact due to inappropriate management. The indiscriminate use of antibiotics and other chemicals has resulted in problems of antibiotic resistance among bacteria, accumulation of chemicals including antibiotic residues, causing ban on aquaculture products by importing countries. There is an urgent need to look at alternatives to antibiotics and other chemicals by developing ecofriendly technologies. The advent of geographical information systems in providing data on climate changes, water quality and consequent disease prediction will enable to take suitable action plan by the aquaculturists. Risk assessment therefore is of paramount importance. Thus, an inter-disciplinary approach is required by scientists and all concerned working in the aquaculture sector to develop appropriate strategies for the sustainable production of aquatic animal food by disease management. To achieve this several levels, such as capacity building in diagnostics, increasing the awareness among farmers on good husbandry practices through eco-friendly management measures such as vaccination, probiotics, immunostimulants, bioremediators etc., needs to be constantly developed and implemented.

B.6. T. Bekker-Nielsen: Long-term consequences of marine harvesting — A case study in the Black Sea

A comprehensive understanding of the consequences of human harvesting for marine stocks and ecosystems is a precondition for a sustainable exploitation of the world's oceanic resources. Attaining such an understanding, not to mention the consensus necessary for its political implementation, is far from easy. Among the obstacles facing researchers are (1) the absence of a baseline, (2) the problems of using catch data as a proxy for marine populations, (3) the difficulty of distinguishing short-to-medium-term consequences of anthropogenic impact (fishing, pollution, destruction of marine habitats) from medium-to-long-term oscillations due to non-anthropogenic causes. A crucial problem with respect to (3) is that the periods for which historical data are available represent a tiny span of the oceans' long ecohistory – in the case of the Mediterranean, for instance, less than 1/20,000th of the time since the reflooding of the Mediterranean basin is covered by textual sources such as catch statistics.

The Black Sea provides a positive exception to this general rule. It is a young sea, created some seven millennia before the present when salt water from the Mediterranean began to flow into what at the time was a freshwater lake; this irruption provides a clear baseline. Furthermore, the sea holds a unique eco-historical archive of fish remains that have sunk to the seabed during the last seven millennia and remain preserved in the anoxic environment of the Black Sea's lower levels (< -200m). Samples can be extracted from the seabed deposits using conventional coring equipment and since the deposits are varved, their contents can be dated to within a single year. A pilot study carried out in 2006 by Inge Enghoff (Natural History Museum of Denmark) and Vedat Ediger (Middle East Technical University) demonstrated that it was possible to identify and date fish remains from old cores extracted in the 1990's with a high degree of precision.

Using fresh cores and today's technologies for preservation and analysis (e.g., DNA sampling), it will be possible to trace the evolution of the Black Sea fish population in even greater detail. Since seabed deposits mainly derive from pelagic fish, these will need to be complemented by data from archaeological sites for benthic and estuarine species (e.g., turbot, sturgeon). By combining these sources of data and correlating the faunal history of the sea with known historical events on land, established hypotheses can be tested. For instance the impact of decreased fishing activity (e.g., following the plague epidemics of the 540's and 1340's) on the marine population; increased fishing activity due to changing demands (e.g., Roman fish processing in the first to third century AD, intensified fishing during the great famine of 1258, the introduction of modern canning and refrigeration technology in the twentieth century); or changes in the legal regimes (Roman, Byzantine and Ottoman law of the sea).

Unlike fishermen's catch records, which record only commercial species and cover decades or centuries, the seabed deposits of the Black Sea notionally provide a sample of all pelagic vertebrates in the ocean over several millennia. Retrieving, analyzing and interpreting them holds great promise but will require the combined skills of biologists, hydrographers, geologists, archaeologists, historians, legal historians and ethnologists.

B.7. T. Bjorndal, R. Arnason, F. Asche: Assessing and predicting the quantity of aquatic fish supply that can be provided in the future.

B.7.1 Comparing Aquatic Hunting and Farming

This research proposal is primarily concerned with assessing and predicting the quantity of aquatic fish supply that can be provided in the future. Aquatic fish supply stems from two sources; capture fisheries and fish farming. The former is limited by (i) nature's productivity and (ii) market demand. Market demand determines what capture products can be harvested profitably. The latter is primarily limited by (i) technology (both fish farming technology proper and genetic technology), (ii) space and other nature inputs for fish farming operations (e.g. clean water, sites), (iii) inputs from capture fisheries and (iv) market demand. Again market demand determines what fish farming operations can be run profitably.

This suggests the following avenues for research:

1. What is the nature upper bound on current capture fisheries supply.
2. What is the nature upper bound on all capture fisheries supply (if the necessary marketing would be implemented). This is less known but with the utilisation of zoo-plankton species, supply could possibly be tripled, but some people would say not sustainably. This suggests investigation into whether this can be regarded as sustainable.
3. Output limitations on fish farming (current species).
4. Output limitations on fish farming (new species, new marketing).
5. Response of fish farming supply to higher real prices.
6. The real limitation of capture fisheries inputs on fish farming output.

B.7.2 Aquaculture

In recent decades, aquaculture has been the world´s fastest growing food production technology. This is a development with a substantial potential, as on a planet that is covered almost three quarters with water, the world's oceans, seas and waterways have still only provided a limited share of its food supply.

Fisheries are the world´s last significant hunting industry, with limited potential to influence the ecosystems productivity as a food producer. The basis of aquaculture is the domestication of aquatic species. The control of the production process allows systematic R&D to be carried out to enhance productivity and foster innovation. Moreover, much of this innovation is relatively easy, as one can adopt knowledge and techniques from agriculture. The adoption of techniques goes well beyond the production process itself, as the value chain for many aquaculture products often resembles the value chain for agricultural projects rather than traditional seafood products.

Increasingly, one can also observe that the supply chain for some fisheries adopt this structure when the regulatory system allows it, with Icelandic cod as the best example.

However, the increased aquaculture production is also a new way to exploit marine ecosystems, and aquaculture activities can certainly create negative environmental externalities. To ensure environmental sustainability, many developed countries have implemented so strict regulations that the industry has little opportunity to develop. Hence, despite the fact that developed countries have the largest seafood markets and the best agroscience institutions, they are to a very limited extent participating in the food production revolution that aquaculture is leading in other parts of the world.

As both the US and EU import more than two thirds of the seafood consumed, it would be interesting to see how these countries contribute to the aquaculture revolution as prime buyers, how this influences the sustainability of the production in the export countries, and the difference in what is an acceptable product and production technology depending on origin (domestic vs imported) and how the regulatory systems influence this industry development. We also expect that impact on exporting countries to vary substantially depending on regulatory structure and governance in these countries.

B.8. Diego Borme: Fishermen of yesterday for the sea of tomorrow

Key sentence:

Compare the ancient and modern methods of exploitation of the sea, focusing on the critical points and considering their sustainability, both ecological and economical.

Starting consideration:

An amount of precious information is hidden in popular ecological knowledge. To reconstruct historical use of sea resources could be very interesting for understanding the actual situation of exploitation or depletion of some fish stocks. On the other hand, ancient fishing techniques, which nowadays are abandoned, were often sustainable and ecologically friendly. Some traditional fishing gears could be considered as alternatives to high-impact fishing, at least in sensible areas, and their selectivity could be studied to improve the selectivity of modern gears.

The knowledge about traditional fishing methods is close to be lost, since most of the fishermen which used them are very old. Thus, interviewing old fishermen and collecting historical information about ancient fishing, should be considered a priority.

In order to correctly interpret the bond between men and sea, as it once was, it is necessary to include the human sciences.

Main investigation methods:

Collection of existing data and interviews with key personalities of the local fishing culture. Data should be collected according to simplified and established schemes in order to facilitate the homogeneity of information and to ensure the maximum extension of the research. The work will mainly consist in collecting, reorganizing and critically assembling the existing knowledge.

Principal aspect:

Study the ecological and economic value of the different methods of exploitation of resources, both current and those no longer in use or historical. Combining various sociological and cultural aspects related to the use of resources, to fully understand the broader context of fisheries.

Involved subjects and their role:

- Ecology: collection of data on the by-catch and analysis of the impact on the ecosystem of various fishing gears; experimental fishing with traditional gears.

- Biology: collection of data and critical analysis of the biological characteristics (growth, longevity, size at first maturity, spawning period) of the main exploited species; filling of gaps in this basic knowledge.
- Aquaculture: study of ancient, traditional or extensive aquaculture activities taken as example of low impact on the environment; experimental cultivation of forgotten species, considered of minor economical importance, to diversify the market supply; restocking of species which are commercially appreciated but whose stock is endangered or locally overfished.
- Economy: economic analysis (in terms of cost / benefit) of the various fishing techniques; feasibility study of cultivation of minor species and restocking of endangered species.
- Sociology: analysis of the sociological aspects related to fisheries (fishermen age, level of education, family issues, ...).
- Law: organized collection of various laws regarding the exploitation of marine resources in the various countries, with particular attention paid to the passed legislation and to the shared exploited areas.
- Naval engineering: study of the characteristics of the hulls traditionally used in various types of fishing; projecting new hulls design that take into account the characteristics found to be best for fishing purpose.
- Material engineering: study of the characteristics of traditional fishing gears (from the point of view of materials) in order to propose biodegradable materials in future fishing (to avoid ghost-fishing and pollution).
- Geology: study of the relationships between type of exploitation and morphology of the coast and seabed; comparison among European regions.
- History: study of historical sources useful to reconstruct the progress in time of the exploitation of resources; particular attention should be paid to the seasonality of fishing and harvesting (to analyze eventual influence of climate change).
- Anthropology: study of the migration of peoples along the coastal regions; study of their culinary traditions, to better understand the market demand of the different European regions.
- Food sciences: study of dietary sources of marine origin, with particular attention to the ”poor” or ”forgotten” products; study of methods for their preparation, to be rediscovered; cooking workshops to popularize the use of by-catch products.
- Literature: collection of regional and dialectal names of the various fishery products; study of literary sources that consider the various aspects of life at sea, which will be used to understand the relationships between the different ethnic groups and the sea, as a tool to understand the cultural significance of sea exploitation.

- Mathematics: study of models that produce the hypothetical scenarios of exploitation using different fishing methods, with particular attention to the comparison of traditional methods and the modern ones.
- Educational sciences: proposals for dissemination and learning paths to inculcate a new consciousness of the sea, which takes inspiration from the traditional knowledge.
- Visual arts: organization of exhibitions and artistic events to raise public awareness on the issues of the exploitation of the sea (i.e. photographic exhibitions on marine themes; exhibitions and classes of naturalistic drawing; art workshops that use marine litter or waste materials derived from fishing).
- Communication sciences: development of a web-site to share information, to ensure the visibility of the project, to follow the progress in various disciplines; support in the production of literature (publication of articles and books).

Localization:

With regard to the more spread fishing techniques, the study will be replicated in different European regions. But it may be extended to any area where a particular fishing gear or technique is or has been used.

Time scheduling:

The project should last five years. A first phase should be devoted to agreement of the methodology. The second phase should be devoted to collection of data and analysis of incoming information using the methods consolidated during the first phase. The third phase should be devoted to sharing and assembling the results.

There should be bi-annual meetings among experts of each different discipline from different regions, to discuss the problems that emerged during the course of the project. Also should be made annual meetings among the leaders of all the involved disciplines, in order to allow the multidisciplinary approach.

Budget:

Since the data collection will be mainly based on interviews, consultation of historical sources and collection of existing data, the main expenditure items will cover the salaries of the staff involved (researchers and others) and the travel expenses. Therefore, the costs related to these activities strongly depend on the degree of extension of the research.

A certain amount of budget should also be provided for scientific experimentation and organization of workshops (i.e. testing of old fishing gears, simulating some particular fishing techniques, testing biodegradable materials, cooking workshops, artistic events, popular publications,...).

Strength of the project:

- Interdisciplinary character
- Integration of existing knowledge
- Recover of cultural heritage
- Relative cheapness of the main investigation methods

B.9. Scott Bremer: Aquaculture narratives of conflict — Embedding aquaculture in its social-political governance context

1. Aquaculture: a terrain for 'multi-faceted conflict'

The globe's insatiable appetite for seafood can no longer be supported by its oceans. With many wild fish stocks on the brink of collapse, this presents a serious threat to food security, with approximately three billion people globally dependent on seafood as their primary source of protein. Aquaculture is put forward as a potentially sustainable supplement to capture fisheries for aquatic food security, resulting in its rapid expansion since the late 1960s. However, this young and fast-growing sector has been similarly blamed with over-exploiting the resources of the coastal marine area; principally through stripping the world's oceans of 'trash fish' for feed, and causing significant localised adverse environmental effects (Naylor et al. 2000). In addition, as 'new kid on the block', aquaculture has clashed with other well-established coastal sectors. In this way, we can discuss the rise of aquaculture as a 'multi-faceted conflict situation'.

The multiple conflicts introduced by aquaculture can be broadly categorised as local or global. Localised conflicts are typified by: (i) competition for limited coastal space and resources between aquaculture and other sectors including shipping, tourism and capture fisheries; (ii) the adverse 'spill-over' effects of aquaculture on other coastal uses, and vice versa; and (iii) the adverse effects of aquaculture on local coastal ecosystems, through escapes or discharges of antibiotics for example. Simultaneously, globalised conflicts arise around themes of: (iv) food security; (v) fair trade; (vi) the impacts of taking trash fish; and (vii) a gap between perception and practice; relatively few people have knowledge of aquaculture, and their perception is often determined by negative media coverage and can be far removed from the reality in practice. Notwithstanding the diversity of these tangled conflicts, they do share three traits. First, they are characterised by a significant degree of complexity, and by extension, uncertainty. Second, they are characterised by a plurality of different perspectives on the definition of the conflict and its resolution. Third, they represent high political stakes, and are thus very controversial.

The conflicts surrounding aquaculture all have a history and a narrative. Indeed conflicts, over food security for example, can themselves be described as meta-narratives, where many divergent narratives clash. Here narratives are described as discursive representations of events and experiences, which bring together knowledge, values and worldviews towards political ends. As discussed by Somers (1994; p. 606), narratives have become concepts of social epistemology and ontology; they are how we "come to know, understand and make sense of the social world, and it is through narratives [...] that we constitute our social identities." Authors like Fløysand, Haarstad and Barton (2010), have recently begun to study aquaculture conflicts as narratives.

2. Seeing aquaculture in its social-political governance context

The first 30 years of the aquaculture boom saw an emphasis on state 'management' and 'planning' to specifically address aquaculture's adverse effects on the environment; framed as environmental or coastal management by both the academic literature (see e.g. Chua, 1992) and international bodies (see e.g. Barg, 1992). From earlier this century, we have seen a shift towards a 'governance' of aquaculture and its relationship with other coastal users, amongst scholars (e.g. Gray, 2005 and Kooiman et al 2005) and international bodies (e.g. Townsend, Shotten and Uchida, 2008).

'Governance beyond government' sees society's collective response to aquaculture conflicts as the joint responsibility of the industry, the state, civil society and the scientific community; operating simultaneously and independently according to their own institutions and guiding principles within the 'governing system'. As a multi-faceted and multi-scale approach, governance seeks to coordinate and harmonise otherwise fragmented responses, and encourage cooperation such that collective decisions become the constellation of all decisions made across all institutions. Actually, Chuenpagdee, Kooiman and Pullin (2008) and Stead (2005) describe aquaculture as long embodying models of governance in practice, particularly through the self-regulation of the industry. The tight and complex network of actors interacting across multiple institutions within the aquaculture food-chain, are steered largely by principles in voluntary guidelines and codes of conduct, with comparatively less state-regulation. However, in recent years there have been calls for a departure from this 'sectorial governance' to see aquaculture as part of its wider social-political governance system (Stead, 2005). This implicates aquaculture governance that engages with stakeholders from the state, civil society and science also; demanding a greater appreciation of the diverse narratives of stakeholders across different institutions, and how these narratives represent aquaculture conflicts and their potential resolution.

By situating aquaculture in a coastal governing system, we can conceive of very different narratives of aquaculture told by different coastal actors in different institutions. For instance, we can contrast the narratives of an aquaculture farmer, telling of her close relationship with her pond and fish as her livelihood, with that of manager of a processing plant further along the food-chain, who may be more inclined to narrate seafood as products and throughput, with that of a member of a local environmental NGO, who sees the whole industry as a threat to mangroves. Such narratives represent the many faces of aquaculture conflicts, narrated in terms of knowledge, values and worldviews.

'Aquaculture governance' therefore presents a novel and interesting lens through which to understand aquaculture conflicts, particularly as it relates to conflicting narratives. There are three important considerations that go with this perspective. First aquaculture governance has a temporal element; aquaculture conflicts have a history that can be mapped to understand the nature of these conflicts today, using narratives. Second, governance has a spatial element; it is important to recognise the multiple scales of aquaculture governance, with social- political networks and institutions at the community level nested in larger national and global networks and institutions. Third, studying aquaculture via a governance lens demands an interdisciplinary epistemology, which mirrors the complexity and plurality of governing systems.

3. Mapping conflicting aquaculture narratives through interdisciplinary study

This proposal suggests unpacking some key aquaculture conflicts according to the narratives told by diverse stakeholders interacting within and across different institutions within the coastal 'governing system'. This approach begins from newly-emerging perspectives on aquaculture within a coastal governing system, and engages narrative techniques that have not yet found wide expression in aquaculture studies; marking this as both a novel and important research topic for understanding and addressing aquaculture conflicts. This proposed study, focussing on complex and dynamic governing systems, and on continuously reconstructed narratives within this system, demands interdisciplinary research. Here, interdisciplinarity is understood as a long-term process of cooperation whereby scientists, in order to mobilise knowledge around this complex and multi-faceted topic, conjugate complementary disciplinary approaches in their ontological, epistemological and methodological dimensions, through the sharing of tools, methods and world views. Interdisciplinarity is not the mere gathering of scientific disciplines towards a common end because it demands of the scientists involved a reflexive scrutiny of their own discipline, and the establishment of an authentic dialogue between the different disciplinary experts (Blanchard, 2011). This proposed topic by its definition, defies the simple aggregation of disciplinary work, and demands partnership, that can be manifested in many ways.

An important starting point for this study is the definition of the governing system and some key conflicts therein. This 'mapping' implicates a partnership between sociologists experienced in social network analysis, and scholars experienced in defining and describing institutions, from political scientists or governance scholars, to institutional economists for example. Similarly, scholars in environmental management, geography and development studies have long employed means of 'stakeholder mapping' and 'rural appraisal' that would benefit this first stage.

Having mapped the system, this presents the challenge of engaging with the diverse narratives from different institutional settings, and teasing out the intertwined elements within these narratives. As to the former, different institutions may implicate different disciplines. For example, accessing the narratives of consumers of aquaculture products in the institution of 'the market' may demand quantitative research by researchers in consumer behaviour, marketing and economics, or even behavioural psychologists. On the other hand, exploring the narratives within a scientific institution implicates qualitative research by scholars of science and technology studies and the philosophy of science. As to the latter point above, narratives are a composite of knowledge, values and worldviews, so it follows that studying them involves both the study of the whole narrative and its composite elements. For example, to the extent narratives are a social epistemology, philosophers of science would take interest in the way knowledge is represented within the diverse narratives; how do institutions shape the knowledge drawn on in narratives, what role does science have in informing narratives, and what is the treatment of uncertainties, for example. Alternatively, political scientists may look at how narratives are used toward political ends within and across institutions, or linguists may look at the particular formulation of the narrative and how it differs across actors and institutions. All of these perspectives collected in partnership, and with authentic interdisciplinary interaction, represent more than the total sum of their disciplinary parts to reveal more of the nature of aquaculture conflicts.

Moreover, by recognising the temporal and spatial characteristics of governing systems around aquaculture conflicts, this implicates further disciplines into the interdisciplinary dynamic. To appreciate the history of conflicts, historians have an important role in such study, while recognising the international scale of conflicts similarly calls for disciplines accustomed to working at that scale, such as international economists, or political geographers for example. Again, the challenge for interdisciplinarity is to ensure that both the interface between historical studies of conflict and their current state, and studies at multiple scales, are ‘seamless’.

Finally, such interdisciplinary research is both descriptive and normative, and as such offers important opportunities for exciting and novel research. For example, there are opportunities or building systematic models of aquaculture conflicts through techniques of ‘mediated modelling’ for example, which converts and reconciles narratives into a systemic representation. Likewise, research like this must explicitly recognise that it inevitably contributes to changes in the system studied, and embrace this through critical models of reflexive science, and a strong discursive dissemination strategy on which to base the dialogue between the research and the public.

References

Barg, U. C. (1992) Guidelines for the promotion of environmental management of coastal aquaculture development. FAO Fisheries Technical Paper 328. Rome: FAO

Blanchard, A. (2011) Reflexive Interdisciplinarity: Supporting Dialogue on the Role of Science for Climate Change. Centre for the study of the Sciences and the Humanities: University of Bergen

Chua, T-H. (1992) Coastal aquaculture development and the environment: The role of coastal area management. Marine Pollution Bulletin, 25(1-4), 98-103

Chuenpagdee, R., Kooiman, J. & Pullin, R. (2008). Assessing Governability in Capture Fisheries, Aquaculture and Coastal Zone. The Journal of Transdisciplinary Environmental Studies, 7(1), 1-20

Fløysand, A., Haarstad, H. & Barton, J. (2010). Global economic imperatives, crisis generation and local spaces of engagement in the Chilean aquaculture industry. Norwegian Journal of Geography, 64(4), 199-2010

Gray, T. S. (2005). Theorising about participatory Fisheries Governance. In. T. S. Gray (ed.) Participation in Fisheries Governance. Amsterdam: Springer

Kooiman, J., Bavinck, M., Jentoft, S. & Pullin, R. (2005). Fish for Life: Interactive Governance for Fisheries. Amsterdam: Amsterdam University Press

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J., Lubcheno, J., Mooney, H. & Troell, M. (2000). Effect of aquaculture on world fish supplies. Nature, 405, 1017-1024

Somers, M. R. (1994) The narrative construction of identity: A relational and network approach. Theory and Society, 23, 605-649

Stead, S. M. (2005) A Comparative Analysis of Two Forms of Stakeholder Participation in European Aquaculture Governance: Self-Regulation and Integrated Coastal Zone Management.

In. T. S. Gray (ed.) Participation in Fisheries Governance. Amsterdam: Springer

Townsend, R., Shotten, R. & Uchida, H. (2008). Case Studies in Fisheries Self-Governance. Rome: FAO

B.10. D. von Büren: Alternative protein sources for pike perch in aquaculture

The use of fish meal as an ingredient in fish feed becomes increasingly problematic due to the pressure on marine resources by the intensive fishing. Alternatives for fish meal are plant-derived materials such as soy beans which are rich in protein. But there are also disadvantages in using plants for fish feed, for example the direct concurrence to human nutrition or the poor suitability for carnivorous fish species such as the pike perch. New alternatives have already been investigated, for example insects. Several studies have been conducted which analysed the use of insect larvae in aquaculture. The soldier fly Hermetia illucens is an often mentioned candidate. It is a widespread species that is able grow on decaying organic matter (Bondari & Sheppard, 1987). Hermetia illucens is rich in protein and therefore a promising feed source in aquaculture. A further advantage is the resource-saving production of these larvae, because they feed on waste materials.

Certain fish species have been reared in aquaculture for several decades now. Well-known examples are the rainbow trout (Oncorhynchus mykiss) or the genus tilapia (Tilapia spp.). The pike perch (Sander lucioperca) is a species that has not been well established yet as species for aquaculture and needs to become more familiar to the consumers. New insights are constantly implied in practice, such as optimal water temperature, stocking density and issues concerning feeding practices (Wang et al., 2009; Schulz et al., 2005; Molnár et al., 2006; Szkudlarek & Zakęś, 2007; Nyina-wamwiza et al., 2005). The pike perch is a carnivorous species and has therefore specific food preferences. Hence, plant-derived proteins are not suitable for optimal growth, whereas soldier fly larvae are more promising.

As an example for other land-born aquacultures the influence of feed containing soldier fly larvae on growth and weight gain of pike perches should be investigated. These outputs should then be compared to outputs from pike perches that were fed with conventional fish feed. The results will show if the alternative feed is good enough to be tested on a larger scale. This would be a first step towards an aquaculture with less use of fish meal.

In further experiments the feeding behaviour and taste preferences of pike perch will be investigated in order to gather information for the application in practical use. Profound studies on taste preferences in fish have already been done by A. Kasumyan and K. Døving (2003). Now it would be of special interest to study the pike perch from this point of view. This has not been done yet and the new findings could have an influence on feeding techniques in other aquaculture as well.

References

Bondari K and Sheppard D C (1987) Soldier fly, Hermetia illucens L., larvae as feed for channel catfish, Ictalurus punctatus (Rafinesque), and blue tilapia, Oreochromis aureus (Steindachner). Aquaculture and Fisheries Management 18: 209-220

Kasumyan A O and Døving K B (2003) Taste preferences in fish. Fish and Fisheries 4: 289-347

Molnár T, Szabó A, Szabó G, Szabó C, Hancz C (2006) Effect of different dietary fat content and fat type on the growth and body composition of intensively reared pikeperch Sander lucioperca (L.) Aquaculture Nutrition 12: 173-182

Nyina-wamwiza L, Xu X L, Blanchard G, Kestemont P (2005) Effect of dietary protein, lipid and car- bohydrate ratio on growth, feed efficiency and body composition of pikeperch Sander lucioperca fingerlings. Aquaculture Research 36: 486-492

Schulz C, Knaus U, Wirth M, Rennert B (2005) Effects of varying dietary fatty acid profile on growth performance, fatty acid, body and tissue composition of juvenile pike perch (Sander lucioperca). Aquaculture Nutrition 11: 403-413

Szkudlarek M & Zakęś Z (2007) Effect of stocking density on survival and growth performance of pikeperch, Sander lucioperca (L.), larvae under controlled conditions. Aquaculture International 15: 67-81

Wang N, Xu X, Kestemont P (2009) Effect of temperature and feeding frequency on growth performances, feed efficiency and body composition of pikeperch juveniles (Sander lucioperca). Aquaculture 289: 70-73

B.11. Dorothy J. Dankel: Building knowledge networks for sustainable maritime systems

B.11.1 Context

A secure supply of fish and shellfish food depends on sustainable management and governance of the maritime system. The interdisciplinary web of topics inherent to the maritime system in Europe is a large topic that is relevant to the sustainable use and governance of important marine resources. Formed in 1902, The International Council for the Exploration of the Seas (ICES) is one of the oldest intergovernmental scientific organisations and was a pioneer in the production of science for policy support when most scientific organizations focussed purely on knowledge development. It is now the primary source of scientific advice to governments and international bodies managing the North Atlantic and adjacent seas. The ICES mission statement is "To advance the scientific capacity to give advice on human activities affecting, and affected by, marine ecosystems." This mission calls for an "establishment of effective arrangements to provide scientific advice," and for coordination for "enhancing physical, chemical, biological, and interdisciplinary research."[103] Today over 1600 scientists from 20 member countries are affiliated with ICES, conducting science and formulating advice as part of the overall ICES network. In its most concrete form, the ICES network is given by the joint attendance of expert groups.

The ICES Working Group on Maritime Systems (WGMARS) is an expert group based on interdisciplinary collaboration and research of maritime systems, with an emphasis on natural resource management. WGMARS is a forum to articulate ideas on knowledge production and advisory capacities within ICES and how these can be integrated and broadened in cooperation with external partners. It is exactly these types of established interdisciplinary research activities that are needed to facilitate sustainable governance of marine ecosystems. However, the attendance of scientist in these expert groups is voluntarily, ICES is not providing travel money. Therefore this application seeks funding to support the further extension of WGMARS' interdisciplinary networking, research and analysis.

B.11.2 What we want to build on

The challenge to ICES is to bring diverse disciplines together in the crafting of ecosystem-based fisheries analysis and advice, but bridging divides among disciplines and areas of expertise is difficult. WGMARS has the task of analyzing the extent to which the recent reorganization of ICES facilitates interdisciplinary analysis. In 2012, WGMARS began a programme of social network analyses (SNA) of the 119 ICES Expert Groups (EGs) with the aim to examine the information flow among individuals and WGs. SNA allows us to follow the actual flow of expertise among individuals or groups as well as compare this flow to ICES formal organizational structures and scientific terms of reference (e.g. illustrates the communication interface of the advice system). Thus far, we have gathered SNA data inter alia on: scientists' attendance and

[103] http://www.ices.dk/iceswork/AVisionWorthSharing2008.pdf

cross-attendance at ICES working groups; scientists' links with European and national research projects and marine monitoring mechanisms; the kinds of expertise the scientists bring to the groups; the kinds of expertise that group chairs feel their group lacks; and the scientists' experiences of the effectiveness of the advice generation.

No single scientist or working group does "ecosystem science" as such; ecosystem science depends on cross- and interdisciplinary work between different scientists and working groups. The ICES network comprises both several highly connected expert groups as well as many that are much more loosely connected to the overall network. In light of the need for interdisciplinary synergy to produce useful ecosystem-level advice, this first foray into the SNA data was able to show where new linkages need to be made, as well as identify redundancies, at least for a relatively small number of particularly important expert groups. Not only is this a useful stand-alone contribution, it demonstrates that further, more detailed analysis has the potential to identify mechanisms to integrate diverse ecosystem sciences.

Further analysis of the SNA data will also be greatly facilitated by focussing on specific needs of scientific advice, particularly those that are experiencing a growing, practical demand for the further integration of ecosystem-level advice. In EU fisheries management, there is an increasing use of long term fisheries management plans to determine the general management approach for individual fish stocks. Current management plans are derived to a large extent from single stock assessment and single stock management. As a consequence, this development has been mostly informed by traditional fisheries science that is biology-based. An important challenge for an ecosystem approach to fisheries management, one that is seen as a priority by ICES leadership and leading clients, is to explore how to generate integrated management plans that correspond to the ecosystem approach. This involves major challenges with respect to governance and integration of different knowledge disciplines, and therefore goes way beyond the biology-based harvest control rules. So interdisciplinary (between different scientific disciplines) and trans-disciplinary (between different forms of knowing) integration is a philosophical and epistemological foundational necessity of such integrated management plans. Hence one of our key strategies for making effective use of the SNA data is to trace the knowledge linkages around these fish stocks themselves, the seas they are found in, and the other species and fisheries with which they interact.

B.11.3 A proposal towards an interdisciplinary approach for understanding the marine knowledge network in Europe

1. **Theoretical background research questions:** On what knowledge base should integrated management plans for an ecosystem approach to marine fisheries in Europe be developed? What practical requirements does developing this knowledge base pose for how ICES organizes its advice generation? Here the different knowledge expertises in WGMARS and extended interdisciplinary networks allow us to build a solid theoretical foundation for these questions. WGMARS is the ICES expert group that has the longest experience with non-economic social scientists working alongside natural scientists.

2. **Empirical-based research question:** What interdisciplinary and trans-disciplinary approaches to developing marine management advice are currently operating in the ICES network? What are factors that shape interactions between individuals and organizations as they seek to generate advice for an ecosystem approach to fisheries management? What are the links between the formal organization and terms of reference of expert groups and the actual communications taking place in the network? Our social network analysis and the analysis of the system governance will allow us to quantitatively and qualitatively probe these questions.

B.11.4 Approach

The development of integrated management plans for fisheries management in Europe is often talked about but rarely effectively addressed. In other parts of the world (e.g. Australia, South Africa), such approaches seem to be more advanced although the governance systems may be somewhat simpler than in Europe. Still it is informative to learn from these experiences and explore their potential applicability in Europe. This requires a close integration of governance expertise with different forms of ecological, economic and behavioral knowledge. The ICES expert group WGMARS is an existing vehicle for this type of research.

Effective interdisciplinary and trans-disciplinary approaches to marine management require a thorough understanding of conductive and inhibiting factors that shape interactions between individuals and organizations. Social Network Analysis (SNA) provides a powerful tool to analyse relationships between individuals and organizations and how effective communication can take place. By applying SNA to the marine resource management systems that ICES is part of, we will gain an understanding of factors that allow interdisciplinary and trans-disciplinary learning.

B.11.5 Future possibilities

Why do we put forward the need for funding of work that already exists in ICES? Most work conducted within ICES, including the work of WGMARS, is done on a voluntary basis and much is done with no monetary support. Yet this interdisciplinary work in sustainable fisheries management is vital to the EU member states and other states. This application seeks support for WGMARS activities, including the continuation and improvement of SNA, the extension of WGMARS into analyses of maritime governance systems, and to bring additional expertise into the Working Group. WGMARS will in particular encourage the participation of younger scientists to become involved in WGMARS and ICES, bringing with them new and broader perspectives in an interdisciplinary working environment.

B.12. Nils-Arne Ekerhovd: Eco-labelling, Fisheries and Sustainable Management

Eco-labelling has been promoted as a way for consumer preferences for environmentally benign products to be transmitted in markets. The label provides information to consumers who may then pay a price premium for the labelled product.

Eco-labelling is growing in popularity, particularly for renewable resources, and has been applied to timber, fish, coffee and other agricultural products and practices associated with biodiversity conservation. The goal of such programmes is to offer market-based incentives for better resource management by leveraging consumer demand for products harvested from well-managed stocks. Case studies indicate that eco-labels can be successful at generating price premiums in many niche markets, but few careful studies have been able to establish environmental or welfare benefits.

A pertinent question, therefore, is whether eco-labelling schemes are effective, in the sense that they contribute to the resolution of the problem that motivated their establishment in the first place. In other words: do eco-labelling programmes contribute to the improvement in the status of fish stocks and ecosystems as well as the sustainable exploitation of fish stocks? Then there is the question of costs and benefits. This not an easy question to analyse. The costs are some extent observable, but the benefits are not. A strong element of public good is involved. According to economic thinking a fishery would only be willing to pay for certification if the costs can be covered by a price premium on the certified products. It is far from certain that the consumers' willingness to pay reflects the benefits of better fisheries management.

A distinction should be made between the direct effects of a certification scheme and the broader consequences that flow from the emergence of that scheme. Using the narrow definition of effectiveness, fisheries certification would be judged effective if it contributes directly to the resolution of the problems it was created to address (overfishing, environmental harm resulting from fishing). Yet a broad conception of effectiveness would consider not only direct effects, but also environmental, social and economic effects that were not necessarily intended or anticipated.

B.13. Damian Fernandez-Jover: Effects of fish feeds on the environment. Use of fatty acids as bio-indicators.

Efforts on the innovation in aquaculture feed have been intense during the last years. The problems related to the use of fish meal and fish oil (FO) have encouraged scientists, companies and managers to replace those traditional ingredients by fats and proteins of different sources, and ingredients from terrestrial origin have been the main contributors to this substitution. Vegetal oils (VO) like soybean, rapeseed, linseed or palm oils are nowadays common ingredients in the food pellets used for feeding caged fish worldwide. However, VO significantly differ in their composition when compared to ingredients from marine origin.

Marine food webs are rich in n-3 fatty acids (FA) because phytoplankton, the base of this food chain, is rich in this component. Vegetal oils, however, are rich in saturated acids like palmitic (16:0) or stearic acid (18:0), monounsaturated FA like oleic acid (18:1n-9), and polyunsaturated FA, especially linoleic acid (18:2n-6) and α-linolenic acid (18:3n-3), but lack the long-chain PUFAs eicosapentaenoic acid (20:5n-3, EPA) and docosahexaenoic acid (22:6n-3, DHA) characteristic of FO (e.g. Turchini et al. 2010). The replacement of FO with alternative oils such as VO in aquafeeds can cause alterations in fish physiology, including the immunological status of cultivated fish. These effects have been extensively studied and can be controlled under laboratory or cage conditions in order to achieve the maximum levels of substitution without compromising fish performance (Turchini et al. 2009, 2010, Montero & Izquierdo 2010).

However, the use of these alternative ingredients in aquaculture is prompting further questions about their effects on the environment. Several studies have appeared highlighting that the FA composition of sediments (Colombo et al. 1997), wild fish populations at different latitudes (Skog et al. 2003, Fernandez-Jover et al. 2007, 2009, 2011a) and other associated fauna-like shrimps (Olsen et al. 2009) can be altered as a consequence of food pellets that are not consumed by the cultured fish and are lost from the floating cages. Therefore, terrestrial FAs have been proposed as biomarkers of the influence and impact of aquaculture on wild fish populations (Skog et al. 2003, Fernandez-Jover et al. 2007, 2011b).

Up to 170 species of wild fish have been documented to associate with fish farms as adults or juveniles worldwide (Sanchez-Jerez et al. 2011). Wild fish populations at aquaculture sites are subject to several anthropogenic impacts, including fishing or even aquaculture-originated contaminants (DeBruyn et al. 2006; Bustnes et al. 2010). If the alteration of FA profiles of farm- associated wild fish diminishes their performance, they may be subject to additional synergistic effects with the other anthropogenic impacts. However, this still remains unattended. Further research into the potential effects on wild fish caused by aggregation at fish farms, modified dietary intake and altered FA compositions should target the mechanisms driving the observed effects.

The study of the introduction of these FA, or undesirable components such as pollutants, in the marine food webs, requires an interdisciplinary approach towards the complete identification of the influence and consequences of aquaculture practices on natural environments. In this way, it would be desirable to know the ecology of the different influenced species, like their trophic behaviour, migrations or reproductive patterns in order to identify which species, especially those targeted by fisheries, are more susceptible to be affected by coastal aquaculture. The application of histological, molecular and biochemical techniques will be necessary to assess the effects on fish physiology and highlight if the proven changes in fish composition may have consequences on the immunological or reproductive performance of wild fauna. Finally, in order to picture the actual extent and magnitude of the potential effects on fish populations, it will be necessary to apply fisheries science and integrated zone management tools in order to conciliate all the stakeholders like aquaculture enterprises, artisanal and professional fisheries or tourism.

References

Bustnes, J.O., Herske, D., Dempster, T., Bjørn, P.A., Nygård, T., Lie, E., Uglem, I., 2010. Salmon farms as a source of organohalogenated contaminants in wild fish. Environmental Science and Technology 44 (22), 8736-8743.

Colombo JC, Silverberg N, Gearing JN (1997) Lipid biogeochemistry in the Laurentian Trough. II. Changes in composition of fatty acids, sterols and aliphatic hydrocarbons during early diagenesis. Org Geochem 26: 257 −274.

DeBruyn, A.M.H., Trudel, M., Eyding, N., Harding, J., McNally, H., Mountain, R., Orr, C., Urban, D., Verenitch, S., Mazumder, A., 2006. Ecosystemic effects of salmon farming increase mercury contamination in wild fish. Environmental Science and Technology 40, 3489-3493.

Fernandez-Jover D, Lopez-Jimenez JA, Sanchez-Jerez P, Bayle-Sempere J, Gimenez-Casalduero F, Martinez Lopez FJ, Dempster T (2007) Changes in body condition and fatty acid composition of wild Mediterranean horse mackerel (Trachurus mediterraneus) associated with sea cage fish farms. Mar Environ Res 63: 1−18.

Fernandez-Jover D, Sanchez-Jerez P, Bayle-Sempere JT, Arechavala-Lopez P, Martinez-Rubio L, Lopez Jimenez J, Martinez Lopez FJ (2009) Coastal fish farms are settlement sites for juvenile fish. Mar Environ Res 68: 89−96.

Fernandez-Jover D, Martinez-Rubio L, Sanchez-Jerez P, Bayle-Sempere JT and others (2011a) Waste feed from coastal fish farms: a trophic subsidy with compositional side-effects for wild gadoids. Estuar Coast Shelf Sci 91: 559−568.

Fernandez-Jover, D., Arechavala-Lopez, P., Martinez-Rubio, L., Tocher DR., Martinez-Lopez., FJ, Sanchez-Jerez, P. (2011b). Monitoring the influence of marine aquaculture on wild fish communities: benefits and limitations of fatty acid profiles. Aquaculture Environment Interactions, 2, 39-47.

Sanchez-Jerez, P., Dempster, T., Fernandez-Jover, D., Uglem, I., Bayle-Sempere, J., Bjørn, P.A., Arechavala-Lopez, P., Valle, C., Nilsen, R., (2011). Coastal fish farms as Fish Aggregation Devices (FADs): potential effects on fisheries. In: Bortone, S. (Ed.), Artificial Reefs in Fisheries Management. Taylor and Francis.

Skog TE, Hylland K, Torstensen BE, Berntssen MHG (2003). Salmon farming affects the fatty acid composition and taste of wild saithe Pollachius virens L. Aquacult Res 34: 999−1007

Turchini GM, Torstensen BE, NgWK (2009) Fish oil replacement in finfish nutrition. Rev Aquacult 1: 10−57.

Turchini GM, Ng WK, Tocher DR (eds) (2010) Fish oil replacement and alternative lipid sources in aquaculture feeds. CRC Press, Boca Raton, FL.

B.14. R. Froese: Generic harvest control rules for European fisheries

The main objective of a sustainable food acquisition from the sea is the securing of stable marine populations. Even though there have been several international treaties on this aspect (e.g. United Nations Convention on the Law of the Sea [UNCLOS 1982], United Nations Fish Stocks Agreement [UNFSA 1995]), the recent ICES 2010 proposal violates any sensible principle with respect to a precautionary eco-system approach and to resource economics. The ICES proposal concentrates on today's focusing question: What is the smallest stock size that can still deliver sustainable catches? This question is regarded as ill-posed because it leads to too small populations, both from a biological and an economical point of view. The sole advantage of this approach is the least possible change relative to today's habits.

As an alternative an adaptive rule set of nine rules is proposed that takes both the respective states of the fisheries and the uncertainties of the underlying development mechanisms into account. The latter aspect is primarily focused by the definition of safety margins with respect to the so-called total allowable catch (TAC) on which the future fishery management regulations should be based. The change of paradigm is represented in the turn of the former basic question into a new formulation: What is the largest stock size that can still deliver good catches? Regulating catch amounts by the TAC approach will link economy to ecology in a more sustainable manner.

Todays catch management considerations are mostly approaches based on a leading species of interest with short-term economic considerations. The significant amounts of by-catch influence the ecosystem both by extracting biomass and changing food chains in inexplicable ways. A paradigm change to multi-species approaches seems more realistic as far as striving for a sustainable state of the marine ecosystem is targeted.

Respective sets of proposed MSY[104]-based fishing rules, including by-catch numbers and effects management have already been introduced in some states (USA, Australia, New Zealand) and should be taken as an orientation rule set for Europe also.

To follow this new direction some admissions have to be made on the present state of affairs. At the time being the catch fleet is way to large, and at least for a certain period of some years subsidies for alimenting fishing related people and maintenance of the long-term required infrastructure seems necessary. Accordingly, accompanying expertise must be searched on how large this support would have to be and to what amount the conservation of infrastructure will be sensible after the period of fisheries convalescence.

[104] maximum sustainable yield

B.15. Jennifer Gee: Measuring Economic, Ecological, and Social Performance of Aquaculture

Ensuring a sustainable aquatic food supply has become critical as fish protein is making up an increasing share of animal protein consumed on all continents (FAO 2012). Further, as the world's per capita fish consumption grows aquaculture products account for an increasing proportion of the global fishery supply and is predicted to account for 52 percent of the share of fish for human consumption (FAO 2012). In Europe more seafood is consumed per capita then the global average, yet growth rates for aquaculture production have been slowing and this presents an opportunity for expansion in the future (Maritime Affairs and Fisheries of the European Commission 2012). To chart a sustainable path forward, it is imperative that decision makers have a rigorous, yet efficient way to quantify and compare the environmental impacts of seafood products. Measuring the actual impacts of aquaculture has proven difficult, however. These challenges stem from a scarcity of data, inconsistent reporting, incomplete science, a wide range of environmental impacts across vastly different production regions, and an ever-evolving definition of sustainability. The first step in charting the path forward came with the development of the Global Aquaculture Performance Index methodology (Volpe et al. 2010). The Global Aquaculture Performance Index (GAPI) employs a proven science-based approach to quantify ecological performance of aquaculture production systems. GAPI allows for an assessment of which policy remedies are likely to yield the greatest improvement in ecological performance.

The next step in constructing a more complete picture of both the current status of aquaculture production as well as the way forward to a more sustainable aquaculture sector is the inclusion of measures of economic and social performance. Notably, the recent revision of the System of Environmental-Economic Accounting (SEEA) (FAO 2012a) presents measures of economic performance within an accounting structure that seeks to compare the depletion of a resource against economic gains from utilizing that resource (Ottaviani 2012). A SEEA briefing note states that, "The SEEA adds value to individual information components by bringing them together to inform integrated policies, evaluate trade-offs between different policies and evaluate their impacts across domains of the economy, the environment and society" (UNSD 2012b). Further, systematic analyses of the salmon farming industry, particularly that of Europe (Asche and Bjorndal 2011) provided the foundation for economic assessments of European aquaculture. Building on the methodological platforms of both the GAPI project and the SEEA Central Framework a more through assessment framework could be created that would allow for the interdisciplinary work that is crucial for shaping a sustainable aquatic food supply chain in Europe.

References

Asche, Frank and Trond Bjorndal. 2011. The Economics of Salmon Aquaculture. 2nd ed ed. Chichester, West Sussex, England ; Ames, Iowa: Wiley-Blackwell.

FAO. 2012. The state of the world fisheries and aquaculture 2012. Food and Agriculture Organization of the United Nations, Rome. Maritime Affairs and Fisheries of the European Commission. 2012. "Aquaculture: Unleashing its Potential." Fisheries and aquaculture in Europe June 2012: 5. Available from: http://ec.europa.eu/fisheries/documentation/magazine/index_en.htm

Ottaviani, Daniela. System of Environmental and Economic Accounting (SEEA) for aquaculture and inland capture fisheries. 2012. FAO Expert Workshop, Gaeta, Italy. 5-7 November 2012.

UNSD. 2012. System of Environmental-Economic Accounting. Central Framework. White Cover Publication. United Nations Statistical Division, Rome. Available from: http://unstats.un.org/unsd/envaccounting/seearev/

UNSD. 2012b. The System of Environmental-Economic Accounts (SEEA). Measurement Framework in Support of Sustainable Development and Green Economy Policy. Briefing Note. United Nations Statistical Division, Rome. Available from: http://unstats.un.org/unsd/envaccounting/Brochure.pdf

Volpe, John Paul., Martina Beck, Valerie Ethier, Jennifer Gee, and Amanda Wilson. 2010. Global Aquaculture Performance Index. University of Victoria, Victoria, British Columbia, Canada. Available from: http://www.gapi.ca

B.16. Jordi Guillen: Accepted and sustainable management reference points

There is the need to provide managers with tools that can inform them what level of fishing effort, quotas or any other management measures is required so that it leads to an optimal and sustainable exploitation of the fisheries. It is important to forecast the evolution in the fisheries and consequences of management measures before they are produced. Bio-economic models are one of the main tools used to forecast the fisheries evolution. (See Prellezo et al., 2010, SEC 2006, STECF, for partial summaries of bio- economic models applied in the EU).

However, estimating the optimal exploitation level is not easy and often depends on manager's decisions (e.g. is it better to maximize catches, landings, private profits, GVA or employment?).

For example, the determination of MSY, the choice of yield to be maximized as landings or catches is often regarded as a matter of policy (ICES, 2010). If yield is considered to be the quantity that is removed from the stock, then it should refer to maximising catch. If yield is considered to be the utilised part from the removed stock, and so the amount contributing to economic or social activity, then yield should refer to landings. However, the decision between whether to maximise catches or landings can lead to significantly different effort, biomass and yield targets when discards occur (see as an example Figure 3 for the Bay of Biscay Nephrops fishery). Moreover, this choice should also take into account the survival rate of the discards and possible alternative uses of discards and their costs (i.e. convert them into fishmeal).

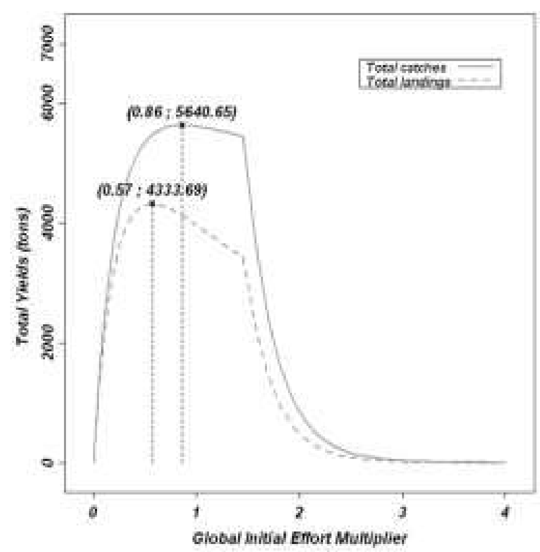


Figure 3: *Nephrops landings and catches as a function of effort and MSY levels*

Alternatively, MEY traditionally provides a reference point where private profits are maximised. However, there is the need to reconsider the use of private profits as a goal in fisheries, especially when governments are not extracting most of the rents from the fisheries. Hence, other indicators such as GVA or employment could be considered (See figure 4).

Hence, it would be important to provide managers with a tool (bio-economic model) that allows them to balance (weight) biological, ecological, economic and social objectives; and this tool would be able to provide them with a sustainable optimal result (located in the curve in Figure 4). If current situation (fishing effort = number of vessels, biomass at sea) differs significantly from this optimal point, then it should also provide the best path to achieve it in a given time frame. Again, the best path to achieve this optimal point and the time to achieve it also depend on manager (political) decisions (i.e. not to reduce fishing effort more than 10 % annually).

Therefore, it would be important that the bio-economic model informs managers of the situation at each sustainable optimal point by providing basic indicators (i.e. number of vessels, landings, discards, profits, gross value added, number of fishers, crew wage, probability of stock collapse). Hence, managers would be able to take decisions based on sound information of the consequences of their actions.

The suitable bio-economic model should have the following characteristics: multi- species, multi-fleets, age structured, allow for simulation and optimization, possibility to model different management measures (changes in selectivity, changes in quotas and effort) and changes in current situations such as fuel price variations. It should also be versatile enough to model different fisheries, not just one.

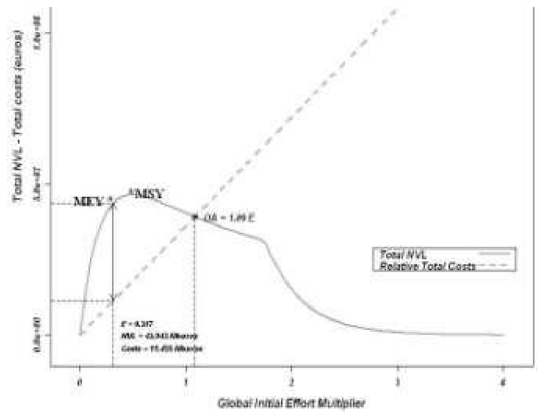


Figure 4: *"Sustainable" reference points based on different management objectives*

It would be desiderable that this model also considers dynamic treatment of discards, price dynamics, dynamic entry-exit of vessels, enforcement and compliance, species interactions (predation).

During my 18 months' Post-Doc at Ifremer, I have been working with the IAM model (Macher, 2008; Raveau et al., 2012; Guillen et al., in press), and we have been able to address some of these issues. Especially the differences between maximising catches and landings (Guillen et al., to be submitted), estimating MSY and MEY in multi- species and multi-fleet fisheries (Guillen et al., in press), the differences between MEY, the maximisation of other economic indicators (Guillen et al., in preparation) and we are currently working to model the dynamic part of the analysis.

However, there is plenty of work to do in this research topic: improve the dynamics = transition paths and its constraints, introduce enforcement and compliance in the model, improve some parts of the model, apply it to other fisheries, model more the effects of uncertainty, obtain feed-back and consensus on the equations and parameters used to have it further accepted, make the model more user-friendly, etc.

Thus, this research requires at least the collaboration of biologists, economists, fisheries experts, engineers (i.e. willing to investigate the effects of gear changes in the selectivity), fishers, politicians.

B.17. E. Hey: Social-ecological resilience and polycentric fisheries governance systems

I suggest that social-ecological resilience thinking and the notion of polycentric governance systems may offer useful conceptual frameworks for situating the initiative, as most disciplines will probably be able to engage with them. Below I include a short account of some of the challenges that fisheries governance has to contend with.

The FAO has developed an interdisciplinary approach to fisheries governance, the so-called Ecosystem Approach to Fisheries (EAF). EAF determines that the "fishery system is a social-ecological system, and consists of linkages between people and the environment, also outside the actual fishing operations".[105] It thus introduces the concept of social-ecological systems into fisheries policy. Thereby implying that "social-ecological systems are linked systems of people and nature" and emphasizing "that humans must be seen as a part of, not apart from, nature – that the delineation between social and ecological systems is artificial and arbitrary." [106]

While these insights are gaining some ground in fisheries governance, a 2009 study co-sponsored by the World Bank and the Food and Agriculture Organization of the United Nations (FAO) reported that, in addition to depleted stocks[107] marine fisheries incur a loss of in the order of US $ 50 billion annually.[108] The report also held that *"The focus on the declining biological health of the world's fisheries has tended to obscure the even more critical deterioration of the economic health of the fisheries, which stems from poor governance and is both a cause and a result of the biological overexploitation."* [109]

The report thereby points to the need to, besides biologists, involve economists in fisheries governance, a point that has been made at least since the 1960's even if the concept of maximum economic yield never made it into fisheries governance. Social-ecological resilience thinking, however, also points to the need to involve sociologists and political scientists in order to gain insights into how social systems and natural systems are inter-linked and how those links can be used to attain more resilient fisheries. More importantly perhaps, social-ecological resilience thinking provides researchers, regardless of discipline, with a conceptual focus that emphasizes inter-connectivity: between human and natural systems, between disciplines and between levels of governance. In respect of the latter one of the questions that arises relates to what types of measures to develop at what level of governance (e.g. local, national, regional or international). It is in this context, I suggest, that the work of Elinor Ostrom on polycentric systems and managing commons is relevant.

These considerations are relevant to international fisheries law and the Common Fisheries Policy (CFP) of the European Union. The CFP is currently in the process of being restructured. Interestingly, despite the much criticized concept of MSY, MSY continues to be central to the

[105] FAO, Technical Guidelines for Responsible Fisheries No.4, Suppl. 2 Add (FAO, Rome, 2009) 15. [106] See Resilience Dictionary, Stockholm Resilience Center, available at <http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a31274 27980004355.html> [107] Also see FAO, The State of World Fisheries and Aquaculture 2010 (FAO, Rome, 2010) [108] World Bank and FAO, The Sunken Billions: The Economic Justification for Fisheries Reform (World Bank: Washington D.C., 2009) xvii. [109] Ibid., xxi.

revision of the CFP, even if there is also a focus on bottom-up approaches and integrating sustainable practices.[110]

In terms of international law, the focus of much of my work, a number of obstacles to attaining more sustainable fisheries also present themselves. These obstacles include, but are not limited to, the following.

- the persistence of ideas once included in international law (e.g. the freedom of fishing
- hindering the establishment of high seas Marine Protected Areas (MPAs) – and the concept of maximum sustainable yield (MSY), which does not sit comfortably with MPAs and addressing fishing effort);
- the fragmented nature of international law (e.g. while fisheries subsidies and over- fishing are addressed in environmental circles – a.o. Johannesburg and Rio+10 –, the WTO has not been successful at addressing subsidies to the sector and within CITES discussion continues to emerge about the appropriateness of listing endangered fish species which are subject to commercial fishing); and
- rules on state consent, reservations to treaties and opting-out procedures, even if the picture is not black-and-white on most of these rules.

These obstacles entail that even if fisheries management embraces ideas such as social- ecological resilience, international law may continue to offer those who are opposed thereto arguments to sustain their position.

[110] See http://ec.europa.eu/fisheries/reform/index_en.htm.

B.18. P. Holm: Scenario Techniques on Nutrition from the Sea

Consider three scenarios, given a projected world human population of 9 billion people in 2050:

Scenario 1: Business as usual

1. Wild capture fisheries stagnating at the present level of c100 million tonnes (peak in 1988 and somewhat lower catches in succeeding years)
2. Aquacultural provisions increase slowly in the next three decades to a level of about 50 million tonnes today. Future growth prospects are inhibited by continuing problems of diverse nature, especially the fact that aquaculture fundamentally depends on wild forage fisheries.
3. World consumption per capita will decline from the present level of about 20 kg to perhaps 15 kg.

Scenario 2: Deus ex machina

1. unchanged
2. Technological breakthrough allows aquacultural production to increase by unprecedented growth acceleration to produce about 180 million tonnes
3. World marine food consumption is stable at 20 kg per capita.

Scenario 3: Perfect Storm

1. The worst predictions come true and wildlife captures collapse in association with the introduction of widespread marine conservation measures (say 40 % of oceans designated Marine Protected Areas) and strict management regimes are introduced in OECD waters.
2. As in 2.2
3. Total marine food production is stable at 100 million tonnes and consumption per capita is almost halved to about 11 kg.

Some research questions:

1. What is the likelihood of assumptions of above scenarios?
2. How will markets adjust: Will there be protein deficiency in less affluent economies? Will the High Seas be carved up into spheres of interest, and will Exclusive Economic Zones become ever more globalized – and indeed perhaps capitalized with future interests? Will rogue fisheries became widespread? Will mitigating food preferences arise with new low trophic level foodstuffs?

3. What will be the social and cultural repercussions of an international marine food scarcity?

4. What is needed in order to prevent social and cultural backlash against necessary bioengineering technology to improve aquaculture? What are the environmental threats? How will the societal structures of coastal economies respond to aquacultural revolutions (for example if aquaculture is relocated to inland farms)?

An interdisciplinary approach is needed to elucidate these questions. From an SSH perspective economics, sociology may address societal questions, geography will be needed to understand landscape restructuring, history and anthropology will be needed to understand societies' willingness and ability to cope with change, aesthetic approaches (literature to architecture) will be called on to understand both food preferences and built environment.

B.19. M. Kaiser: Aquaculture: from farm to fork – and globally embedded in sustainable societies

Background: Global food-security and food-production faces a variety of challenges: (i) (effects of and contribution to) climate change; (ii) continued growth of world population; (iii) natural resources (fish stocks / arable land) already being used to the limit or above; (iv) global health issues related to nutrition (malnutrition vs obesity; food safety); (v) the imperfections of market mechanisms as guarantor of supplies that meet needs and economic realities of markets; (vi) politics being largely dominated by narrow national interests. // EU is currently only 60 % self-sufficient in aquatic food-products, while demand keeps rising. // A steady supply (in some countries: increased consumption) of aquatic food products is recommendable in a healthier and more balanced diet. // But: Aquaculture in many varieties and countries is still below good sustainability, many problems are still to be solved, though it is better than critics assert; has positive potential.

Project framework: In order to contribute to a desirable development in terms of sustainability (environment, economy, social/culture/ethical), and in order to allow flexible solutions, adapted to local/regional/cultural varieties among producers and consumers, an inter-disciplinary approach needs to be taken, aspiring to more holistic and integrated assessments and paths for development. In this effort, technical expertise needs to complement several fields of (natural) science expertise, while all this needs to be integrated in frameworks with expertise from law, economy, philosophy/ethics, cultural and historical studies, and empirical sociology.

Research questions: A varied range of aquatic products (Ω3-rich fish, lean fish, molluscs, crustaceans, aquatic plants) necessitates extensive global trade and differentiated forms of productions. From this several challenges arise: (i) What are the effects of expert-oriented productions on domestic markets, and to what extent does food-security and sustainability imply a minimum of regional production for domestic needs? (ii) To what extent is intensification of production lines necessarily in conflict with e.g. maintaining ocean resources (feed!), biodiversity and minimal environmental harm? (iii) What are models and historical examples of good resolution of conflicts (e.g. with agriculture, tourism, etc) over land-use or sea-use? (iv) To what extent can cultural, religious and other values (e.g. animal welfare) in both producing and consuming countries and their populations be respected and guide developments? (v) To what extent and under which conditions can soft-law (guidelines, certifications, voluntary standards etc) as supplementary to hard-law (e.g. food safety regulations) steer and contribute to a more sustainable productions of aquatic food? (vi) To what extent and under which conditions does growth of aquaculture production contribute to positive socio-economic developments in production areas, including gender issues? (vii) What are the experiences of expert-based knowledge-transfer on aquaculture from industrialized to developing countries in the South? (viii) To what extent is the need of more sustainable production dependent on more sustainable consumption (e.g. ‘political consumerism’)? (ix) What are promising species for future aquaculture development? (x) How can the ecological footprint (CO_2, energy etc.) of an aquatic product be assessed and made visible?

Objectives: The complexities of the problems will limit the extent to which rigorous primary data on a global basis will be generated in the project. However, secondary data sources, supplemented by in-depth case-studies of selected species / countries, and qualitative data (interviews, workshops etc) can provide sufficient basis for the following objective:

- to produce a 'global handbook' / 'global assessment' on "Experiences of and trajectories for sustainable global aquaculture production", aimed at the whole value-chain and the scholarly sector supporting it;
- on the basis of this publication, produce a three-part TV feature (in cooperation with a professional team) on global aquaculture, as an attempt of balanced scientific information for a wider public.

B.20. K. M. Karlsen, O. Andreassen, B. Dreyer, Ø. Fylling-Jensen: Identification of challenges and improvements for sustainable seafood supply in Europe (iSea)

Background

In a global food supply perspective, the potential for increased supply of seafood is promising. However, both seafood from wild fisheries and farmed fish face major challenges related to sustainability. The main sustainability challenges pertaining to the wild capture fisheries are the management of wild fish stocks, over-capacity in the fishing fleet, and fuel consumption related to the harvesting operation. Whereas in fish farming the management of farm sites and shortage of resources needed to produce feed presently limit further growth. A dilemma with respect to the feed production is whether wild fish should be harvested for direct human consumption only, or if low value species should be used to feed high value species (aquaculture species and livestock). A third dilemma occurs between traditional fisheries, aquaculture and other industries (tourism, oil exploration, new energy etc.) related to the use of the oceans and costal waters.

Sustainable management and production is necessary for further growth of the world's seafood supply. However, the concept of sustainability is complex. This is illustrated by the fact that sustainability has been used and is perceived differently by various stakeholders. Stakeholders use different parts of the concept of sustainability to strengthen their claims and arguments, but seldom clarify more precisely what is meant. Is the concept referring only to environmental sustainability or to economic and social sustainability as well? Equally important is to specify at which level sustainability should be achieved (locally, regionally, nationally or at a global scale). The various dimensions of sustainability may partly be inconsistent, and in many cases difficult to measure. Hence, the claim often heard from all interested parties, that the industry is (or should be) sustainable, may imply many challenges, particularly in setting up a regime which can measure sustainability (in the broader definition of the word) with some degree of precision.

In conclusion, we see a seafood industry (fisheries, aquaculture and seafood processing) characterized by rapid growth and with great potential, but presently limited by accusations of operating in an unsustainable manner. Consequently, it is important both for the industry, public authorities and other stakeholders to clarify the concept of operational sustainability in general and specifically how it relates to seafood industry in Europe.

Interesting questions are: How are we going to achieve sustainable seafood supply in Europe, and how are we going to manage the areas at sea and land to secure a sustainable seafood production in Europe in the mid and long term?

Objectives

Sustainability is a complex and multi-disciplinary field, thus, this project will include different scientific disciplines within the MINT-disciplines and SSH-disciplines, and the primary objective of this project is:

- Identify challenges of a sustainable seafood supply in Europe, and suggest how these challenges could be met to achieve a sustainable growth, which includes environment, people, employment, innovation, regulations, and a strong blue economy in Europe.

Secondary objectives:

- Evaluate the current framework for sustainable seafood supply in Europe related to environmental, economic, social and institutional dimensions of sustainable development.
- Carry out comparative studies in terms of sustainability: 1) Wild fisheries vs. Fish farming in Europe, and 2) Seafood production vs. agriculture production.
- Suggest which elements and principles to include in a generic management framework for sustainable development within the seafood industry in Europe based on research as well as best practices from the industry.

B.21. G. Kraus & R. Döring: Taking a different perspective on fisheries management

The world population will further increase over the next decades and fish is one of the main protein sources for many countries especially in Africa and South East Asia. During the past few decades, depletion of many commercial fisheries became a common phenomenon world-wide with presently only few signs of recovery. This situation has caused concerns not only among politicians and scientists involved with assessing and managing fisheries, but also among those dependent on fisheries for economic or food reasons. Moreover, the poor state of fish stocks and destructive habitat impacts of certain fishing practices have elicited a generally negative picture about fisheries in the broader public and concerns about the ecological footprint of the fishing industry are in focus of today's general debate about fisheries and aquaculture.

Policy oriented fishery science has traditionally focused on the ecology of target species of commercial fisheries and methods for sustainable exploitation, i.e., how can we make sure that a fishery does not take more fish out of the system than the stock can provide over long time without loosing its productivity. Ecosystem impacts of fishing and how an environmentally friendly fishery governance and management system should look like have only recently been in focus of the debate on fisheries. Today's fisheries management systems were developed starting from these deliberations about the health and productivity of fish stocks with some consideration of ecosystem impacts. Unfortunately, since the implementation of the first Common Fisheries Policy in 1982 and a European fisheries management system this focus did not change much. Here, we propose a project providing the science base for an alternative approach to decision-making in the management of living marine resources. The European Union imports large amounts of fish to supply the common market — also in Germany. The overuse of stocks worldwide let to the discussion, if several aquaculture products can substitute the supply of wild stocks. Additionally, aquaculture may also supply the market for renewable energy (like sea weed) or special products for cosmetics etc. The approach we are proposing would overcome the traditional management distinction between capture fisheries and aquaculture and cover all aspects of fish production from catch to table in an integrated way. The proposed project might nicely complement the present management and decision support system in Europe by providing an alternative science base for decision-making, but it might as well be suited as new framework for a completely different management system, which in turn may require a different legal and institutional framework. In particular, we propose to reverse the management focus from ecosystems and stocks towards the end of the production chain, i.e. to start thinking from the fish product and investigate how optimal production chains and the related governance and management systems should look like under consideration of the ecological footprint of the products (from catch to table) as well as the economic and social dimension of the entire production chain.

Local demands are influenced are by global developments and global markets determine the demand for and thus the success of local products more and more. In such a situation where global markets are heavily interacting with local resource management issues, management needs to take a broader perspective and integrate across all aspects of the sector they are managing.

In the field of aquatic food supply this means a successful future management would need to take into account how markets for aquatic food and non-food products influence the entire aquatic sector including fishery, aquaculture and at least to some degree Blue Biotechnology and other maritime activities competing with the production of aquatic food. Starting to manage the products rather than focusing on the resources is one means to integrate the different aspects of aquatic food production into one comprehensive management approach. A comprehensive comparison of production methods in fisheries and aquaculture starting from the product and going back to the starting point of the production chain while considering economic, ecological and social aspects of the production process is new in aquatic sciences. By integrating research on ecology, legal aspects, governance, institutions and societal and political priority setting this project proposal is interdisciplinary at its core.

B.22. S. Kuikka, P. Haapasaari: Definition of risks in fisheries: combining biology, economic and social sciences

Background

The Common Fisheries Policy gives a background and general aims for fisheries management in EU. However, the legislation is not detailed enough to guide in calculating and communicating the risks, as e.g. management objectives are poorly specified. There is a need for systematic mapping and description of those variables/elements that are seen, by stakeholders, to be the most important elements of risks.

Tingley et al (2010) compared risk perceptions in four different countries, and concluded that there are clear differences in the ranking of different types of risks. Addressing the different perceptions of risks can lead to more policy relevant science, and help problem solving in fisheries management negotiations. EU is a wide area, and the different views need to be taken into account.

Aims

The aims are as follows:

1. to identify the main elements of risks seen by stakeholders in different countries
2. to link them by causal maps to see their mutual dependences
3. to analyze how large proportion of relevant risks can be estimated by current tools
4. to make a preliminary risk analysis for some of the causal maps created to understand the main challenges in the estimation of risks

Methods and need for interdisciplinary research

The main tools suggested are:

1. the mental modeling tools described in Tingley et al, supported by
2. the causal network analysis , Haapasaari et al, (in press) and finally,
3. Bayesian network analysis (Jensen,2001 and Uusitalo 2007) to provide probabilistic estimates for main risks.

Lane and Stephenson (1998) propose an overall framework for risk analysis in fisheries decision making. They stress that fisheries management should be based on integrated evaluations of biological, economic and social uncertainties, risks and objectives, and propose a framework for the incorporation of the elements of both risk assessment and risk management in decision making. As well, the DPSIR (driving forces-pressures-state-impact-response) approach (Camanho et al. 2010) provides an integrated framework to describe the relationships between the diverse origins and consequences of problems. Many risks in fisheries are caused by social (e.g.

characteristics of fisher community) and economic drivers (e.g. demand, prices), which create pressures (fishing effort, non-complying with legislation, discards) that affect the biological state of the system (fish abundance), and further impact the social and economic performance of the society. Legislative and educational actions are needed to response to undesired impacts, and can be targeted to any part of the chain between drivers and impacts. Interdisciplinary methods and approaches are needed to expand the knowledge base of fisheries management towards a more holistic direction, and thereby to ensure the sustainable use of fish resources. Moreover, approaches to facilitate the challenge related to the communication of scientific findings must be developed. An interdisciplinary risk analysis model provides a framework to examine interactions between various uncertainties, objectives, and stakeholder interests, and thereby to anticipate consequences of alternative decisions prior to their implementation. Use of results The results can be used to focus interdisciplinary research on issues which are seen relevant by stakeholders. Moreover, the results can be used to focus the future EU data collection activities (e.-g. social sciences related information is not collected at all at the moment) and to help in understanding the interdisciplinary challenges of fisheries management science, which are likely relevant for other areas of science focusing on sustainability issues.

References

Camanho A.S., Hora, J., Gaspar, M.B., and Oliveira, M.M. 2010. Analysis of the artisanal fisheries in the Atlantic Arc based on the DPSIR framewwork. FEUP/IPIMAR Report of Project PRESPO.

Haapasaari, P., Mäntyniemi, S. Kuikka, S. 2012. Framing the problem with stakeholders: five views to herring fishery management. Ecology and Society, in press.

Jensen, F.V. 2001. Bayesian networks and decision graphs. Springer, New York.

Lane, D.E., and Stephenson, R.L. 1998. A framework for risk analysis in fisheries decision making. ICES Journal of Marine Science 55:1-13.

Tingley, D., Asmundsson, J., Borodzicz, E., Conides, A., Drakeford, B., Eethvarethsson, I.R., Holm, D., Kapiris, K., Kuikka, S. & Mortensen, B. 2010. Risk identification and perception in the fisheries sector: Comparisons between the Faroes, Greece, Iceland and UK. Marine Policy, 34 (2010) 1249-1260.

B.23. Ø. Lie: "Marine Food Genomics" - employing genomics as a powerful and sustainable tool to address and improve a wide variety of very important traits and measures throughout the whole seafood value chain and thus meet with grand food supply challenges.

Genomics is a powerful, sustainable, cost cutting and versatile toolbox that will enhance the competitiveness of the players and provide healthy abundant blue food for the consumers, an important substitute to agricultural products when the population growth (9 bill by 2050) is requiring total new volumes of food supply. Moreover, genomics has proven the toolbox the last couple of decades to be by far the most powerful one to unravel total new biological insight of vast format; the number one life science tool box. And for the purpose to exploit to the maximum is implications, cross sector and interdisciplinary concerted efforts has proven to be a pre requisite. Hence, food genomics is a must in any contemporary research program and policy that aims at moving forward smart and sustainable aquatic food supply at new scales.

Some rationale behind this statement is more concretely laid down below:

No other single tool can address and improve that many traits with implications throughout the whole value chain than can genetic enhancement and breeding and moreover in the most sustainable way: growth rate, feed conversion ratio (fcr), fillet yield and a long variety of meat qualities and complexion (color etc), general robustness and resistance to specific diseases, meat quality etc. Moreover, breeding have become blessed with a new array of strong tools in the wake of the race of sequencing also now the genomes of industrial important terrestrial and aquatic species.

Recent advances in genome sequencing and high throughput technologies revolutionize our ability to understand the molecular basis economically important complex traits like diseases and food quality. The international frontier in animal, fish and plant breeding are currently converting genome information into breeding tools that are significantly more cost effective and less time consuming than conventional methods: paradigm shifts in genetic enhancement methods from classical quantitative genetics, via molecular parentage and id testing to marker assisted selection, genomic selection and down the road epigenetics based approaches to modify gene expression and gene environment interaction to customize products to a wide variety of markets and needs. Recent advances in food chemistry and processing technologies increase the possibility to optimize the utilization of food components along the food chain. Genetic barcoding can be developed for robust tracking and tracing along the food chain for quality assurance of brands and safety

Population growth, urbanization and income growth in developing countries are fuelling a massive global increase in demand for food of animal origin. The demand-driven livestock revolution is one of the largest structural shifts to ever affect the global food markets. Animal food production has increased dramatically in the past and that is very likely to increase in the future. With the expected rate of population growth (1,5 % per year), combined with an estimated increase in animal consumption of 7 % per year the coming 15-20 years, demand for animal food will grow enormously.

In the past 30 years, the same factors that drove the enormous increase in total meat consumption, in addition to an increased awareness of health issues in relation to food have more than doubled the global consumption of fish. From 45 million tons in 1973, total fish consumption jump to more that 110 million tons in 2006. Aquaculture accounted for 47 % of the world's fish food supply in 2007, up from just 7 percent in 1973 (FAO, 2009). With wild fish production under pressure, it is expected that already in a few years, aquaculture will be the greatest source of the fish consumed by the human population worldwide.

In order to fulfil the expectation to aquaculture as a major source of animal proteins to a growing populations, it has to be through an expansion of the water surface area under cultivation or increasing yield per unite of area cultivated. To increase yield, they can either increase input or achieve greater efficiency from a given level of inputs. The use of high quality seed developed through efficient breeding program will be crucial to this development, not only to increase the aquaculture productivity, but also to food security and to reduce the impact on the environment.

Sustainable and social responsible food genomics needs robust concerted efforts across sectors, stakeholders and disciplines.

B.24. E. Mikkelsen: Understanding and managing habitat – fisheries interactions

Wild fisheries face a number of threats and stressors, including from climate change, pollution and overfishing. While pollution control seems to have been improved the latter years, at least in the developed countries, overfishing is still a major problem. The effects of climate change are still not well understood, and may also be difficult to counter or even reduce within the time-horizon most policy-makers have. The combined effects of these stressors are largely blank areas on the map of the road to sustainable aquatic food supply. Not only must the effects be understood, but efficient policies to limit them must also be developed.

The result of the above-mentioned stressors' impacts can at least to some degree be seen as habitat change for wild fish populations. This includes also the effects of destructive fishing practices and negative effects of aquaculture on wild fish. "Habitat" includes a number of dimension and characteristics, including temperature, salinity, acidity, nutrient/prey availability and competition, prevalence of predators, and more. This has effects on habitats' carrying capacity, on individual fish and fish stocks' growth rates, and thus on sustainable harvests in fisheries.

In addition to work within single disciplines, trying to unravel these effects on fisheries are today mainly done using two types of models:

- Analytical bio-economic models seeking to understand major mechanisms and policy options.
- Numerical end-to-end models including earth sciences, biology/ecology and economics.

While the first type of models gives the possibility of detecting rather robust results regarding mechanisms and policy options, applicable to a number of applications, they are many times too coarse and simplistic for designing real management policies. The second type of models can give valuable input to practical management, but they appear to a large extent as "black boxes", where the mechanisms determining outputs are hidden. It usually also takes a long time to establish and validate these second type of models. This limits their usefulness in times of large transitions in ecosystems or economy.

I propose to consider the two large research questions:

1. Can the insights and approaches from analytical bioeconomic models and end-to-end integrated models be combined to better understand the effects of different stressors on fish stocks, modeling it as habitat-fisheries interactions?
2. Can the insights from answering question 1 give new and improved policy options and measures?

Researchers from earth sciences, biology, ecology and economics should cooperate with the aim of combining the best from the two different types of models above, to understand how different stressors affect wild fish stocks and fisheries. These hopefully improved insights should be applied together with insights from political scientists, sociologists and philosophers/researchers on ethics to design, develop and explore policy options and policy implementation.

A little more on bioeconomic models of habitat-fisheries interactions:

There is a substantial literature of bioeconomic modeling related to fisheries, and some bioeconomic modelling of fisheries and habitat/environmental influences (see Knowler (2002) and Upton and Sutinen (2003) for overviews). However, the broader ecosystem aspects, and even more the issue of multiple stressors, are still not well developed. Multispecies fisheries models (Eide and Flaaten 1998), habitat-fisheries models (Foley, Armstrong et al. 2012) and fisheries models including external stressors such as climate change, aquaculture or pollution (Eide 2007; Mikkelsen 2007; Smith 2007) have been studied. Though few bioeconomic fisheries modeling exercises have focused on exogenous stressors (i.e. unrelated to fishing), an early study was carried out by Bell (1972), who presented a bioeconomic model including a habitat variable, namely water temperature, in an empirical model of a fishery. Much more work is needed to analyse the effects of different stressors together, both climatic and non-climatic stressors, and to determine management implications.

References:

Eide, A. (2007). ”ECONOMIC IMPACTS OF GLOBAL WARMING: THE CASE OF THE BARENTS SEA FISHERIES.” Natural Resource Modeling 20(2): 199-221.

Eide, A. and O. Flaaten (1998). Bioeconomic Multispecies Models of the Barents Sea Fisheries. Models for Multispecies Management. T. Rødseth. Heidelberg, New York, Physica-Verlag: 141-172.

Foley, N., Armstrong, C.W., Kahui, V., Mikkelsen, E., Reithe, S. (2012). ”A Review of Bioeconomic Modelling of Habitat-Fisheries Interactions.” International Journal of Ecology.

Knowler, D. (2002). ”A review of selected bioeconomic models with environmental influences in fisheries.” Journal of Bioeconomics 4: 163-181.

Mikkelsen, E. (2007): “Aquaculture-fishieries interactions.” Marine Resource Economics 22: 287-303.

Smith, M. D. (2007). ”Generating Value in Habitat-dependent Fisheries: The Importance of Fishery Management Institutions.” Land Economics 83(1): 59-73.

Upton, H. F. and J. G. Sutinen (2003). ”When do marine protected areas pay? An analysis of stylized fisheries.” American Fisheries Society Symposium 41: 745-757.]

B.25. M. Moren: Sustainable food supply from the oceans; a question of food safety, food security and bio-diversity

With a growing population, estimated to become 9 billion in 2050 (UN_DESA 2009), food security is of paramount international concern. Fish consumption has increased yearly by 0.51992, up to 16.7 kg per capita in 2009. Future increase of demand may be helped largely by the development of sustainable aquaculture systems (multi-species systems, Shearer, 2012) but much of the captured fish, now used for human consumption, may become too polluted to be eaten safely and species may diminish (or gain population size) due to climate changes. Accordingly, the management of the ocean for food supply is a question of food security, food safety and maintenance of bio-diversity.

The ocean does not only provide food through fisheries and aquaculture, it also an arena for petroleum activities, renewable energy and mineral extraction, a pathway for global shipping, and a hiding place for waste dumping and pollution. National governance needs to balance these issue and the decisions will always have an impact on the ecosystem and biodiversity. Ecosystem-based strategies are currently used as methods of governing such a multi-actor, multi-objective setting. In many cases the potential negative effect on food supply is difficult or impossible to predict. The precautionary approach is often recommended by scientists and environmentalists, but are we precautious enough? Examples from Norway are the challenges on whether to allow for oil exploration in sensitive spawning grounds close to the Lofoten archipelago, and if it should be allowed to dump chemical-contaminated mining wastes in fjords. The first question is about the potential ecological risks in case of oil spills, while the other question is whether or not to accept destruction of benthic fauna and severe impacts on several fish species in fjord ecosystem. These are some of the difficult questions the government is facing at present. Governments around the globe are facing similar challenges. At the same time we need to manage persistent and ongoing alterations and negative effects on the marine environment (e.g. fisheries, pollution and habitat deterioration). To make matters even more complicated, climate change and ocean acidification add to this and complicates our ability to give advices.

One important question is what we consider to be sustainable development, another is when do we use the precautionary principle and what is a precautionary level? Finally: can the precautionary principle and the ecosystem-approach, which managements now try to use, make us obtain food safety and food security? These are questions at the crossroads between natural science, socioeconomics and philosophy. Up to now governments have tried to solve them purely on a natural science approach. However, since societal choice and weighing of objectives is so central to how one defines sustainable and precautionary in each case, consensus is not met.

The IMR (Inst of Marine Research) and NIFES (Nat Inst of Nutrition and Seafood Research) are governmental funded research institutes with an advisory role that supply the Norwegian government with scientific based advice in matters of marine ecosystem science, biodiversity, fisheries, aquaculture and the safety of human consumption of fish and shellfish. We propose a project which will use the example of sustainable food from the ocean in relation to other uses as a discussion ground for developing such a multi-disciplinary set of precautionary and sustainable objectives, both to show in practice how it can be achieved but also to further develop the methods for handling such intricate management challenges (e.g. ecosystem-based risk assessment).

B.26. H. Mulyati, J. Geldermann: Managing Seaweed Supply Chain Risk from Indonesian Source to Global Markets

Abstract

Seaweed supply chains face a dynamic business environment with complex disturbances in both supply and demand aspects. Long-term solutions should be prepared to ensure a sustainable seaweed industry in Indonesia. This thesis will attempt to design a model of seaweed supply chain risk management in Indonesia to reach sustainability and a competitive advantage. The specific objectives of the thesis are: 1) Identifying and categorizing the risks of seaweed supply chain; 2) Assessing the risks along the seaweed supply chain – risk analysis, assessment, and impact measurement in terms of likelihood of occurrence and potential consequences; and 3) Designing supply chain risk management for the seaweed industry in Indonesia using decision analysis. This will generate and consider alternative scenarios and solutions with a robust analytical tool to support decision makers in the seaweed supply chain using multi criteria decision analysis (MCDA).

B.26.1 Introduction

Indonesia has a big opportunity to become one of the seaweed producer in the world that has large areas for seaweed cultivation (1,110,900 million ha). The biggest producers of seaweed are spread across South Sulawesi (31.89(6.66Marine Affairs and Fisheries, Republic of Indonesia, 2010).

Seaweed is widely used for raw materials in food (human and pet food) and nonfood industries (pharmacy, cosmetics, bioenergy). Seaweeds or marine macro algae were classified into three main groups based on their pigmentation: Phaeophyceae (brown algae), Rhodophyceae (red algae) and Chlorophyceae (green algae), respectively (FAO, 2003). Brown and red algae are the most useful for development of food industry because they have polysaccharide content. They produce three hydrocolloids: agar, carrageenan, and alginate. A hydrocolloid is a non-crystalline substance with very large molecules and dissolves in water to create a viscous solution (Glickmans, 1987). Several types of green algae are used as salad ingredients.

The seaweed industry has many advantages for development in Indonesia, such as potential export commodities, simple cultivation technology, and short cultivation cycle (45 days) across the whole year, no substitute commodity and absorption of many areas of labor. But, development of the seaweed industry faces many problems such as low seaweed quality, gap targets between seaweed cultivation (on-farms) and production (off-farms), the fact that increased seaweed cultivation is not being followed by increased seaweed industry, and production has been limited to semi-finished industry such as sheet (chip) and powder.

Seaweed supply chains face a dynamic business environment with complex disturbances in both supply and demand aspects. Disruptions of raw materials supply, such as volatility of raw material supply, can lead to downtime and consequent failure to satisfy the customer's requirements on time. Volatility in terms of price may result in difficulties in passing on price changes to the customer and potentially have the consequence of lost profit. Poor quality of seaweed product may impact on the level of customer satisfaction, with consequences for future outcomes. The industry also faces vulnerable conditions or temporary competitive advantages caused by uncertain conditions such as economic disruption and both natural and man-made disasters. Long-term solutions should be prepared to create a sustainable seaweed industry in Indonesia. This ideal condition requires comprehensive research through the seaweed supply chain which considers its risks. Furthermore, the development of the seaweed supply chain may introduce a move from national market to international supply chain.

B.26.2 Research Statement

Risk is the fundamental element that influences seaweed supply chain sustainability and competitiveness. Risks along seaweed supply chains should be managed, as well as members' interdependence on each other. If there are disturbances in one part of the supply chain, the effect of the disturbances affects the whole chain dynamically. The research question is "How to mitigate seaweed supply chain risks in Indonesia using a decision support tool to achieve sustainability and competitive advantage?"

B.26.3 Research Objectives

This thesis will attempt to design a model of seaweed supply chain risk management to reach sustainability and competitive advantage in Indonesia. The scope of this thesis focuses on food processing in the seaweed industry (agar and carrageenan). The specific objectives of the thesis are:

1. Identifying and categorizing the risks in the seaweed supply chain; incorporating the source and categorization of risks, what may trigger them and the relationship with the supply chain functioning effectively and efficiently;
2. Assessing the risks along the seaweed supply chain – risk analysis, assessment and impact measurement in terms of likelihood of occurrence and potential consequences;
3. Designing robust strategies to mitigate supply chain risk and a decision support tool for the seaweed industry in Indonesia. This will generate and consider alternative scenarios and solutions with a robust analytical tool and framework to support decision makers in the seaweed supply chain.

B.26.4 Research Contributions

There are abundant theoretical studies regarding supply chain risk and supply chain risk management. Supply chain risk (SCR) is a relatively new topic in the supply chain management literature and is an increasingly popular research area (Sodhi and Tang, 2012; Vanany et al.,2009; Ritchie and Brindley, 2007; Peck,2005; Jüttner, 2005).

Supply chain risk is assessment of failure by its probability of occurrence that is caused by an event within internal and external supply chain affecting the business process negatively (Zsidisin and Ritchie, 2010; Pfohl et al., 2010, Kersten et al.,2006; Tang, 2006; Norrman and Jansson, 2004). Yet limited in depth empirical research on supply chain risk in different fields has been published.

Therefore, this study will fill the gap between theoretical and empirical research in the supply chain risk field. In addition, it will contribute managerial aspects for decision makers or members of the seaweed supply chain. The strategic decision model will be used by seaweed farmers and seaweed manufacturing. This study could answer questions on how the risks along the seaweed supply chain can be managed. For these reasons, MCDA is well suited for analyzing the qualitative and quantitative behavior of the supply chain risk of seaweed. The researcher found no application of MCDA in the field of SCR. Several advantages of MCDA: help decision makers learn about the problem, provide a focus and a language for discussion, help to structure the complex problem, take the balancing of multiple factors, integrate objective measurement with value judgment, and manage subjectivity (Figuera et al., 2005; Belton and Stewart, 2002).

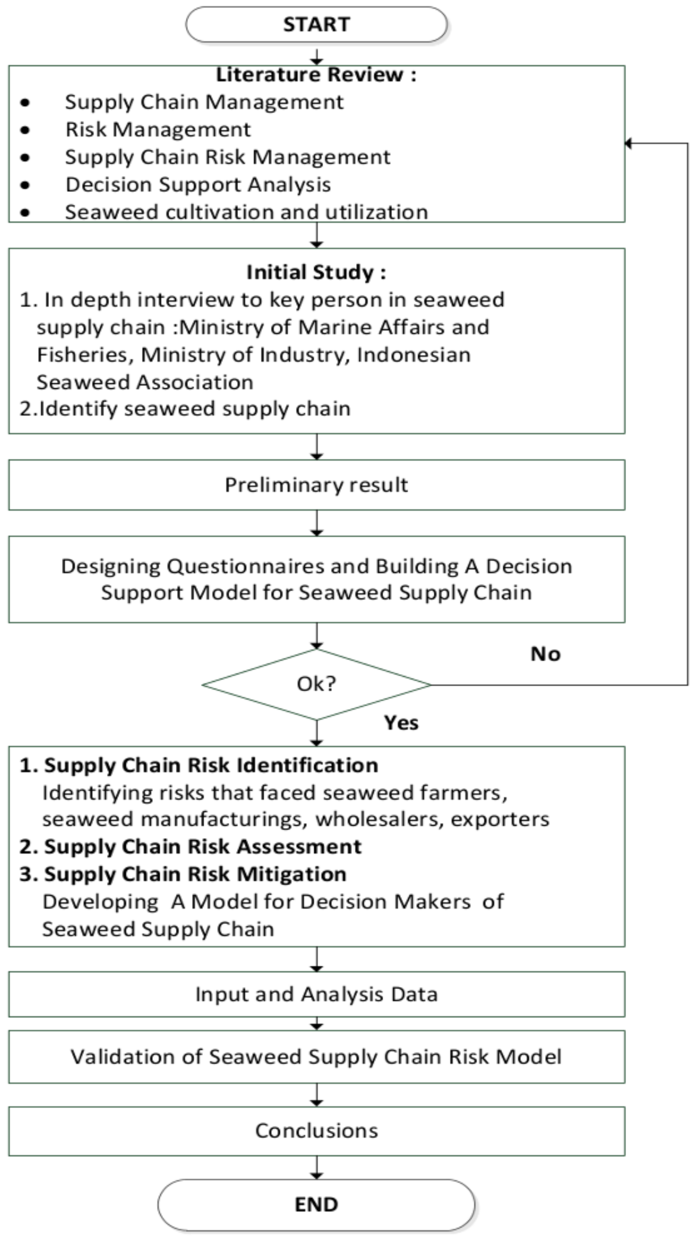


Figure 5: *Research Framework*

B.26.5 Research Methodology

The steps of the study comprise risk identification and categorization, risk assessment, and risk mitigation (Sodhi and Tang, 2012; Zsidisin and Ritchie, 2010; Faisal, 2009; Manuj and Mentzer, 2008; Wu et al., 2006; Khan and Burnes, 2007; Norrman and Jansson, 2004). Supply chain risks categorize into three categories: internal to the firm (process and control risks), external to the firm but internal to the supply network (supply and demand risks), and external to the network (environmental risks) (Kersten et al.,2006; Jüttner, 2005; Christopher and Peck, 2004; Jüttner et al.,2003). The framework of research shows in Figure 5. Initial data was obtained through semi-structured interviews with key stakeholders: Ministry of Fisheries and Marine Affairs Republic of Indonesia, Ministry of Industry Republic of Indonesia, Indonesian Institute of Science, and Indonesian Seaweed Association. The data for this research will be gathered using a number of approaches:

1. Survey
This method provides opportunities for the researcher to analyze real condition of seaweed industry in Indonesia. The researcher can investigate and explore the condition of the biggest producer in Indonesia.

2. Documentary analysis
This method involves the study of existing documents to understand their substantive content. Documentary sources were needed when situations or events cannot be investigated by direct observation or questioning. These may be public documents such as media reports, government reports, or publicity materials. This research will collect documents from Ministry of Marine Affairs and Fisheries, Ministry of Industry, the Indonesian Seaweed Association, and literature such as journals and books, as well as information from public media.

3. In depth interviews
Semi structured interviews will be undertaken, using responsive, flexible, and interactive questioning techniques. The interviews will use questionnaires to identify supply risks, operational risk, control risk, demand risk and environmental risks. The respondents include seaweed farmers, seaweed manufacturing, wholesalers, and exporters.

4. Focus Group Discussions (FGD)
This approach involves several expert respondents from key stakeholders (national or local government, Indonesian seaweed association, and academician) to discuss the risks in the seaweed supply chain and how to manage them. The researcher provides some questions about the supply chain risk and explores the ideas put forward by participants.

B.26.6 Work Packages

The next steps of this study focus on several questions seeking to develop seaweed supply chain risk decision support:

1. How can the seaweed supply risks be quantified?
2. What type of MCDA needs to be developed to build a strategic decision framework for the seaweed supply chain?

3. How can the research findings be validated?

4. What recommendation can be implemented of the research's findings for decision makers of seaweed supply chain?

References

Anonymous (2011). Ministry of Marine Affairs and Fisheries. Industri Rumput Laut Indonesia. http://www.bbrp2b.kkp.go.id/publikasi/lain/inbudkan-1.pdf

Belton, V. and T.J.Stewart (2002). Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publisher, USA.

Chopra, S. and P. Meindl (2007). Supply Chain Management: Strategy, Planning and Operation. 3rd edition. Prentice Hall, New Jersey.

Christopher, M. and H. Peck (2004). Building the Resilient Supply Chain. International Journal of Logistics Management, Vol. 15 No. 2, pp 1 -13

Faisal, M.N (2009). Prioritization of Risks in Supply Chains. Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers. Wu, T and J.Blackhurst. Editors. Springer.

Figuera, J., S. Greco and M.Ehrgott (2005). Multiple Criteria Decision Analysis: State of The Art Surveys. Springer

Glicksman, M. (1987). Utilization of Seaweed Hydrocolloids in The Food Industry. Hydrobiologia 1517152: 31– 47. 12 International Seaweed Symposium, Netherlands.

Jüttner, U., H. Peck, and M. Christopher (2003). Supply Chain Risk Management : Outlining Agenda for Future Research. International Journal of Logistics: Research and Applications, Vol. 6 No.4, pp. 197–210.

Jüttner, U. (2005). Supply Chain Risk Management: Understanding to Business Requirements from a Practitioner Perspective. International Journal of Logistics Management. Vol.16 No.1,pp 120-141.

Khan, O. and B. Burness (2007) Risk and Supply Chain Management: Creating A Research Agenda. The International Journal of Logistics Management, Vol. 18 No.2, pp. 197–216.

Kersten, W. et al. (2006). Supply Chain Risk Management: Development of A Theoretical and Empirical Framework. InKersten, W. and T.Blecker (Ed.). Managing Risks in Supply Chains: How to Build Reliable Collaboration in Logistics.Erich Schmidt Verlag, Berlin, pp. 3–17.

Manuj, I. and J.T.Mentzer (2008). Global Supply Chain Risk Management. Journal of Business Logistics, Vol.29, No.1 pp 133 - 155.

McHugh, D.J. (2003). A Guide to The Seaweed Industry. FAO Fisheries Technical Paper 441, Rome, Italy. Norrman, A. and U. Jansson (2004). Ericsson's Proactive Supply Chain

Risk Management Approach After A Serious Sub Supplier Accident. International Journal of Physical Distribution and Logistics Management, pp. 434–456.

Peck, H. (2005). Drivers of Supply Chain Vulnerability: An Integrated Framework. International Journal of Physical Distribution and Logistics Management, Vol.35, No.4, pp. 210–232.

Pfohl, H.C., H. Köhler, and D. Thomas (2010). State of The Art in Supply Chain Risk Management Research: Empirical and Conceptual Findings and A Roadmap for The Implementation in Practice. Logistic Res., pp. 33–44. Springer, Verlag.

Ritchie, B. and C. Brindley (2007). Supply Chain Risk Management and Performance: A Guiding Framework for Future Development. International Journal of Operations and Production Management, Vol 27 No.3,pp 303-322.

Sodhi, M.S. and C.S. Tang (2012). Managing Supply Chain Risk. Springer

Tang, C.S. (2006).Perspectives in Supply Chain Risk Management. International Journal Production Economics, Vol. 103 No.2, pp. 451–488.

Vanany, I. S. Zailani and N. Pujawan (2009). Supply Chain Risk Management: Literature Review and Future Research. International Journal of Information Systems and Supply Chain Management, Vol. 2 No.1, pp. 16–33. January–March.

Wu, T. J.Blackhurst, and V.Chidambaram (2006). A Model for Inbound Risk Analysis. Computers in Industry Vol.57, pp 350-365.

Zsidisin, G.A, and B. Ritchie (2010). Supply Chain Risk: A Handbook of Assessment, Management and Performance. Springer.

B.27. A. Myhr: Domestication of salmon — biological, social and ethical issues

B.27.1 Background

Norwegian salmon farming has arguably contributed to changing the way the salmon species is perceived both as a source of food and as an essential element of traditional and contemporary cultural practices.

In this project one of the aims is to examine preconditions for introduction of new emerging biotechnologies within aquaculture. New technologies are characterized by uncertainty with respect to the expected beneficial effects as well as possible adverse effects. They may have a major impact on social development, raising questions about whether the development is desirable, for whom, as well as the impact decisions made now may have on future options. One of the main challenges with new technologies is how to use the new opportunities these technologies offer us, while at the same time considering how we take care of biodiversity, promote sustainability and prevent harmful effects to health. This has caused an increased interest in that ethical, legal and social perspectives are included in the research process itself, as well as on the technological applications developed through it, to ensure that it can be socially robust, ethically sound, economically viable and environmentally responsible. The importance of including such perspectives ”upstream” in the research may also help identify and prioritise research needs, and it may support evaluations of the adequacy of relevant existing regulatory frameworks.

We will in this WP put an special emphasise on salmon as this is the most important fish in Norwegian aquaculture. The research will be carried out for (i) identification of visions and values related to salmon and how they influence the economic and environmental debates, (ii) conducting a scientific literature survey on recent biotechnology developments related to salmon genetic improvement, vaccines and feed, discussing their potential effects on the species (iii) analysing the ethical challenges related to different kinds of use of salmon resources, and (vi) comparing some of aspects of aquaculture controversies in Norway to other countries in Europe and then with other aquacultured species to explore preconditions and risk related to aquaculture industry. The complexity of the issues will be met with an interdisciplinary approach.

B.27.2 Technological development, biotechnological possibilities, new options

The farming of fish has only been possible due to technology developments related to the use of hatcheries, net pens, fish feed, feeding stations, harvesting methods and processing. The domestication has been accompanied with systematic breeding to encourage growth, earlier sexual maturation and reproduction as well as reduced aggression. The first stages of aquaculture in Norway consisted in small, locally owned enterprises, using small nets and having relatively low production. As the technology became more advanced, it enabled larger facilities, but the high density of fish created favourable living conditions for pathogens affecting frequency and diversity of disease outbreaks. Another important problem is related to discharges of production waste and escapees. New technological trajectories as transgenic fish, genetically modified (GM) vaccines and feed, are considered to be potential solutions to some of the problems the industry are facing today. A key factor to the continuous growth of the fish farming industry has been the development of effective fish vaccines (Berg et al., 2006). Still, pathogens such as bacteria, parasites and viruses cause a reduction in the production of domesticated fish, and represent both an animal welfare and an economical problem. It has been difficult to develop traditional vaccines to protect against certain viral and parasitic diseases, and hence there is at present a high emphasis on the use of biotechnology for developing GM/DNA vaccines as well on the use of nanotechnology as carrier for vaccines or by providing new pharmaceutical solution to this problem (Myhr & Dalmo, 2005, Lü et al., 2009). Improved breeding strategies have also been emphasised from the early stages of fish farming. Initially the purpose was improved productivity traits, while the present focus is more on disease resistance, survival and product quality. Markers for genes involved in growth and controlling aggression as well as resistance to different diseases can now be used for selection either using marker-assisted breeding or GM strategies. The development of aquaculture has alerted us to the special role and value of the salmon. Through the industrialised change of the salmon one can better appreciate the uniqueness of wild, non-modified salmon – not as something completely different, but as something that stands in a relation because it is not completely under human control. But we also do develop a different relation to the salmon as part of our husbandry.

The aim is to discuss in what ways technological interventions as the introduction of biotechnological vaccines, as well as using new initiatives for breeding as marker assisted selection and genetic modification (GM), have significance for the salmon's status. Recent technological developments together with knowledge gained by breeding as well as the salmon genome project and similar initiatives may provide solutions to the present challenges by diseases, parasites and escapes. Present vaccination approaches are limited to some bacterial and viral diseases while there are no vaccines against other parasites of fish. GM and DNA vaccines may offer a technological solution to these problems. Moreover, DNA markers and transgenics have open up new possibilities for genetic improvement of aquaculture species (Hayes and Andersen 2005). DNA markers have already been applied in aquaculture breeding for direct and highly accurate selection of specific traits (e.g. disease resistance). GM has enabled development of transgenic fish with improved growth rate, such as the AquAdvantage. Approaches that combine interesting characteristics, as enhanced growth and disease resistance, together with approaches for development of sterile fish or fish where reproductive activity can be down-regulated is also highly relevant since this will minimise the risk of transgenic fish breeding with wild populations after escape.

Activity 1. Survey of biotechnological innovations of relevance for salmon aquaculture.
This will be performed by a literature review to describe the state of the art of research with regard to new developments within vaccines, feed and on fish genetic improvement. Through this literature review we intend to: i. Describe different strategies for vaccination, feed, genetic improvement of relevant traits in farmed fish with emphasis on salmon ii. Discuss the opportunities and challenges this technology may offer to the aquaculture industry, consumers, environment and society The review will include searching databases

(e.g. ISI web of knowledge, Google scholar, PubMed, etc.) for peer-reviewed academic literature, as well as industry reports and national and international policy documents. Furthermore, recent unpublished results on GM fish in on-going projects will be monitored through networks and participation in relevant project seminars and conferences. We will use Atlas.ti that is a qualitative analysis software to organise and analyse the information gathered (see www.atlasti.com for more information).

Activity 2. Explore social, cultural and ethical significance of different kinds of biotechnological interventions in aquaculture.

Surveys as well as ethical analyses have suggested criteria for distinguishing between different kinds of GM according to their traits introduced. There are arguments suggesting that new vaccines as well as GM strategies for disease resistance and sterility (preventing interbreeding between escaped and wild salmon) may be more acceptable than initiatives with the purpose to increase productivity as growth enhancement. Another important issue is whether the technological interventions change the nature of the species, and to what extent this represents a threat to the value of the wild salmon. Based on the review in 2.1, this activity will analyse ethical arguments for the acceptability of different potential uses of biotechnology interventions. This will further be explored by interviews with stakeholders.

Activity 3. Map stakeholders and their arguments involved with salmon and compare with other species

We will identify arguments with the intention to compare with perspectives on aquaculture in other countries in Europe, with focus on social and cultural preconditions, especially regarding the special status of salmon for certain groups of Norwegian and as an luxury food.

B.28. Dimitra Mylona: Tuna fishing in the Aegean from antiquity to early 20$^{\rm th}$ century

The earliest evidence for fishing of the seasonal migratory Scombridae, mostly bluefin tunas, bonitoes and chub mackerels in the Aegean dates to the 11$^{\rm th}$ millennium BP. Masses of these fish had been caught, preserved and eaten by the Mesolithic inhabitants of coastal Aegean settlements. This picture of abundance comes to stark antithesis with the deserted thynneia (stationary tuna traps) and the scant catches of the same fish in the Aegean of the present day. However, bluefin tunas were explored to a varying degree of intensity over the subsequent millennia. Archaeological and historical evidence document the economic, social and ideological role of tunas and other related species especially the bonitoes, bullet tunas and little tunnies (here forth tunas), with certain periods in time and certain geographic areas being more prominent than others.

Research on the economic significance of tunas in antiquity tended to downplay its importance. Several factors are responsible for this position, many of them inherent in the development of the relevant discourse both in humanities and in biological sciences. In recent years changes in research priorities, wider dissemination of information and change of the epistemological paradigms have increased our understanding of the tuna and the dynamics of their populations and movements, have multiplied the tuna related data from the Aegean and have re-shaped the theoretical and methodological tools by which we approach the past and specific aspects of it, such as the tuna fishing.

The proposed research program aims to explore these new possibilities in the investigation of tuna fishing of the past (from antiquity to early 20$^{\rm th}$ century) along the Aegean coasts, by combining biological, archaeological, historical and anthropological approaches and knowledge. The research will focus on the bluefin tuna (Thunnus thynnus), nowadays an endangered species, and to a lesser degree to smaller members of the Scombridae family (e.g. bonito-Sarda sarda, bullet tuna- Auxis rockei, little tunny – Euthynnus alletteratus), because traditionally all these species were fished alternately by the same fishermen, often using the same tools, and are part of the same fishing regime. It is hoped that such a research will help us understand which factors affected the fluctuation in the importance of tuna fishing, being them biological, social or other. The Aegean with its complex physical and cultural landscape and its turbulent history appears as a promising setting for this kind of research. The intense archaeological, historical and recently biological research in the area provides a tightly knit background.

Suggested research actions are the following:

- Literature research that will highlight those aspects of tuna biology and ethology that are relevant to their exploitation. One important aspect is the determination of their exact routes and the timing of their appearance in particular locations all over the Aegean. This could be achieved by archival work and the recording of tuna catches in strategically placed landing harbors for a certain period of years.
- Collaboration with a number of excavations in key areas, where increased exploitation of tuna, bonitoes and little tunnies is documented, either archaeologically or by modern

statistics, and application of specialized field techniques (e.g. water flotation) for the collection of fish bone data. The purpose of this is the enrichment of the available evidence with relevant, focused, high quality data.

- Two fold historical work: a) analysis of ancient (and Byzantine) written sources, inscriptional or literary, which refer to the organization of tuna fishing, preservation and trade (with the additional recording of evidence on salt production which appears to be tightly linked to tuna fisheries); b) archival work in the files of the Ministry of Agriculture, Fisheries Division. 19th and early 20th century contracts are kept, that pertain to the leasing of thynneia (permanent tuna traps). The purpose of this research is to establish a concrete trail of evidence for the existence and the organization of the tuna exploitation and also of possible changes in it. This line of research is partly complimentary to the archaeological one.

- Anthropological and ethnographic work in communities which are still involved in the exploitation of migratory fish. This can be done in situ, through the standard methodology of interviews etc, and by studying specialized archives, such as the ethnographic archives of the Greeks of Asia Minor or the Pontic area.

This proposed research requires the collaboration of a range of researchers, which will cover the key sides: biology, archaeology, ancient history, modern history, anthropology. Work on some of these fields is already under way on a small scale, by individual researchers (archaeology, ancient history), while for others (biology, modern history, anthropology), the research agenda has to be formulated from scratch. However, similar work on some aspects of the proposed project has already been done in the Western Mediterranean, and in the case of biology, in Turkey. Therefore, some orientation can be gained from there. The proposed research requires a minimum of three years to develop, ideally more. Work like this, especially its anthropological aspect would be important for educating coastal populations about the problems facing the bluefin tuna stocks and the possible alternative through focus on related non endangered species such as the bonitoes or little tunnies. Also this work can be particularly beneficial to those communities which are involved in the exploitation of the migratory fish, especially the smaller species, because it provides historical depth to their activity and a “story” that may help to make their product recognizable and facilitate its promotion in selected markets.

The proposed research as it has been described above is geographically and thematically focused. However, aspects of it can develop independently or they can be linked to similar research in adjoining areas. The new data that will be generated would provide a rich body of evidence for a number of in depth studies in other aspects of marine food exploitation.

References

Anon. 2011 Report on the ICCAT-GBYP Symposium on trap fisheries for bluefin tuna (Tangiers, Morocco – May 23 to 25, 2011), Collect. Vol. Sci. Pap. ICCAT, 68(1), 1-13.

Lytle, E. 2006. Marine Fisheries and the Ancient Greek Economy. PhD Thesis, Duke University.

MacKenzie B., H. Mosegaard, A.A. Rosenberg, 2009, Impeding collapse of bluefin tuna in the northeast Atlantic and Mediterranean, Conservation Letters 2(1), 26-35.

Mylona, D. 2008. Eating Fish in Greece from 500 BC to AD 700. A Story of Impoverished Fishermen of Lavish Fish Banquets?" (BAR International Series 1754), Oxford.

B.29. Cristina Nervi: Fish products supplies to Sardinia in Roman period

B.29.1 Introduction

I'd like to investigate the importations of fish products to Sardinia — among them salsamenta, garum derivatives from the tuna and anchovies, mackerels, bluefish in general imported from Iberian Peninsula, Africa and Italian Peninsula in Roman times.

Considering also

- the migrations in the Mediterranean Sea of those fish species, their routes,
- the vessels where the fish stuff were exported — amphorae
- and the shipping routes that were used for the commerce in the western Mediterranean area.
- analyzing the sea current, the seasonality of the navigation the difficulties of some sea zone — such as Bonifacio, among Sardinia and Corsica

B.29.2 Methodology

Create a data base of the fish products amphorae diffused in Sardinia:

- in city, ports — in order to reconstruct the shipping routes, and
- also in the hinterland – to demonstrate the use of the products even in area less romanizated
- tracing the shipping routes in different seasons and weather conditions investigating the importance of intermediary ports, as those of the Balearic Islands
- bioresources: the seasonality of the fish trek in the Western Mediterranean area, migrations of the tunas and the other bluefishes.

B.29.3 Aim

Creating an assembly of data, derived from different study matters: archaeological and scientific, about fish foodstuff in Sardinia during Roman period.

Addressed area: History

Contributions of other disciplines: study of the sea currents, related to the winds; biology/ichthyology (habits and migrations of the bluefish)

B.30. K. Ott: “Mixing Aquatic Food”: Prospects for (More) Sustainable Aquaculture

Aquatic food stems from different waters, as rivers, lakes, oceans, ponds, and artificial aquaculture. Demand for aquatic food will be high in the future at a global level. Supply is seen critical. As we all know, many marine fish stock are overfished or are fished close to upper limits of sustainable yields. In theoretical perspective of strong sustainable development, fish stocks have to be seen as living funds which can regenerate over time if pressure is relieved. In general, it seems reasonable to invest in natural capitals, especially in living funds (Ott & Döring 2008). The fishery policy in the European Union has taken first steps into the right direction in order to bring fisheries into safe biological limits.

Complementary to these efforts, there should be reforms in aquaculture to make these supply systems more sustainable, too. Food from aquaculture may substitute for other aquatic food and might, ideally, contribute in relieving pressure of more natural fish funds. Aquaculture has a bad reputation among ecologists and among supporters of the environmentalism of the poor (Martinez-Alier 2002, chapter 5) since it is argued that aquaculture often destroys ecological systems, as mangrove forests, and, by doing so, compromises local livelihoods. But some European examples of aquaculture indicate that aquaculture is open for reforms. As in many technological systems, there might be different “generations” of systems which improve over time. Reforms of contemporary aquaculture can and should take pre-modern, traditional aquaculture into account. We assume that there was much wisdom in traditional agriculture which has been lost or downplayed within the dominant agricultural paradigm of the 20. century. Given all the disadvantages of “modern” (Western) diets, post-modern sustainable food production should take a closer look on traditional practices. Traditionally, wild or semi-wild vegetable has contributed to food security in many cultures. Often, it was a reserve in times of food scarcity. There are eatable (semi)aquatic vegetables in many regions.

Under these assumptions, it might be reasonable to launch some pilot projects of combined plant-animal-aquacultural systems in appropriate regions, as China and Vietnam. We propose a research strategy in order to investigate such systems according to their economic feasibility, contribution to food security and ecological outcome. These systems could be “low-input”-systems with respect to chemicals but could generate options for direct local consumption, local marketing, and processing for remote markets. Being low input systems, they will probably yield less animal protein per ha than current aquacultures. On the animal side of such systems, there can be fish, shrimps, and snails. Such systems allow producing plant-based calories on the same area. Accordingly, such systems can support diets which draw on low(er) amounts of animal protein — such as most traditional diets. Such systems of production as well as consumption could revive traditional knowledge about aquatic vegetables and how to gather and process them. The pilot projects should research different combinations of fish, non-vertebrate animals, plants and even fungi in order to assess sustainable yields. It shall be assessed how different plant-animal-combinations perform on the different criteria for food security and how a more natural food web could be established in such systems.

Such pilot projects should include the local population with respect to traditional knowledge, diet habits, societal acceptance of food, cultural memory of food, and the like. It might also stimulate cultural debates about what can and should be perceived as being “eatable”. The research would belong to Mode-II-sustainability-science. Such science is transdisciplinary, normative, participatory and case-study oriented. The outcome of such research should imply some suggestions for prudent policy making.

References:

Martinze-Alier, J. (2002): Environmentalism of the poor. Cheltenham: Elgar.

Ott, K., Döring, R. (2008): Theorie und Praxis starker Nachhaltigkeit. Marburg: Metropolis.

B.31. Martin Pastoors: Learning for interdisciplinary research on Sustainable Fisheries (and Aquaculture)

Context

The ICES Working Group on Maritime Systems (WGMARS) is an expert group based on interdisciplinary collaboration and research of maritime systems, with an emphasis on natural resources management. WGMARS is a forum to articulate ideas on knowledge production and advisory capacities within ICES and in in cooperation with external partners can be integrated and broadened. It is expected that these types of research activities will be able to facilitate sustainable governance of marine ecosystems.

In 2012, WGMARS carried out a social network analysis (SNA) of the experts involved in different ICES expert groups with the aim to examine the information flow among individuals or organizations. The hypothesis is that the actual flow of information among individuals or groups is usually not well represented by formal organizational structures. Since ecosystem science depends on cross- and interdisciplinary work, WGMARS specifically looked at the human links (defined as shared participants between two or more EGs) within the ICES expert group (EG) network. The results show that ICES has several expert groups that are highly connected in the ICES network but also some with very low connectivity scores. In light of the need for interdisciplinary human synergies, WGMARS 2012 already gave examples of how this first social network analysis could be helpful to identify mechanisms to integrate diverse marine science for ecosystem insights.

In EU fisheries management, there is an increasing use of long term fisheries management plans to determine the general management approach for individual fish stocks. The history of these management plans derives to a large extend from single stock assessment and single stock management. As a consequence this development has been mostly informed by traditional fisheries science that is biology-based. An important challenge for an ecosystem approach to fisheries management is to explore how to generate integrated management plans that correspond to the ecosystem approach. This involves major challenges on governance and integration of different knowledge disciplines, and therefore goes way beyond the biology-based harvest control rules. So the challenge of interdisciplinary (between different scientific disciplines) and trans-disciplinary (between different forms of knowing) integration is an obvious attribute of such integrated management plans.

Challenge

1. How can integrated management plans for an ecosystem approach to marine fisheries in Europe be developed and what requirements would that pose for governance and knowledge?

2. What can be learned from the interdisciplinary and trans-disciplinary approaches to marine management about the conducive and inhibiting factors that shape interactions between individuals and organizations for an ecosystem approach to fisheries management?

Approach

The development of integrated management plans for fisheries management in Europe is often talked about but rarely effectively addressed. In other parts of the world (e.g. Australia, South Africa), these approaches seem to be more advanced although the governance systems may be somewhat simpler than in Europe. Still it would be very informative to learn from these experiences and explore their potential applicability in Europe. This will require a close integration of governance expertise with different forms of ecological, economic and behavioural knowledge. The ICES expert group WGMARS could be used as a vehicle to analyse these lessons and to suggest potential implementation issues in Europe.

Effective interdisciplinary and trans-disciplinary approaches to marine management require a thorough understanding of conducive and inhibiting factors that shape interactions between individuals and organizations. Social Network Analysis (SNA) provides a powerful tool to analyse relationships between individuals and organizations and how effective communication can take place. By applying Social Network Analysis to the Marine Resource Management Systems that ICES is part of, we will gain an understanding of factors that allow interdisciplinary and trans-disciplinary learning.

Required

- Funds for social network analysis.
- Funds for evaluation of integrated management plans
- Participation in WGMARS 2013-2015 of experts from different disciplines and different regional backgrounds
- Funds for travel and subsistence for experts

B.32. Eliana Piccardi: Marine environments as a powerful but delicate 'system' of resources

Corsica island, for its geographical characteristic, its position, and above all its ancient traditions and history in the whole, seems to be a quite favoured place where the topics bound to the exploitation of marine resources throughout the human history. In particular, on its Eastern coast, the presence of wide-extended coastal lagoons area, since antiquity exploited until nowadays, appears as a possible working-area. And more, the fishes passing routes around the island, following the sea-flows, have furnished a resource since antiquity.

Figure 6: *Corse and Sardegna islands*

On the same way, also the near island of Sardinia has both lagoons areas -especially on the western and south-western coasts-, and it was crossed throughout its history by fishes-routes around the island, and especially between it and the two smaller ones at the South-West, the S.Antioco island and the S. Pietro one, where tuna-fishes passages are still nowadays exploited. Particularly in Sardinia, these resources are known and appreciated since the Phoenicians and Punic times onwards.

The two islands, seeminlgy as a 'cardo' in the central Mediterranean Sea, are, therefore, together, a good place to show how the marine environments may form a powerful, but in the same time a delicate one, 'system' of resources with a great potential and with the exploiting ways of them.

Of course, such a process cannot be a one-direction one, and it needs a careful attention also to all the possible imbalances brought to the weak marine-system by the human impact. For both the islands some proposals of lines within this frame may be pointed out.

PRELIMINARY GEOGRAPHICAL & BIOLOGICAL AND HISTORICAL CENSUS by two équipes jointly working in parallel projects

The specialists of these disciplines will describe and collect all the pieces of information about the morphologic, biologic aspects on one side, and about the human and historic ones on the other, with a particular attention to a diachronic perspective from the prehistoric times until nowadays.

In this phase, the HISTORICIANS and the ARCHAEOLOGISTS, also taking advantage from the other scientific data, as for instance the ones from the archaeo-malacofauna specialists, will have the task to recreate the human sceneries of the past, crossing for the historic ages t he various sources: written ones but especially the material culture ones.

This will allow to lay down the basis for an operating plan which will develop following various directions, also after parallels branches, and, above all, every now and then, by meeting and crossing their experiences and data (eventually, for respecting a given timetable, and even to spare money, also by the mean of video-conferences): every team will expose their own data and, above all, will lay down their issues and the critic-knots emerged, in order to exchange ideas and opinions, to find possible and shared solutions.

GEOGRAPHICAL-GEOLOGICAL èquipe:

will draw useful maps of the evolution of the coastal areas, especially the ones seat of the main lagoons and ponds areas and place of the main fishes-streams, but also detecting the ways of the main waves and wind-streams, in order to watch all the changes throughout the times and to value their impact on the territory and landscape, especially by remarking the possible influence on and from the human settings, on and from the human exploitation, since the antiquity to the up-to-date- situations.

BIOLOGICAL, ARCHAEOBIOLOGICAL équipe:

this équipe will investigate the presence of sea-species, from ichtyic-fauna to the various mollusks — the ones with alimentary qualities but not only, like murices and pinna nobilis and other types envolved in past manufacturing processes (for colouring cloths, making bottons and so on) — types and eventually coral, and also the presence of the marine plants like e.g. the posidonia and other seaweeds not only to keep watched the whole marine environment in its balance, but also to put in act strategies to temper the human settlements and exploitation (see below) with the saving and preservation of the existent environment (or, even, but with a lot of necessary prudence, with some programmed intervention as restocking and so on).

On the other side, the part of the équipe dealing mostly with the reminders of all the aspects of the sea-fauna left from the past, will get the data concerning the former periods, both about the natural presence of resources and about their eventual exploitation in the past. Also in recent scientific happenings it has been showed as the shells are a record particularly significant of the coastal environments evolution.

GEOGRAPHICAL-HUMAN LANDSCAPES GEOGRAPHY équipe

this group will have, beyond its own task of registering the evolution of the human settings and exploitations of the coastal spaces — especially near the lagoons, ponds and fishing areas throughout the times-, the aim to relate the upper mentioned équipes, including the 'historic' one, with the local human presence, not only by collecting a series of data, but especially by a work of information, training and getting awareness of the inhabitants: they have to be acquainted with the potential resources but also with the very delicate balance they have to deal with, as a human heritage from the ancestors' past, and as a precious present patrimony to be preserved and transmitted to the future generations.

ECONOMIST, JURIDICAL AND SOCIOLOGIST équipe:

as one might very easily judge, in this group we gather specialists from various branches who also might to be kept distinguished: but, as we believe, from their working within a synergic frame, it should come out a life & exploiting strategy for these areas, by regulating both the settlements, especially the ones with tourist destination, and the coastal related human activities, pointing out the advantages and the boundaries of them, proposing and sharing the related rules.

Possible concrete cases of study and of application

- CORSICA:
  - the lagoons and ponds area of the Eastern coast: around the Roman town of Mariana (Étang de Biguglia) and, a bit Southern, around the ancient Greek town of Aleria (Étang de Diana, de Urbino); both areas and sites are also quite interesting for registering the evolutions brought by the two important rivers, respectively the Golo and the Tavignano.
  - the tuna-fishes-passage at North of the Cape Corse, with the promontory of Monte Bughjiu and the lower ponds area — wider in ancient times
- SARDINIA:
  - the lagoons and ponds areas of the Oristanese coast (Tharros area with S. Giovanni, lagoons of S. Giustina, of Othoca and Neapolis) in the central-West coast; the ones of Bithia/Chia, Nora and S.Gilla and Quartu S.Elena around Cagliari in the South and South-West coast).
  - the points for the fishes (especially tuna ones) passages: along the coasts of the lesser islands of S.Antioco and S.Pietro at the South-West of the island; the ones around the Asinara and La Maddalena archipelagos in the Northern part.

B.33. T. Potthast: Some Project Activity Ideas on Sustainable Aquatic Food Supply

Context:

Without any doubt, food supply from aquatic resources – freshwater and even more so marine – will play a decisive role for the possibilities and limits of sustainable development on global as well as regional levels. Food demand is growing not only due to the increasing human word population but also to shifts in diet with higher amounts of protein (meat including fish/crustaceans). At the same time, arable land as a major source of food is under pressure by the aforementioned factors, added by soil degradation, loss of arable land and increasing nonfood use. This goes together with an ongoing overall loss biodiversity – both natural and in crops/husbandry – and increasing adverse effects of climate change, especially in the countries of the global south.

Not only classical fisheries but a growing number of attempts for aquaculture (from algae via crayfish to salmon) are sought to respond to this situation and by this token changing many aquatic waterbodies into new forms of anthropogenic/cultural ecosystems. Costal/aestuarine habitats are maybe those with the highest dynamics and pressure regarding most of the aforementioned issues; in addition coral reefs and stocks of many fish species are highly endangered, even more so under conditions if climate change. The overall development in past decades seems to be unsustainable. In a nutshell, *linking aquatic biodiversity protection to forms of sustainable aquatic food sequestration and production* will become a major task for establishing a future sustainable development. It goes without further elaboration that natural sciences, engineering as well as law, ethics, economics, political, social and cultural sciences shall have contribute their expertise in an interdisciplinary way. Moreover, research on the great transformation for sustainable development will have to proceed transdisciplinary, including stakeholders from politics, administration, business and civil society.

Sub-project(s): Taking "culture" in sustainable aquatic food supply seriously

Aquatic food supply primarily seems to be an issue of alleged hard facts of natural sciences (ecosystem structure, physiological/habitat demands of species, hydrology, oceanography, climatology etc.), engineering (fisheries technologies, setup of aquacultures), nutrition and classical market economy, of course including law and political science for the respective dimensions. In relating to and complementing these perspectives, it shall be asked what kind of culture(s) are the basis of recent and future activities of extracting and producing food from the water and their historical and cultural basis. Food is more than protein and carbohydrates and production includes decisive cultural factors. For example, it already has been addressed that the shift from fishing to growing seafood is not a trivial one. Also the issue of what counts and is accepted as (sea)food is changing. Possible research questions, which would have to be investigated by interdisciplinary teams and transdisciplinary dialogue, would be:

- Similarities and differences between agri- and aquaculture: economic and professional organisation, ownership, governance frameworks, regional specificities

- Cultural dimension of aquatic foods: what counts as food, what not in different national, regional cultural contexts? What about the shift from tradition and aesthetics to ethics when people choose (not) to accept certain products or production measures; what could be strategies to address those differences and conflicts (examples: whaling, genetic engineering, fairtrade etc.)? What are the underlying values, how could they be explicated and negotiated?

- Ethics and politics of aquatic food sustainability: a) Descriptive dimension: What counts as sustainable will be very different in different contexts. Are cultural, religious, national differences the (only) major issue or are differences within societies like social and economic groups to be found in many countries around the globe also (or even more) important? b) Normative Dimension: Which developments can be identified as (un)sustainable on which arguments; what can be accepted also across social groups and/or cultures; where are possible limits of plurality – especially when relating to international law and governance? This relates to the aforementioned value dimension and the need for a value-informed governance

- What and how does the currently spreading political concept of bio-based economy or bio-economy relate to overall political and cultural contexts and to sustainable aquatic food production

- How will measures of adaptation and mitigation with regard to climate change (maybe including climate engineering) resonate with approaches to sustainable aquatic food production regarding technical, political, social and ethical aspects

B.34. Diwakar Poudel: Bio-economic contribution for ecosystem based fisheries management

Background

Ensuring a sustainable food supply to the ever increasing population worldwide is a huge problem. To feed the increasing population needs a sustainable management of natural resources which is interlinked to several disciplines. To continuously supply the aquatic food resources to the world needs an integrated ecosystem based management of marine resources.

While on the other hand an overexploitation of aquatic resources such as commercial fisheries has been a severe problem in the recent decades (FAO. 2008). The overexploitation could be a consequence of several factors, some unforeseen or others not considered by the disciplinary scientists, which requires inter and or multidisciplinary effort to overcome the problem. The single species management concept of 'maximum sustainable yield (MSY)' may fail to provide optimal management strategy for the marine resources in the multispecies ecosystem. Similarly, an under-exploitation of some predators in the ecosystem may also cause a reduction of its prey that in the long term causes collapse of fisheries, therefore a multispecies modeling is crucial for the optimal management fisheries in the prey-predator ecosystem.

Several kinds of uncertainties in the growth of the resources and in the management of the fisheries may exacerbate the situation. For example, uncertainties in individual fish stock growth, their interactions, uncertainties in measurement etc.

The possible fish collapse thorough overexploitation is minimized through an optimal management of fish resource that requires ecosystem based fisheries management that combines of several disciplines such as economical, biological and management aspect to suggest decision rules for several species in the bio-ecosystem. The optimal management requires identifying accurate fish stock levels over the time horizon, taking care of the fish interaction in the ecosystem, taking care of the uncertainties in the management regime and the uncertainties in the growth and development of the fishes in the ecosystem apart from the economics of the resources.

My study propositions (below) integrate the economic policy with the management regime to manage the resources optimally, taking into consideration of

- the biological perspectives such as growth and development model
- the economics of the resources
- the uncertainties of resources growth and development, uncertainties in management

Proposition I: Optimal management of Barents Sea fish species in a three species interaction ecosystem

This research contributes in the ecosystem based fishery management through the development of bio economic multispecies stochastic model for Barents Sea fisheries. The model suggests optimal fishing policy for two species in a three species predator prey ecosystem in the Barents Sea. We consider three species (cod, capelin and herring in the Barents Sea), incorporate uncertainties in the fish growth in all species and suggest optimal harvesting strategy. We employ a logistic growth model and downward sloping demand function for predator and a linear demand function for prey species. We have employed stochastic dynamic programing to solve a three dimensional model, where catch is optimized based on a multispecies feedback strategy. The optimal catch for stochastic interaction model is more conservative compared to deterministic policy. We showed that stochasticity has strong effect on optimal exploitation policy in the prey (capelin) compared to the predator (cod).

Proposition II: Assessment of Risk of fish stock collapse in multispecies fisheries ecosystem

Collapse in commercial fisheries has been a serious problem in fishery management. Overexploitation is considered to be the main cause of collapse in most of the fisheries. However, a purely stochastic growth and multispecies interaction could also lead to fishery collapse. This research investigates the risk of stock collapse in a multispecies stochastic model with prey predator interaction in the ecosystem. We employ a logistic growth model and downward sloping demand function for predator and a linear demand function for prey species. First we obtain optimal solution in the multispecies model and then carry out Monte Carlo simulation with the optimal solution.

The study finds that risk of stock collapse is relatively higher in the prey species than in its predator. Furthermore, a small stochasticity in the prey species leads to its extinction if its predator stock is high. While the risk of predator species collapse due to stochasticity is low in the abundance of prey stock in the ecosystem. This study demonstrates that the harvesting decision made optimally, minimize the risk of collapse in the predator species. Nevertheless, it is almost impossible to avoid extinction of the prey species if its stock is below certain critical level at high degree of stochasticity.

B.35. A. Proelss: Sustainable Management of Fish Stocks and Conservation of Marine Species under International Law

B.35.1 Background

The world's marine species are threatened by a multitude of anthropogenic impacts, ranging from fishing, oil and gas exploitation, sand and gravel extraction, shipping, military exercises, construction of pipelines and offshore wind farms, to recreational activities. Fishing is, by far, the most aggressive form of ocean use. It is well known that most commercially relevant fish stocks are overfished to a degree considerably exceeding sustainable yields. With regard to European fish stocks, if current fishing pressure continues, 91 % of the European fish stocks will remain below the targets set by the Johannesburg Plan of Implementation (JPI). The JPI states that fish stocks should be maintained or urgently restored to levels that can produce the maximum sustainable yield (MSY) — and, where possible, no later than 2015. This commitment, although not legally binding in a formal sense, has been reaffirmed in the outcome document "The Future We Want" of the recent Rio+20 Conference in which the international community further committed itself to enhance action to manage by-catch, discards, and other adverse ecosystem impacts from fisheries.

The problem of overfishing is not limited to European waters. Reported landings from marine fisheries worldwide have been stagnating for two decades, and the number of collapsed stocks has continuously increased. The entry into force of the United Nations Convention on the Law of the Sea (UNCLOS) in 1994 and of the United Nations Fish Stocks Agreement (UNFSA) in 2001, as well as the adoption of the FAO Code of Conduct for Responsible Fisheries and the JPI, have had virtually no impact on the sustainable management of fish stocks. Similarly, the relevant legal instruments applicable to the management of marine mammals have not proven successful in establishing an effective international conservation regime. This can be seen, in particular, in regard to the controversial issue of scientific whaling in the context of the International Whaling Convention (IWC), which has arisen every year since the implementation of the moratorium on commercial whaling in 1986. Another urgent issue is the over-exploitation of living natural resources beyond the targeted stocks and species. Up to one third of the total production from marine capture fisheries is caught as unwanted by-catch and discarded into the sea. By-catch from fishing activities also encompasses seabirds, marine mammals, benthic communities and coral reefs. Rather than preventing by-catch, current fisheries management regimes contribute to it by failing to establish a mechanism for its reduction. This fact clearly demonstrates that marine species protection and sustainable fisheries management are inextricably connected and interdependent for their success, and therefore should not be treated as two separate normative entities.

The governance structures of fisheries management organizations and other international organizations (such as the International Whaling Commission) have failed to foster innovative approaches on the international and regional levels for marine conservation, despite the urgent need for the improvement and on-going development of governance processes. As a consequence of these shortcomings, the lack of sustainable fisheries management tools, the constant disregard for and violation of the precautionary principle and the lack of enforcement of existing management instruments are critical and urgent issues in marine conservation.

B.35.2 Project Outline

International law could make a significant contribution to sustainable fisheries management if it is implemented in a manner that creates more incentives for its observance. In its current state, there are a number of legal gaps, for example in regard to by-catch, and there are serious issues where management and conservation measures adopted by the competent regional organizations are not compatible with, and often contradictory to, the founding treaties of these institutions as well as the general principles of international environmental law. Although the precautionary and ecosystems approaches are specifically mentioned in the UNFSA as crucial conservation and management instruments, there is a considerable lack of clarity on the content of these approaches and how they ought to be implemented in the context of fisheries. It is particularly striking that the guidelines contained in Annex 2 of the UNFSA for the application of the precautionary principle have not yet been analyzed in detail and with the necessary multidisciplinarity.

Against this background, the project examines the impact of international law on the conservation of marine species in areas beyond the limits of national jurisdiction. The project is based on the assumption that the partial or, in individual cases, even complete failure of fisheries management and conservation regimes around the world is not only a consequence of a lack of political will to implement sustainable fishery and protection regulations, but is also due to the incorrect application of management instruments and environmental law principles, such as the precautionary principle. Its main goal is to define alternative ways for regional fisheries organizations to operationalize the precautionary and ecosystem approaches, and thereby, unfold the true potential of international law and governance to facilitate sustainable management and conservation of marine species. Proper implementation of these approaches will not only strongly contribute to the effective conservation of marine species, but will also, in the long run, foster economic development in the relevant sectors. By identifying legal gaps and analyzing the role, importance and effectiveness of those legal tools which are commonly regarded as the relevant parameters of international law, this project will develop structured guidelines and action plans for individual organizations to effectively implement management and conservation regimes advocating the sustainable management of fish stocks and conservation of marine species.

At the same time, the legal research will be accompanied by interdisciplinary work which will define the biological parameters on which the pertinent management and conservation measures adopted within such regimes ought to be based. This work is all the more mandatory, as a legal rule or principle will defeat its purpose if and to the extent to which the enacted measure(s) do(es) not correspond with a reality which has been accepted as true in the legislative procedure. Such ‘symbolic’ or ‘alibi’ laws, or international agreements respectively, may worsen the factual situation, because the adoption of effective measures is further delayed. This is particularly problematic in the field of species protection and biodiversity conservation where delay may ultimately lead to the extinction of a certain species. With regard to the example of fisheries management, applying a definition of the term ‘overfished’ that takes due regard to the requirements of both fisheries biology and environmental economics will ultimately decide upon whether the enacted regulations will meet their objectives or not.

B.36. J. Pucher: Sustainable development of aquatic food value chains by integration of suitable small scale aquaculture enterprises into small scale farming systems in developing countries

B.36.1 Introduction

Fish and other aquatic products are worldwide seen as healthy food, being an important source of animal protein and beneficial bioactive compounds for human nutrition such as omega 3 fatty acids, essential amino acids, antioxidants, vitamins and minerals. Altogether, these compounds make consumption of aquatic foods an important part of healthy diet for people. In 2007, fish protein accounted for 15.7 % of animal protein consumed worldwide (SOFIA 2010). Especially in developing countries in South-East Asia and Central Africa, fish protein accounted for even more than 20 % of animal derived protein intake, which mainly originated from small scale fisheries (Béné et al. 2007; SOFIA 2010). This underlines the high importance of fish for food security especially in these developing countries.

The increasing demand in aquatic foods, due to the rising human population as well as increased per capita demand in aquatic products, is putting high pressure on natural stocks of fish and other aquatic organisms in both, inland and marine water systems. Over the past decade, the utilization of highly effective fishing gear and landing technologies kept the global landing amounts of fishes and other aquatic products from marine and inland water bodies relatively stable at about 90 million tons per year but resulted in an overexploitation of the natural stocks (SOFIA 2010). The increased demand in aquatic food and the overexploitation of natural stocks resulted in a global aquaculture production growth of yearly 5-7 % within the past decade (SOFIA 2010). Globally, aquaculture production growth varies considerably, with the highest share of aquatic foods being produced in Asia, Europe and Latin America. Nowadays, approximately half of the fishes being consumed worldwide are produced by aquaculture (SOFIA 2010).

Aquaculture production can be classified according to their intensity of production, financial return, technical input and stocking density (Edwards et al. 1988). Intensive aquaculture is run in large enterprises targeting international markets with fish as a gourmet food product and an alternative food for meat. Main emphasis in European research programs and funding is put into the development of large scale, intensive aquaculture technology, due to the high return from supplying international markets.

But more important for the future food security of the world´s poor population in the developing countries is the development of small scale aquaculture enterprises which are supplying the households as well as local and regional markets with scarce animal derived protein and increase the value creation from water resources, raise income generation and employment and reduce human migration into cities. These aquaculture enterprises can be integrated into the resource flows on-farm or within the region thereby reducing wastes, upgrading low-cost resources into higher-value products and enabling a more efficient nutrient cycling. Especially in regions, which highly depend on regional, overexploited natural fish stocks as animal derived protein sources, small scale aquaculture has the potential of being an alternative farming activity for small scale farmers in developing countries to secure the supply with animal derived protein.

The management of such integrated, small scale aquaculture systems is widely described on a pond basis (New et al. 1995; Tacon 1995; Tacon and De Silva 1997). Typically, small scale aquaculture enterprises are run semi-intensively by using polycultures of different fish species. These fish species are feeding on different feed resources to reduce the inter-species competition and utilize all pond internal feed resources ranging from phytoplankton, zooplankton and zoobenthos to macrophytes and periphyton. External pond inputs are restricted to organic and sometimes inorganic fertilizers, to increase the pond productivity, as well as supplemental feeds of lower feeding quality, to supplement feed resources that are limited in the ponds (De Silva 1995).

To integrate small scale aquaculture practices into the local circumstances without putting the farmers into the risk of miss-investment, different modifications in the water management and fertilization scheme as well as a suitable choice of fish species, stocking densities and feeds are needed. Only locally adjusted small scale aquaculture enterprise with established value chains and market channels have the potential of being beneficial to the stakeholders.

B.36.2 Objective

A multidisciplinary evaluation of the current and future status is proposed, with the aim to only introduce suitable, low-risk small scale aquaculture practices to regions with underdeveloped aquaculture in an ecologically, economically and socially sustainable manner and to adapt the technology to the local condition by following the entire value chain of the aquaculture food product.

B.36.3 Methodology

Multi-disciplinary description of the target region

This multi-disciplinary pre-analysis consists of the bio-physical circumstances of the region including current and future climate, (seasonal) water availability, land use, environmental sensitivity as well as the availability and utilization of regional resources such as feed material, organic fertilizers, and potential wastes to be used for alternative feed productions. Further, a market analysis is to be conducted including the governmental development plans, infrastructure, transportation, market accessibility, educational status of potential farmers as well as processors, preferences of consumers of the aquatic food products and the accepted processing technologies for such products (drying, freezing, smoking, fermenting, fresh in whole or filets). A socio-economical analysis will be conducted by including religion, culture, income pattern, level of subsistence, gender roles, acceptance of collaboration in farmer unions, knowledge transfer, handling of (financial) savings, and risk aversion. The conditional, quantitative data will be transferred into a GIS based map which consists of several layers of these factors which were evaluated in multi-disciplinary analysis. Qualitative data will be integrated by means of Bayesian model approaches (Kam et al. 2008). These layers predetermine the suitability and potential of the intensity and kind of aquaculture activity being introduced into the region.

Classification of small scale aquaculture practices

Different packages of aquaculture production systems will be categorized according to their cost-benefit performance, market orientation, environmental performance, drought resistance, susceptibility of target fish species to diseases, nutrient and resource efficiency and benefit for resource utilization in combination with other land uses. Further factors of classification are the demand in feed resources, technology, pond design, transportation, water, infrastructure, hatchery technology, market accessibility, post harvest processing, labour and knowledge of workers. These aquaculture systems will range from low-cost input and low-tech systems for households with a relatively high degree of subsistence to intensive aquaculture operations with high quality feed and high technology requirement for in the culture as well as in seed supply.

Final analysis and creation of recommendations

By plotting the GIS/Bayesian model map of conditional data and the requirements and performances of the different packages of aquaculture practices, certain aquaculture technologies can be excluded from implementation while others will meet the requirements in certain regions and will be recommended to be implemented.

References

Béné, C., Macfadyen, G. and Allison, E.H. (2007). Increasing the Contribution of Small-scale Fisheries to Poverty Alleviation and Food Security. Rome, United Nations Food and Agriculture Organization (FAO).

De Silva, S.S. (1995). Supplemental feeding in semi-intensive aquaculture systems. In: New, M. B., Tacon, A. G. J. and Csavas, I., Eds. Farm-made aquafeed. FAO, Rome: 24-60.

Edwards, P., Pullin, R.S.V. and Gartner, J.A. (1988). Research and education for the development of integrated crop-livestock-fish farming systems in the tropics. Manila, Philippines, International Center for Living Aquatic Resources Management.

Kam, S.P., Barth, H., Pemsl, D.E., Kriesemer, S.K., Teoh, S.J. and Bose, M.L. (2008). Recommendation Domains for Pond Aquaculture. Penang, Malaysia, The WorldFish Center.

New, M.B., Tacon, A.G.J. and Csavas, I. (1995). Farm-made aquafeeds. Rome, FAO. SOFIA (2010). The state of world fisheries and aquaculture. Rome, FAO Fisheries and Aquaculture Department.

Tacon, A.G.J. (1995). Feed formulation and on-farm management. In: New, M. B., Tacon, A. G. J. and Csavas, I., Eds. Farm-made aquafeeds. FAO, Rome, FAO Fisheries Technical Paper 343: 61-74.

Tacon, A.G.J. and De Silva, S.S. (1997). Feed preparation and feed management strategies within semi-intensive fish farming systems in the tropics. Aquaculture 151: 379-404. Laut Indonesia. http://www.bbrp2b.kkp.go.id/publikasi/lain/inbudkan-1.pdf

Belton, V. and T.J. Stewart (2002). Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publisher, USA.

Chopra, S. and P. Meindl (2007). Supply Chain Management: Strategy, Planning and Operation. 3rd edition. Prentice Hall, New Jersey.

Christopher, M. and H. Peck (2004). Building the Resilient Supply Chain. International Journal of Logistics Management, Vol. 15 No. 2, pp 1 -13

Faisal, M.N (2009). Prioritization of Risks in Supply Chains. Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers. Wu, T and J.Blackhurst. Editors. Springer.

Figuera, J., S. Greco and M.Ehrgott (2005). Multiple Criteria Decision Analysis: State of The Art Surveys. Springer

Glicksman, M. (1987). Utilization of Seaweed Hydrocolloids in The Food Industry. Hydrobiologia 1517152: 31– 47. 12 International Seaweed Symposium, Netherlands.

Jüttner, U., H. Peck, and M. Christopher (2003). Supply Chain Risk Management : Outlining Agenda for Future Research. International Journal of Logistics: Research and Applications, Vol. 6 No.4, pp. 197–210.

Jüttner, U. (2005). Supply Chain Risk Management: Understanding to Business Requirements from a Practitioner Perspective. International Journal of Logistics Management. Vol.16 No.1,pp 120-141.

Khan, O. and B. Burness (2007) Risk and Supply Chain Management: Creating A Research Agenda. The International Journal of Logistics Management, Vol. 18 No.2, pp. 197–216.

Kersten, W. et al. (2006). Supply Chain Risk Management: Development of A Theoretical and Empirical Framework. InKersten, W. and T.Blecker (Ed.). Managing Risks in Supply Chains: How to Build Reliable Collaboration in Logistics.Erich Schmidt Verlag, Berlin, pp. 3–17.

Manuj, I. and J.T. Mentzer (2008). Global Supply Chain Risk Management. Journal of Business Logistics, Vol.29, No.1 pp 133 - 155.

McHugh, D.J. (2003). A Guide to The Seaweed Industry. FAO Fisheries Technical Paper 441, Rome, Italy. Norrman, A. and U. Jansson (2004). Ericsson's Proactive Supply Chain Risk Management Approach After A Serious Sub Supplier Accident. International Journal of Physical Distribution and Logistics Management, pp. 434–456.

Peck, H. (2005). Drivers of Supply Chain Vulnerability: An Integrated Framework. International Journal of Physical Distribution and Logistics Management, Vol.35, No.4, pp. 210–232.

Pfohl, H.C., H. Köhler, and D. Thomas (2010). State of The Art in Supply Chain Risk Management Research: Empirical and Conceptual Findings and A Roadmap for The Implementation in

Practice. Logistic Res., pp. 33–44. Springer, Verlag.

Ritchie, B. and C. Brindley (2007). Supply Chain Risk Management and Performance: A Guiding Framework for Future Development. International Journal of Operations and Production Management, Vol 27 No.3,pp 303-322.

Sodhi, M.S. and C.S. Tang (2012). Managing Supply Chain Risk. Springer

Tang, C.S. (2006).Perspectives in Supply Chain Risk Management. International Journal Production Economics, Vol. 103 No.2, pp. 451–488.

Vanany, I. S. Zailani and N. Pujawan (2009). Supply Chain Risk Management: Literature Review and Future Research. International Journal of Information Systems and Supply Chain Management, Vol. 2 No.1, pp. 16–33. January–March.

Wu, T. J. Blackhurst, and V. Chidambaram (2006). A Model for Inbound Risk Analysis. Computers in Industry Vol.57, pp 350-365.

Zsidisin, G.A, and B. Ritchie (2010). Supply Chain Risk: A Handbook of Assessment, Management and Performance. Springer.

B.37. Martin F. Quaas: Taking into account consumer demand and employment in fisheries

Context

It is widely acknowledged that improvements towards a more sustainable fishery management requires to take ecological multi-species interactions into account and that the aim should be the ecosystem approach to fisheries management (McLeod et al. 2005). From the economic point of view, demand-side interactions between different species of fish are of equal importance. If the supply from one fish stock increases (as, for example, the supply of Northeast Arctic cod in recent years), not only prices for landings from this stock will decrease, but prices for substitute fishes will decrease as well (as, for example, Eastern Baltic cod). While these interactions have been largely neglected in the scientific literature, it has recently been shown that they may have important consequences for fishery management, and that fisheries management that neglects these interactions may have detrimental consequences (Quaas and Requate, forthcoming). I propose to develop a multi-species approach for fisheries management that broadens the ecosystem approach to fisheries by taking into account the economic, demand-side interactions of different species. A question of particular interest is:

1. How would a shift towards maximum sustainable yield management in European fisheries affect insufficiently managed fish stocks in other parts of the world (for example at African coasts), due to demand-side interactions between fisheries?

Associated with this is the question of who gains and who loses from a more sustainable management of marine fisheries. In particular, it is well-known that employment in fisheries may decrease when overexploitation is stopped (Weitzman 1974). This may be of high political importance specifically in coastal regions with otherwise weak economic performance. Examples include coastal regions in Southern Europe (Spain, Portugal, Greece), Canada (in particular Newfoundland), but also in developing countries in Africa and elsewhere. I propose to systematically study these distributional impacts of fishery management. Specifically, I propose to address the following question:

2. How would a shift towards maximum sustainable yield management (in European fisheries and in other regions) affect employment in fisheries, and how should this effect be taken into account in public decision making?

References

McLeod, K.L., Lubchenco, J., Palumbi, S.R., Rosenberg, A.A. (2005). Scientific Consensus Statement on Marine Ecosystem-Based Management. Communication Partnership for Science and the Sea. www.compassonline.org/pdf_files/EBM_Consensus_Statement_v12.pdf.

Quaas M. F. and Requate T. (forthcoming) Sushi or Fish Fingers? Seafood Diversity, Collapsing Fish Stocks, and Multi-species Fishery Management. Scandinavian Journal of Economics.

Weitzman, M. L. (1974). Free access vs private ownership as alternative systems for managing common property. Journal of Economic Theory, 8(2), 225–234.

B.38. Chris Reid: Historical developments in fish supply chains in the North-East Atlantic: trends and shocks

Michael Graham opined in the Fish Gate that 'what happens on land is only half the story of fish, perhaps much less than half.' His arithmetic may be questionable, but Graham's division of influence reveals an essential truth: the commoditisation of fish has never been entirely a matter of life in or on the seas. And so neither is the sustainability of aquatic food supplies.

Current circumstances in the supply of fish are products of historical processes. Some parts of this story are better known than others because the historical record remains fragmented and partial. Hence, its value to contemporary debates is negated, potentially to the detriment of policy formation. Historians can best engage with other research communities through extant concepts. The fish supply chain concept recognises interdependence between various stages in the commoditisation of marine resources, a perspective that is congruent with maritime history epistemology. It also offers possibilities for multidisciplinary research into the causes of trends and innovations. Links in the chain between trawler and table are not independent, such that developments in any given linking activity engender perturbation throughout the entire system, sometimes to no great effect but otherwise with significant implications.

Historical developments in supply chains and their interaction are understood imperfectly at many different levels: commodity, nation, and region. We propose a systematic mixed methods research approach to understanding their evolution in the North-East Atlantic region. The project, as envisaged, aims to support the testing and appraisal of a range of testable hypotheses, specifically those considering the presence, timing and direction of causal relationships that ultimately impinge upon sustainability. It necessitates the collation of three forms of evidence. First, the project will focus on constructing time series on component elements of the supply, such as landings, prices, processing, international trade, and consumption at various levels (fishery; state; region). An essential component of this work will be establishing the provenance and reliability of constructed series, issues typically overlooked. Second, it will integrate historical records of business enterprises and the business environment, such as surveys of fish processing and distribution, business accounts, and records of trade associations, combining both quantitative and qualitative sources. Finally, it will collate and evaluate a broader range of qualitative evidence. This would include, for example, records of governments and supranational bodies, and trade associations and unions, and draw strongly upon the trade press, which remains an underexploited source of information. This class of evidence might also include personal testimony, such as letters, diaries and interviews held in archives, and potentially the collection of new oral histories. The advantage of a mixed methods methodology over a conventional approach lies in the capacity to triangulate evidence from several different sources and build detailed and nuanced event histories that illuminate trends and shocks.

Conceived as part of a broader multidisciplinary project, the temporal and spatial dimensions of the project, and its contribution to a greater research design, remain to be negotiated. Existing research initiatives, specifically conferences and publications of the North Atlantic Fisheries History Association, suggest a case study approach focusing on areas of greatest research intensity. In the North-East Atlantic region, this recommends the development of a programmes extending to four countries (Denmark, Germany, Norway, the United Kingdom), with particular reference to the post-1920s experience, although the intention is to develop a methodology that is scalable and sufficiently flexible to facilitate integration with other project resources.

B.39. Kathleen Schwerdtner Máñez: Living marine resources in the Coral Triangle: new knowledge for sustainability (LIMES)

This proposal suggests investigating the exploitation of living marine resources in the centre of the world's marine biodiversity, the Coral Triangle. The tropical marine waters of the Coral Triangle form an area with such an enormous abundance of species that for a long time, it provided an apparently unlimited supply of resources. Covering a roughly triangular-shaped area of the marine waters of the Philippines, Eastern Indonesia, Malaysia, Papua New Guinea, Timor-Leste and the Solomon Islands, the Coral Triangle constitutes the richest shallow-water ecosystems in the world. The region is characterised by the occurrence of over 500 species of reef-building corals, which hosts large numbers of fish, corals, molluscs and sponges. These resources sustain the livelihood of more than 130 million coastal habitants and millions more worldwide. According to a recent study by Burke et al. (2012), more than 85factors. Until today, governmental and non-governmental actions and management plans have largely failed to provide a solution for this. Living marine resources in the Coral Triangle are now at risk and with them food security and basic livelihood conditions of coastal inhabitants.

Little is known about the economic history of marine resource exploitation in this region. Influential factors such as increasing demands for maritime products have just begun to be analysed on a case-by- case basis. The proposed project uses concepts and theories from economics and sustainability science in combination with historical evidence to analyse the economic history of economically important resources. Under the title: **"Living marine resources in the Coral Triangle: new knowledge for sustainability" (LIMES)**, the project aims to identify the economic, social, political and ecological conditions under which resources have been exploited over time. By investigating how these conditions have led to specific exploitation patterns, the LIMES project will identify factors which influence if a resource is exploited sustainably or not. In this way, the project will bring new knowledge that helps to address one of the most pressing environmental problems of our time: the depletion of living marine resource.

Environment and resource economics have significantly contributed to our understanding of why overexploitation and species extinctions in the marine realm do occur (Faucheux % Noel 2001, 252- 264). But the exploitation of living marine resources is an inherently multifaceted interaction between humans and nature. It involves ecosystem components (such as species or parts of them) and the ecosystems of which they are part, resource users and their social environments, harvesting and utilization techniques and equipment, markets, traders and trading routes. Resource exploitation is therefore influenced by numerous economic, social, political and ecological issues such as resource scarcity, consumer's demands and costs, and formal and non-formal regulations, and ecosystem configuration and structure. All of these factors are subject to changes over time. Consequently, an investigation of resource exploitation processes and patterns can not rely on a disciplinary perspective. Instead, such an analysis needs to acknowledge resource exploitation as a complex system, whose understanding requires contributions from different scientific disciplines.

The LIMES project aims to integrate various scientific insights into **a multidisciplinary**

research approach, the social-ecological systems framework. Within this framework, social and ecological systems are understood as strongly coupled, complex and co-evolving systems which inversely impact on each other. By addressing the simple question: "Which factors favour sustainable resource exploitation, and which do the opposite?"; the proposed project aims **to provide new knowledge to govern the exploitation of living marine resources towards sustainability**. The project will move towards a **comparative analysis of living marine resource exploitation in the Coral Triangle**. It aims to **identify sustainability-influencing factors** through an **analysis of the communalities and distinctions in resource exploitation patterns over time**.

Two theories are of special relevance for the proposed project: the **theory of common-pool resources** and the **theory of path-dependency**: Common-pool resources are natural or man-made resources from which it is difficult to exclude or limit users. The availability of these resources is influenced by the consumption of resource units — that is, every fish caught is one fish fewer to other users. The fact that common-pool resources are subtractable makes them vulnerable to depletion. When valuable common-pool resources are in an open access situation — that is, an absence of rules which restrict access and use — resource users face strong incentives to intensify their use (Ostrom 2005). This has led to overuse and depletion of many common-pool resources. Common-pool resources in the marine realm are also known as **marine commons** (Berkes 2006) or ocean resources (Tisdell 1986). Many living marine resources are also fugitive (Ciriacy-Wantrup % Bishop 1975) - they are mobile – and occur transboundary (Munroe 1982), that is they move from one jurisdiction to the other. All resources in the LIMES project are marine commons, and some can also be characterized as fugitive and transboundary resources. This has important implications for their governance, because property rights for mobile resources are more difficult to establish.

The **theory of path dependency** acknowledges that the causes for present-day exploitation patterns lay in the past. It has been described as a significant part of the history beyond social dynamics (Lech et al. 1999), ecological dynamics (were the theory is usually referred to as historicity), and the development of social-ecological systems (Levin 1997). The theory was further used to explain why social-ecological systems are locked into specific states (Schlüter % Herrfahrdt-Pähle 2011). This is important for applying the social-ecological system framework in the proposed project, in which the analysis of resource exploitation patterns will be combined with an investigation of their economic history. Acknowledging path dependency requires studies of the material and cultural past to understand why and how specific exploitation patterns occur. Such studies also provide historical evidence to explore the conditions for governing natural resources towards sustainability (Henley 2008).

The economic history of living marine resources and their exploitation has traditionally been a subject of history and fisheries science. Occasionally, resource economists have dealt with these issues (for example Tisdell 1986, McElroy 2002). Only since one or two decades, interdisciplinary research is now addressing the factual complexities of resource exploitation systems. Part of this development has been the use of the social-ecological system framework for investigating marine and coastal social- ecological systems (Atkins et al. 2011, Perry et al. 2011). Still, few studies have explicitly analyzed marine resource exploitation from an interdisciplinary perspective (but see Badjeck et al. 2009), and those who did usually lack the historical perspective.

Having said that, there has been an increasing awareness within the natural sciences of the value of a more temporal dimension in explaining and solving the problems of the present (Poulsen 2008). Using historical data to analyse anthropogenic impacts on marine systems has tremendously challenged our understanding of the oceans. Debates on pristine systems and the construction of ecological baselines are receiving enormous attention and have been published in major journals including Nature, Science, and Trends in Economy and Evolution.

Southeast Asia has received little attention in this respect. The published work on economic history of resource exploitation in Southeast Asian waters (Butcher 2004, Boomgaard 2005) and the Coral Triangle (Knaap % Sutherland 2004, Sutherland 2000, Macknight 1976) largely stems from historians and need for an interdisciplinary perspective.

Against this background, the proposed LIMES project **constitutes an innovative conceptional contribution to the current scientific discussion on marine and coastal social-ecological systems**. It also focuses on one of the **most urgent political issues of our time: the overuse and depletion of living marine resources**. By integrating a historical perspective into the analysis, LIMES will be at the forefront of an ongoing development. The proposed project **fills a critical gap**, because it (1) uses an explicit **interdisciplinary framework in combination with historical analysis to address real- world complexity, (2) concentrates on issues of sustainable resource use in the centre of the world's marine biodiversity**, and (3) aims to provide **new knowledge which can be applied for improved governance of these resources**.

References

Atkins, J.P., Burdon, D., Elliott, M., Gregoy, A.J., 2011. Management of the marine environment: Integrating ecosystem services and societal benefits with the DPSIR framework in a systems approach. Marine Pollution Bulletin 53, 215-226.

Badjeck, M.-C., Mendo, J., Wolff, M., Lange, H. 2009. Climate variability and the Peruvian scallop fishery: the role of formal institutions in resilience building. Climatic Change 94, 211-230.

Berkes, F. 2006. From community-based resource management to complex systems: the scale issue and marine commons. Ecology and Society 11 (1): 45.

Burke, L., Reytar, K., Spalding, M., Perry, A., 2012.Reefs at Risk. Revisited in the Coral Triangle. World Resources Institute.

Butcher, J.G. (2004) The Closing of the Frontier. A History of the Marine Fisheries of Southeast Asia c. 1850-2000. KITLV Press, Leiden.

Ciriacy-Wantrup, S.V.; Bishop, Richard C., 1975. Common Property as a Concept in Natural Resources Policy, Natural Resources Journal 713.

Faucheux, S., Noel, J.F., 2001. Ökonomie natürlicher Ressourcen und der Umwelt, Metropolis.

Henley, D. 2008. Natural Resource Management: Historical lessons from Indonesia. Human Ecology 36, 273-290.

Knaap, G., Sutherland, H. (2004) Monsoon Traders: Ships, Skippers and Commodities in Eighteenth- Century Makassar. KITLV Press, Leiden, The Netherlands.

Lech, M., Mearns, R., Scoones, I. 1999. Environmental entitlements: Dynamics and institutions in community-base natural resource management. World Development 27 (2), 225-247.

Levin, S.S. 1997. Management and the problem of scale. Conservation Ecology 1 (1), 13.

Macknight, C.C. (1976) The voyage to Marege. Macassan trepangers in northern Australia. Melbourne University Press.

McElroy, J. 2002, Antarctic fishery: history and prospects. Marine Policy 8 (3), 239-258.

Munroe, G.R., 1982. Fisheries, extended jurisdiction and the economics of common property resources. Canadian Journal of Economics 15, 405-425.

Ostrom, E. 2005. Understanding institutional diversity. Princeton University Press, Princeton and Oxford.

Perry, R.I., Ommer, R.E., Barange, M., Jentoft, S., Neis, B., Sumaila, U.R. 2011. Marine social– ecological responses to environmental change and the impacts of globalization. Fish and Fisheries 12 (4), 427–450.

Poulsen, B. (2008). Dutch Herring: An Environmental History, C. 1600-1860. Aksant Academic Publishers.

Schlüter, M., Herrfahrdt-Pähle, E. 2011. Exploring resilience and transformability of a river basin in the face of socioeconomic and ecological crisis: an example from the Amurdarya river basin, Central Asia. Ecology and Society 16 (1):32.

Sutherland, H. (2000) Trepang and Wangkang. The China trade of eighteenth- century Makassar c. 1720s-1840. Bijdragen tot de Taal, Land- en Volkenkunde 156, 451-472.

Tisdell, Cl. 1986. Conflicts about living marine resources in Southeast Asian and Australian waters: Turtles and Dugong as cases. Marine Resource Economics 3 (1), 89-109.

B.40. António José Marques da Silva: Cod meets salt — culinary encounters and desencounters between North and South of Europe.

This project is a pluri-disciplinary study about the role of the cod fish in culinary systems of North and South Europe today as the result of cultural encounters in the “longue durée” between these two regions.

Today as never, the Europeans tend to believe that Southern and Northern peoples have very different cultures and ways of life. They ignore that even being very different, the construction of each of the two cultures is the result of a very long historical process of cultural interaction between South and North. Salt and fish participate in a trading cycle between North and South since a very long time: the salt of the Mediterranean is exported to the North of Europe and the cod fish of the North of Atlantic is consumed in the Southern Europe at least since the Early Middle Age. The circulation in all the North Atlantic and the Mediterranean sea of fishermen and traders of both regions has been an important reason of cultural interaction between the North and the South of Europe during a very long times. Today, with the development of alternatives ways to transport and conserve the food, the Atlantic is not today the direct link between these two regions like it was before. The memory of this long term cultural interaction is today almost only perpetuated by the consummation of the cod fish both in South and North Europe. In fact, the cod fish continues to be an important element of the culinary system of several Southern and Northern Europeans countries and participated in a very different way on the culinary cultures of these two regions.

In the North of Europe, the cod continues to be consumed fresh today in large quantities principally in countries like United Kingdoms, Netherlands, Germany, Denmark and Norway. The salted cod fish is at the same time a solid reference of the alimentary identities of different regions of the South of Europe. The salt was traditionally used in both regions to conserve the fish but in the era of the freezer, the South continues to prefer the salted cod and not the fresh one like in the North Europe. The salted cod fish is steel today the principal ingredient of a large numbers of recipes like “Zuppa di Bacalao”, “Bacalhau à Brás”, “Brandade de Morue” or “Bacalau a la viscaina” that integrated this exogenous ingredient in the Southern culinary systems. In another hand, the designation of the cod fish often maintains in different languages of the South of Europe an etymological relationship with the name of the fish in the Northern European languages.

The popularity of this food in both regions caused recently the collapse of the Northern cod fishery. The purpose of this project is essentially to understand how the cod fish acts simultaneously as a common cultural reference shared by North and South of Europe and at the same time as element of distinction, why it keeps the memory of a long cycle of cultural encounters between this two regions and what is his future. Not dissociating present cultural practices, the historical roofs of these practices, and their future in a same project is his originality.

The strategy of this project will follow five different complementary directions:

1. Historical contextualisation of the cultural encounters between North and South involving the exploration and transaction of salt and cod fish in “the longue durée”.

2. A comparative and historical linguistic study of the culinary lexical of the cod fish in the Europeans languages.

3. A comparative anthropo-sociological study of the integration of the cod fish in the local culinary systems of countries of the North and the South of Europe.

4. An economical/ecological study to understand what is the future of the consummation of the cod fish in Europe and his impact in the ecological sustainability of his catch in the Northern Atlantic in the next years.

5. Promotion of new cultural encounters North/South, sharing with the community (publications, exhibitions) the results of the study.

B.41. P. Sorgeloos: Sustainable Aquatic Food Supply in 2050: urgent need for a new interdisciplinary – holistic research approach

Observations:

- 70 % of our globe is covered by water, nonetheless seafood (in its broad sense, namely all aquatic products) contribute only marginally to our overall food needs: only 2 % (when expressed in quantity; 16 % of our protein needs) comes from the aquatic environment

- Fisheries, or hunting the seas, has been the main source of seafood so far. Increasing or even maintaining the harvest derived from fisheries is not sustainable for several commercial species.

- Although aquaculture (the farming of aquatic plants, fish and shellfish) has been practiced for over 2 millennia it is only in recent decades that it started to significantly contribute to our seafood needs: less than 5 % before the 1970s to reach 50 % in recent years. With an average annual growth rate of approx. 8 % aquaculture is the fastest growing sector in food production

- Asia where about 90 % of all seafood is produced has been practicing an ecosystem-friendly type of aquaculture, characterized by 1) species low in the food chain, i.e. "extractive aquaculture", harvesting organic (shellfish) and inorganic nutrients (seaweed), often the result of natural or man-made eutrophication, and 2) integration with other aquatic and terrestrial farming practices (resulting in bioremediation practices, nutrient recycling, more efficient use of the various niches in the ecosystem, less diseases, etc).

- Since the 1960s, so-called "business aquaculture" has gained more and more interest (first in the industrialized countries but later on everywhere): i.e. better knowledge of the life cycle of the organisms, new technological developments and especially attractive market demands resulted in the successful development of new monoculture approaches for the commercial production of various species (e.g. salmon, trout, catfish, shrimp): all species that require large feed inputs and their farming has a major impact on the environment; it is widely accepted that this aquaculture farming practice is not sustainable following its present approach (especially regarding feed/nutrient ingredients and environmental impacts because of the monoculture approach)

- In Europe, consumers have a pronounced preference for seafood that is high in the food chain. In other regions (Asia, Africa) predominantly herbivores are consumed but as living standards rise, a shift to consumption of fish from higher trophic levels is observed. This will put an increasing burden on the ecosystems.

- The pressure on the environment of the rapidly growing industrial aquaculture is strongly related to feed composition (fishmeal versus vegetable resources) and conversion rate.

- Over recent years China has expanded its integrated farming practices, especially in coastal areas where multi-species farming areas of several km^2 are in operation

Needs:

Although the biological and technological (multidisciplinary) research needs that are required to make aquaculture more sustainable have been identified by various organizations, the basic difference between the Eastern and Western approach in aquatic food production (and I wonder if this is not in other sectors as well) should be better studied and this will require an interdisciplinary/holistic approach as it considers differences in basic disciplines, such as:

- research perception and planning: Asians think in more dimensions than we do in the West, we often blame this as “intuition” , how can we reconcile both? Can this not result in a new synergy between East and West in solving societal problems?
- business approach and socio economics of big integrated food production systems as now in operation in China, with several species/markets, involving many thousands of “farmers/employees”: following our Western industries this approach is not feasible in the Western world
- How can our Western world think and act in a more integrated fashion? Actively exploring interactions/synergies between different industries and interests: generating power, producing food, remediating environmental problems, tourism, etc.
- In primary production, aquaculture is still often considered as an oddity while basic concepts such as marketing, management, chain of custody & quality control, etcetera, are largely similar with other traditional agriculture exploitations. Adequately responding to various “growing pains” of aquaculture would benefit considerably from a better integration into primary production policies.

B.42. Heather J. Stewart: The Impact of Economic Theory in National Policy Choices Regarding Access, Allocation and the Right to Fish.

Whether one looks to the past common-property status of high seas capture fisheries or the role of perverse economic incentives within the persistent global challenge of overcapacity, overfishing is an economic problem. An on-going study, driven by research in the official United Kingdom (UK) and Scottish government archives, has revealed that the historical decisions taken by the UK government when forming fisheries policy were not predominantly guided by economic or commercial influences. Instead, access conditions and allocation mechanisms tended to be chosen for their ability to reconcile political intra-British conflict, caused by the distinct size, ownership and organisational structures of the English and Scottish fleets. Building upon these findings, this research proposal considers the extent to which the economic theories and concepts of fisheries management have in practice shaped the diverse national policy decisions regarding quota management throughout the Common Fisheries Policy.

In the UK, what has been revealed is that the ability of local interests to influence the policy-making process- and the subsequent government objective of sustaining regional employment- created a situation in which the role of economic theory became increasingly marginalised. In its place, a rhetorical commitment to the concept of equity forced the government to accept specific regulations and mechanisms throughout the period 1979-84. By 1984, the Scottish Fisheries Minister openly admitted that an attempt to allocate the UK quota on a more rational basis had been obstructed by the political power of the inshore fleet.[111] As a direct result of the administrative and economically inefficient management system, the UK overshot its TAC allocations for the most important commercial stocks throughout 1979-1983. This examination of the divergence between theory and practice in UK fisheries policy over the period 1945-95 has produced a greater understanding of how economic ideas are practiced within political institutions. The concept of equity, which has remained at the forefront of UK and EU policy, can be interpreted as a as a malleable, political concept, whose definition shifted over time, in order to produce a political end that was often contrary to proven and effective management theory. Ultimately, what can be shown is that the evolution of fisheries management in the UK was shaped by shifts within the relative strength of different interest groups.

This trumping of interests over ideas continued not only throughout the devolution of management responsibilities to producer organisations in the late 1980s and 1990s- which was, arguably, an industry-led initiative designed to lock present and future rights to regional cleavages- but evidence suggests that this trend continues today. Reviewing evidence given by the UK and Scottish Ministers at the recent Deartment of Environment, Food and Rural Affairs (Defra) Committee on the 'Reform of the Common Fisheries Policy', July 2012, demonstrated that the social benefit of fisheries management remains at the forefront of decision-making policy for

[111] NAS (1992d) Af62/5942 Fisheries Quota Management, White Fish, 1986-93, letter from MAFF M T Haddon to DAFFS R.J.W Clark, 29 October 1986

Scottish fisheries.[112] Defra and Marine Scotland both opposed the mandatory introduction of tradable fishing concessions (TFC) as a panacea for all fishing fleets, however, the Scottish department was identify by the Committee as taking a particularly aggressive stance towards the TFC concept.[113] This was represented through unwillingness to place faith in impact assessments[114] — which had the objective of securing profitability within the industry — but also through the Scottish government's definition of national interest as the protection of current ownership structures in order to preserve social benefits.[115]

The main objective of the proposed research project will be to extend this line of analysis to examine the political-economy of ideas and interests across a selection of the different management regimes that exist within the EU. Over the last 20 years, most Member States have moved towards private property rights in their fisheries, however, each has done so in a different way and to a different extent. The research would aim to construct a cross- country comparison of the extent to which economic theory has been utilised and applied within the different domestic management systems. The role of economics will be examined against the backdrop of the diverse national political interests connected to the industry, with a research aim the discovery of the relative weight between theory and interests in shaping policy decision, and how and why this balance has shifted over time. This could represent an enquiry into how decisions are taken in the present or, alternatively, it could take a more protracted perspective as a historical analysis of the policy-making process in the different countries. The historical analysis applied to the UK was instrumental in revealing why an administrative mechanism was supported for so long, and what factors initiated and inhibited the gradual introduction of quasi-market mechanisms in the 1990s. The research would focus principally upon the different national choices made in regard to access conditions, criteria for allocating national quotas and the choice between an administrative or a market mechanism. Different national attitudes towards the use of market mechanisms would form the backbone of the research, however the theory of regulation, principle-agent issues, monitoring and enforcement, incentives and investment theory have all been identified as economic concepts which could be used as themes to examine the policy-makers and industries interaction with applied economics.

Alongside revealing the relative trade-offs between economic ideas and interests across different Member States, this study could contribute to a greater understanding of the factors which influence the dissemination and acceptance of economic ideas within government. Another research aim would be to shed light on why the economic ideas and theories of fisheries management have been accepted and implemented only in some states. What affects the willingness of politicians to listen to economists, and their often long-standings ideas, and why does the same economic idea gain a foothold in one country but not, until much later, in another?

[112] House of Commons, Oral Evidence taken before the Environment, Food and Rural Affairs Committee Reform of the Common Fisheries Policy, Follow up Session, Tuesday 10 July 2012, Evidence hears in Public Question 1-36. Accessed: http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenvfru/uc521-i/uc52101.htm

[113] Ibid. Questions 207: George Eustice to Richard Lochhead, Scottish Government's Cabinet Secretary for Rural Affairs and the Environment [114] Ibid. Question 210: Eustice and Lochhead [115] Ibid. Lochhead evidence to Committee, 2 November 2011. Available: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvfru/1563/111102.htm

B.43. E. Tzanatos: Sustainable Aquatic Food Supply — Towards an integrated management of fisheries in the context of Marine Spatial Planning

A new tool that aims to coordinate the stakeholders of the marine environment in order to manage its resources sustainably is Marine Spatial Planning. In the Marine Strategy Framework Directive, spatial planning and protection measures are indicated as very important for the implementation of the EU marine strategy. Today, even though Marine Protected Areas are considered a useful approach for the management of resources, their establishment and limits are often based on insufficient data. Additionally, the lack of data can lead to inefficient protection of even high priority habitats and ecosystems (e.g. Posidonia beds and coralligeneous formations in the Mediterranean) due to their mapping being spotty and incomplete despite the existence of legal framework for their protection.

In recent years the Ecosystem Approach to Fisheries Management indicated the necessity to study and manage fisheries within the ecosystem where they are being practiced, since they are an inseparable part of their environment. This approach, however, requires zooming out of the fish stocks and broadening the scope of study to incorporate information on habitats, biodiversity, oceanography, fishing strategy and tactics and socio-economics together with the primary stock-relevant information.

The present proposal aims to present a framework for the management of fisheries using the ecosystem approach and incorporating it in the context of marine spatial planning. This would require the collaboration of specialists from a number of fields (oceanography, geology, socioeconomics, habitat and biodiversity specialists, GIS specialists, fisheries scientists). The interdisciplinary approach would ensure the successful outcome of such a project.

The project could be carried out in the form of case studies (with the actions described below taking place in parallel in different areas, e.g. one in the North Sea, one in the Baltic Sea, one in the eastern Atlantic and one in the Mediterranean depending on the composition of the consortium). The main axes of the work (that could constitute respective work packages in a project, apart from the necessary work packages regarding Coordination and Dissemination) would necessarily include a number of aspects.

An important component of the work is an extensive habitat mapping, a characterization and identification of important habitats requiring the collaboration of biologists, geologists, oceanographers and GIS experts. This characterization should include elements such as the rarity of the habitat, the importance and ecosystem services for fisheries (and other) resources, habitat condition, biodiversity, the use of each area and anthropogenic impacts. Mapping will be performed by oceanographic cruises and regarding the benthic realm it will be carried out by a combination of methodologies such as side-scan sonar, sub-bottom profiler, scientific diving, ROV and in situ samples. For the pelagic environment this will include seasonal physical and biological oceanographic sampling. The main outcome of this work package shall be the identification of priority locations for conservation and protection.

Another important aspect in order to evaluate the different areas of the marine environment is the study of the distribution of fish over the different habitats as well as of the role of different habitats for the most important fish populations. This part will be mainly carried out by fish biologist and fisheries science experts with the aim to identify essential fish habitats. Important areas such as spawning grounds or nursery grounds can be identified. This will be carried out including seasonal sampling through experimental trawling (or a variety of other gears if the substrate does not permit) in a network of sampling stations defined based on the mapping. Fish abundance indices (such as CPUE) will permit the assessment of the importance of each habitat type by species. Apart from fish abundance, other biological information (e.g. length frequencies, reproductive stage, condition index) will be collected. These will be used in order to evaluate the importance and role of different habitats for the main fish populations. Both fish abundance and other data will be modeled together with habitat type and other explanatory variables (e.g. depth) in order to construct predictors for inference in similar environments.

Having assessed the distribution of fish species over different habitats and the utilization of those habitats by fish, an important next step is their evaluation for fisheries both concerning production and economic yield. This work will require the collaboration of fisheries management and socioeconomic experts. This work must include a study of the spatial and temporal distribution of the main fishing strategies and tactics in the study areas together with the fishing yield (in terms of both fish biomass and profits). It will also include recording of socioeconomic elements and other than fisheries uses of the areas. It will be possible to identify the importance of each area for fisheries, the existing alternatives for fishermen in case the area will be closed for fishing and even the main socioeconomic attributes of the fishing communities. The ultimate aim of this part will be to make predictions over the effects of spatial closures or other restrictions and to locate them in the broader utilization of the marine environment.

A final synthetic part will incorporate the results of the work packages together and will finally propose marine spatial plans of the areas under study, identify priority locations for protection or habitat types requiring further study. While the participation of stakeholders in all parts of the work would be desirable, in this part it is an essential element. An evaluation of management alternatives regarding their biological, fishing and economic effect should also be a part of this work. Eventually the outcome of the project could become a roadmap for the application of marine spatial planning into fisheries management.

B.44. N. Vestergaard: Management of the Marine Resources

The use of marine resources has been increasing throughout this century and there is no sign of a lower pressure. Ocean and seas are worldwide under pressure by pollution and eutrophication associated with agriculture, industry, mega cities and transport; furthermore, overfishing adds an additional pressure to the marine ecosystems.

While some of the marine resource and environmental issues may at first glance call for a technical solution, there are beneath economic driving forces. Without understanding the underlying economics (i.e. the market failures), solutions cannot be expected to prevail. In addition, economics are an important driver behind technical innovation. This challenge, however, comes with dilemmas in form of opportunity costs for improving the marine environmental conditions, and it is essential to evaluate the impact on economic welfare by any action. There is then two sides: 1) understand the human behavior and how to regulate it, and 2) evaluation of outcome. In economics, incentives are important and the incentives have to be modeled explicitly when dealing with management issues. But this will in many cases not be enough, because understanding of the basic scientific problem or issue is necessary to create solid and sustainable solutions.

The value of marine resources goes well beyond the value obtained when used as a private good. Many marine resources serve different roles an ecosystem and have therefore also public values. There is a need for coupling of economic modeling and ecosystem modeling to address the economic value of e.g. a species as a commercial catch and as a part of the eco-system, e.g. forage fish. Also the value of water quality in marine areas has both private (indirect use values) combined with public good characteristics.

In the future, marine spatial issues (in many cases together with land spatial issues) will be a more important aspect of marine resource planning. One issue is the current use of marine areas for different purposes, such as fishery, transport routes, aquaculture, wind power, mining etc., but in future, because of e.g. climate changes, the current spatial use will most likely change. There is a need for predictive models that can provide insight into what changes to expect in the future. So, to conclude there is a need in the future for research from an ecosystem point of view of the use of marine resources. To demonstrate in a credible way the trade-offs involved in the different uses, knowledge from several scientific groups is necessary.

B.45. D. Vidas: Sustainable Aquatic Food Supply

The title indicates an antropocentric perspective. However, it is an essential one, since supply of the food is a primary need. Today, human nutrition is to an important extent dependent on the protein secured by fisheries. The key emphasis, therefore, is that this food supply needs to be – sustainable.

Regarding food supply from the sea, i.e., marine living resources, international law of the sea has been developing over the past several centuries. A treatise which is widely considered as the foundation of the law of the sea doctrine – the 1609 Mare liberum by Hugo Grotius – argued that fish resources from the sea are in fact inexhaustible. On the factual basis so understood, the principle of the high-seas freedom of fishing was based.

Today, of course, we have recent figures, inter alia from FAO reports, on fully exploited, overexploited and depleted fish stocks. With today's technology and human capabilities (and our increased numbers, from 500 million people in the early 17th century to 7 billion today), fish can be (and are) fished so that whole stocks are depleted, and even entire species made extinct. Moreover, over-fishing, often due to misuses of high seas freedom of fishing, now widely known as illegal, unregulated and unreported (IUU) fishing and the related chain of activities, have given rise to serious concerns.

Our current legal framework for marine fisheries rests on the 1982 UN Convention on the Law of the Sea. The Convention has enabled the present-day division of the seas and oceans into various zones of sovereignty, sovereign rights and jurisdiction. Current and foreseeable treats to sustainability of fishing, however, increasingly indicate that we may need to come to the regulatory stage at which we start to acknowledge that the territorial dimension (or its absence) is not the primary one that matters, and that in any part of the sea, be it under sovereignty or not, we should be ultimately led by some of the same, shared concerns.

In that respect, leading law-of-the-sea experts today warn that the need for rational management of many fisheries is not limited to the high seas and that any approach that leaves aside the huge portion of the oceans under national jurisdiction may be flawed. Some (e.g., Treves) ask whether future will bring a reassessment of the results obtained through the institution of the exclusive economic zone, and whether new approaches will emerge, envisaging areas within and outside national jurisdiction as a whole.

Some scientists are now proposing a new approach to global sustainability, by defining so-called planetary boundaries within which they expect that humanity can operate safely[116]. They have identified nine such boundaries and, drawing upon current scientific understanding, have proposed quantifying seven of these – among which ocean acidification and rate of biodiversity loss are included. They argue that transgressing one or more of the boundaries may be harmful or even catastrophic, due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change.

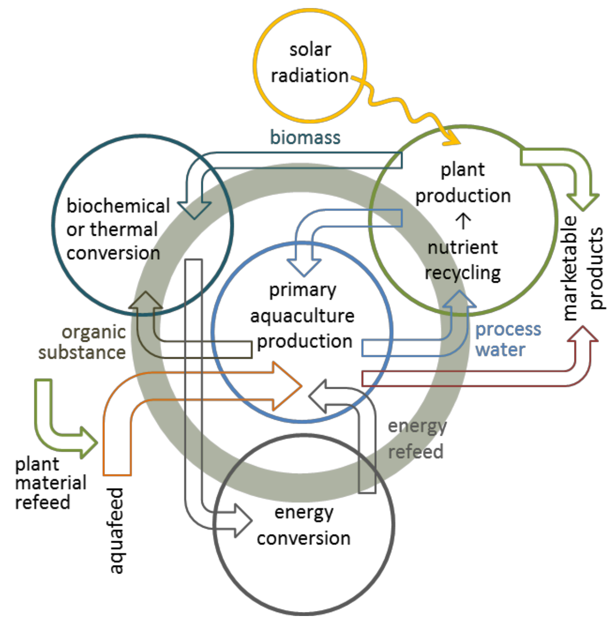
[116] J. Rockström, W. Steffen, K. Noone et al., 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity', Ecology and Society, Vol. 14, 2009, available at <www.ecologyandsociety.org/vol14/iss2/art32/>. A Feature, containing an edited summary based on that paper, was published in Nature, issue of 24 September 2009.

Although the proposed boundaries are rough, first estimates only, and are surrounded by large uncertainties and knowledge gaps, this proposed concept of planetary boundaries may nonetheless offer an important new perspective, in which it is conceivable that maintaining our jurisdictional boundaries – including maritime ones – may become conditional upon respecting certain overall, planetary-scale boundaries. And conversely, we will increasingly need to focus on the boundaries of jurisdiction vs. boundaries as defined by scientific findings, and not solely or even primarily the boundaries of one jurisdiction vs. the other jurisdiction. That does not imply a call for disregard of the jurisdictional dimension – much more that we need to consider seriously how to contextualise it within the rapidly changing factual circumstances.

This perspective of reconceiving our approach to how to organise a sustainable aquatic (marine, in this case) food supply invites for an increased interdisciplinary cooperation between international law and natural sciences.

The line of research inquiry proposed here focuses on the importance of the impact of natural sciences on the future development of the law of the sea. While the impact of scientific disciplines directly related to marine studies, such as oceanography, hydrography or marine biology, has been (albeit to varying degrees) incorporated in law-of-the-sea development so far, new challenges flow from the findings of atmospheric and Earth sciences. Processes such as climate change and ocean acidification, which are also related to the sustainability of marine resources, will increasingly require an understanding of the overall Earth system change in the current and future development of the law of the sea.

B.46. U. Waller: SESAME — Scientific Engineering Support of Aquatic Multitrophic Environments



Aquaculture expands due to the overfishing of the natural resource. The landings from fisheries will not meet the demand of the world population. The still inadequate management of the fish stocks and the foreseeable effects of the global change will likely increase this trend. The European Commis- sion points to this uncertainty. Today the fish in- dustry demands products from aquaculture that is more intensively producing. Without new technol- ogy growing aquaculture will have negative effects on the environment. Risks of a non-sustainable development of aquaculture are well documented. New biotechnologies as well as the combination of different types of aquaculture operations are nec- essary.

Recirculation aquaculture systems (RAS) designed after the state of the art and embedded in a **multitrophic environment** has high potential to support sustainability and economics. Current in- vestigations show the technical and economic feasibility. Embedded RAS can produce freshwater or marine species of any origin at almost every location, uncoupled from the environment.

The production of sea fishes whose natural stocks are endangered is an important aim of marine inland aquaculture in Europe and in view to the stock depletion by fisheries inevitable. The economic viability of European aquaculture will benefit from new species of high market value. To develop sustainable aquaculture for these species it is necessary to encompass the life cycle. Europe can refer to successful research and development in non-indigenous fish and crustacean which should be ex- panded to more species of interest.

Aquaculture was long time the discipline of biology. Despite the high differentiation of this science biology can only work on parts. Close cooperation between engineering science, natural science, and industrial economics is necessary. In RAS development the **biology (B)** defines the process parame- ters. The pocess technology and the process chain are defined by **engineers (E)**. Research and devel- opment are under permanent **management control (M)** (industrial economics). Thus, research and development include different steps and collaborators and must be carried out in close cooperation as indicated in the table below.

	WORK TASK	INVOLVEMENT
1	Selection of new species	B, M
2	Investigations into RAS-specific physiological traits of new species (definition of optima and limits)	B
3	Trial run in experimental RAS	B, E, M
4	Development of species-specific biological algorithms	B
5	Development of species-specific numerical production models	B, E
6	Engineering of species-specific RAS (process technology, automation)	E, B, M
7	Pilot run in the species-specific RAS (evaluation of species performance)	E, B
8	Validation of numerical models (algorithms)	E, B, M
9	Transfer into commercial RAS operation	E, B, M