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The Ecosystem Approach to Aquaculture: An analysis of adaptive governance and management of small-scale coastal shrimp aquaculture in Thailand

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An analysis of adaptive governance and management of small-scale coastal shrimp aquaculture in Thailand

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SUMMARY

The strategy of the ecosystem approach (EA) as well as the related adaptive framework of resilience are used to analyze the social-ecological system consisting of the marine and coastal ecosystem surrounding Thailand and the human governance systems (institutions and organisations) related to tropical coastal shrimp aquaculture management. The Ecosystem Approach to Aquaculture (EAA) is considered as a relatively new approach, although many aspects of it have been around for some time with different forms and terminology. In this paper, adaptive management strategies are analyzed and discussed in relation to conventional top-down governance approaches. The Consortium on Shrimp Farming and the Environment, an international group acting as a bridging organisation and external driver to this system, are discussed and analyzed for their important function of applying pressure and affecting change, contributing to increased resilience and decreased vulnerability. The promotion of voluntary management measures such as Codes of Conduct (COC) and Better Management Practices (BMP) to this case study demonstrates the importance of a match of scale between natural resource management policy and small-scale producers in Thailand's coastal shrimp farming industry. Problems of fit between the primarily local and technical COC's and BMP's and the broader framework of the EAA are identified and considered to increase understanding and to promote successful implementation strategies. Important weaknesses of conventional top-down, linear and non-participatory management policy are also reflected upon in an attempt to shed light on the challenges and opportunities for broader scale adaptive management.

Issues for implementation and recommendations for further research are also considered.

Key words/ terms:

adaptive governance, adaptive co-management, aquaculture, ecosystem approach, organizational change, redundancy, resilience, scale

ACRONYMS AND ABBREVIATIONS

BMP	Better/ Best Management Practice
CAS	Complex Adaptive System
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
COC	Code of Conduct
EA	Ecosystem Approach
EAA	Ecosystem Approach to Aquaculture
EAF	Ecosystem Approach to Fisheries
EBM	Ecosystem-Based Management
FAO	Food and Agriculture Organization of the United Nations
GAA	Global Aquaculture Alliance
ICZM	Integrated Coastal Zone Management
IUCN	International Union for Conservation of Nature – World Conservation Union
LDC	Less Developed Country
NACA	Network of Aquaculture Centres in Asia-Pacific
NGO	Non-Governmental Organization
SES	Social-Ecological System
UNEP	United Nations Environment Program
WB	World Bank
WWF	World Wide Fund for Nature

1. INTRODUCTION

1.1 Background Realities

The Millennium Ecosystem Assessment (MEA), the most extensive collaborative and scientific initiative ever undertaken to assess the planet's ecosystems (UNEP, 2006), has recognized that humankind's very survival is dependant on the services supported by ocean and coastal ecosystems. In addition, the demands of a rapidly growing human population have been the fundamental driver for our ability to significantly modify the planet on which we live (Vitousek et al., 1997). Over one third of the world's population lives in coastal areas, less than 5 percent of the earth's total land area (MA, 2005), and most services derived from these ecosystems are being degraded and used unsustainably and therefore are deteriorating faster than other ecosystems (UNEP, 2006). Mangrove ecosystems are particularly vital and endangered coastal ecosystems, of which as much as half have already been lost (Thornton et al., 2003).

With the major drivers of change, degradation, or loss of marine and coastal ecosystems and services understood to be mainly anthropogenic, a transdisciplinary approach is necessary to appreciate that effective governance requires the view that natural and human systems are not separate entities, but rather are complex adaptive systems (CAS) where the whole is greater than the sum of the interacting parts (Manson, 2001). Berkes and Folke (1998) introduced the concept of linked social-ecological systems (SES) as a response to simplified reductionist views and management strategies. Increased analysis and understanding of SES and effective management strategies for responsible and sustainable natural resource use is therefore crucial to increase our capacity to enact effectual governance of them.

1.2 Aquaculture Development

Overexploitation and collapse of an increasing number of catch fisheries globally has resulted the decline of the total annual capture amount, with little chance of increasing numbers of naturally produced seafood (FAO, 2006; Worm et al., 2006). This

increasingly degraded state of the world's industrial fisheries, combined with a steadily rising global demand for seafood consumption and use, is cause for serious concern with regards to human dependence on their existence for food security and employment (FAO, 2006; Rönnbäck et al. in press; UNEP 2006; Worm et al., 2006). Widespread focus is therefore shifting to the perception that increased aquaculture will be the only viable hope for meeting the rising world demand for fishery products (MA, 2005). The Food and Agriculture Organization of the United Nations (FAO) define aquaculture as "*the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming entails some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc., and also implies individual or corporate ownership of the stock being cultivated*" (FAO, 1995). Aquaculture has become the fastest-growing food-producing sector on the planet (FAO, 2006), accounting for one half of total worldwide fish production and consumption (FAO, 2007). With an annual average growth rate of 10% (FAO, 2006), it seems feasible for the aquaculture sector to more than double its current production in less than 30 years, far outweighing the shrinking fishery amounts. All the potential exists therefore, of adding increasingly significant value by way of increased production and contribution to world fish supplies (FAO, 2007). The aquaculture industry's rapid growth and expansion globally however, has caused a wide increase in negative environmental impacts such as pollution, habitat destruction, biodiversity loss, disease transfer, and negative social impacts such as land and livelihood impacts and conflicting demands for resources. Aquaculture is now at a crossroads in its development and there are many critical aspects of sustainability that need to be addressed. Growing focus on multiple indicators of sustainability, such as resource usage, environmental degradation, negative social interactions and financial viability, have brought into question the sustainability of some aquaculture industries such as shrimp farming (Beveridge et al. 1997, Naylor et al. 2000, Neori et al. 2004). There is a strong need, creating opportunities and challenges for the sector to develop and embrace innovative and responsible development leading to increased sustainability. Bennett and Balvanera (2007) articulate the importance of developing and managing future food production systems in a way that ensures resilient provision of multiple

ecosystem services at both local and global scales, as well as including a multiple stakeholder perspective in a wider context.

The FAO support the adoption and promotion of such a framework in the form of the Ecosystem Approach to Aquaculture (EAA), which brings forth a holistic and inclusive approach to support the resilience and sustainability of the social-ecological systems that underlie all aquaculture operations. The EAA is considered a relatively new approach, although many underlying principles of it have existed for some time with different forms and terminology.

1.3 Coastal Aquaculture

Mariculture (the production of aquatic organisms in brackish and marine water) in the tropics is a most diverse activity that encompasses many different species and culture systems. Some species now stand for the bulk of the production, as in the case in Thailand with shrimp (L. vannamei, P. monodon). Such forms of aquaculture have the potential to be one of the most influential drivers of change on coastal and marine ecosystems. This is evident as coastal aquaculture does not require arable land (diminishing with desertification of agricultural land) or freshwater (continuing exhaustion of freshwater reserves), and is therefore the leading candidate to meet humanity's growing food demands (Neori et al., 2007). Tropical coastal aquaculture, as represented and explored in this paper with the important study of Thailand's coastal shrimp farming industry is inextricably linked to significant economic, ecological, and social issues operating on different scales. This case is of important value for knowledge and learning when analysed as a social-ecological system with interrelated social and biophysical constraints and opportunities for management.

1.4 Research Aim

The aim of this paper is to analyse governance and management strategies in the tropical coastal context of shrimp aquaculture in Thailand with particular attention to the associated problems of fit between different scales for the development and implementation of the Ecosystem Approach to Aquaculture (EAA). Increased knowledge

of these important dynamics in cases such as this are needed in order to reduce barriers and support opportunities for new and innovative management strategies. Important considerations are the local, regional and global drivers of change and development in the context of a historically traditional activity of people with a strong culture and knowledge base tied to the sea and marine resource use. Vital to any examination of this area is the acknowledgement that there are two central features shaping coastal shrimp aquaculture in Thailand. Firstly, that it is an activity predominately carried out by small-scale farmers, who account for 80% of producers in the country (FAO, 2007; The National Aquaculture Sector Overview (NASO)), and secondly as an export-driven activity undertaken almost exclusively to supply wealthy foreign market demand for this high-value seafood product.

1.5 Research Questions

The primary research questions of this study are the following:

- What methods and strategies adaptive governance requires to be able to address multiple cross-scale interactions within the Ecosystem Approach?
- Are strategies of adaptive co-management using Codes of Conduct (COC) and Better Management Practices (BMP) on a local level, and effective fit for management of small-scale coastal shrimp farming?
- What aspects need to be considered when analyzing the relationship of fit between multi-scale dynamics within a system and the interactions with higher and lower scales?

Ecosystem Approach (EA) principles such as decentralization of management to the lowest appropriate level and matching of the scale of management to the scale of the system and the challenges within the system are explored and developed as relevant aspects for the implementation of the EAA in this case and broader contexts.
An analysis of core differences between conventional management and the EA is performed to help the reader to clarify the significance of the complexity inherent in the EAA principles, corresponding to the complexity of the social-ecological system to be managed. This study of the issues related to the development and implementation of the EAA for tropical coastal shrimp aquaculture in Thailand is intended to contribute to

building theory and increased understanding to direct the path of governance and management towards a broader and more adaptive approach. Effective understanding and implementation of these strategies will be essential to address the inherent environmental and social issues of tropical coastal aquaculture within the broader context of the complex dynamics of the underlying social-ecological system.

1.6 Limitations

The tremendous amount of data related to tropical shrimp aquaculture, as well the scope and complexity of important and relevant drivers across scales are limiting factors to a complete assessment of such a wide reaching case. Methods employed in response to these challenges were to complement a thorough literature review with gathering of additional new data through specific targeted interviews. Aquaculture has been called an activity heavily dependent on learning-by-doing (Meffe, 2002), which may just present an opportunity for effective implementation of adaptive management strategies that also fit that same description.

2. THEORETICAL FRAMEWORK

2.1 Theoretical Review

An extensive amount of research has been carried out with regards to tropical shrimp aquaculture, particularly as international awareness of negative environmental and social impacts has grown. On one side, there has been a great deal of work done lead by NGO's and others, focusing on environmental damage, particularly loss of mangrove ecosystems and salinization of agricultural lands. Primavera (1998). From the other perspective, much research and development has been promoted by government and industry for aquaculture science and technology development, focusing on increasing productivity and minimizing detrimental effects (Raux and Bailly, 2002).

Gaps in information and understanding are evident, however, as there has been a significant lack of work that has placed non-natural human created aquaculture systems of coastal aquaculture development within the broader context of ecosystem and human

system dynamics. The Ecosystem Approach to Fisheries (EAF), for example is much more developed and recognized, as Kautsky (2007-08-20) has explained that with fisheries, there is a greater realization of the dependence on natural processes beyond human control. The perspective when it comes to aquaculture, however, is not often as broad or inclusive as there can be more of a tendency to "think we can control everything" (Kautsky, 2007-08-20), and therefore that it is not necessary to take an Ecosystem Approach.

This research aims to contribute to the understanding of practical management issues as well as to further develop theory to facilitate increased capacity of institutions to manage the rapid change and impact of our use of the planet's ecosystems.

2.2 Theoretical Concepts

2.2.1 Complex Adaptive Systems

A key aspect of understanding complex adaptive systems is the realization of the limitations of reductionist approaches that aim for understanding by reducing a system to its components. Complex Adaptive Systems (CAS) theory states that the whole is greater than the sum of its parts - the integrated parts interact with decentralized self-organization, autonomous selection processes, adaptation, and the evolution of emergent properties (Manson, 2001). Additionally relevant to this analysis is the concept of cross-scale communications with other systems. Risk and uncertainty weigh highly when considering complex dynamics of the whole system. Buchanan (2002) states that "*no amount of information on the individual species… can hope to reveal the patterns of organization that make the collective function as it does*."

2.2.2 Social-Ecological Systems

Social-ecological systems (SES) are complex, integrated systems in which humans are part of nature. Social-ecological systems act as complex and evolving integrated systems

(Adger, 2006; Berkes and Folke, 1998). Effective governance of social-ecological systems requires rules that evolve.

2.2.3 Ecosystem Services

Ecosystem Services (ES) are all of the benefits in the form of goods and services that humans obtain from the natural processes of ecosystems (MA, 2005). These include the production of goods e.g., food, fibre, water, fuel, genetic resources, pharmaceuticals, etc.; regeneration processes e.g., purification of air and water, seed dispersal and pollination; stabilizing processes e.g., erosion control, moderation of weather extremes; life-fulfilling functions e.g., aesthetic beauty, cultural value; and conservation of options e.g., maintenance of ecological systems for the future (Daily, 1999)

2.2.4 Resilience

Resilience refers to the capacity of a social-ecological system to deal with change and continue to develop. This suggests both the ability to withstand shocks and disturbances, as well as the capacity to rebuild and renew itself afterwards (Folke et al., 2005). Walker and Salt (2006: Ch 4) discuss the adaptive cycle (see Fig. 1) as a metaphor for examining how systems move through different phases and helps us to understand the dynamic nature of systems organization and response to a changing world.

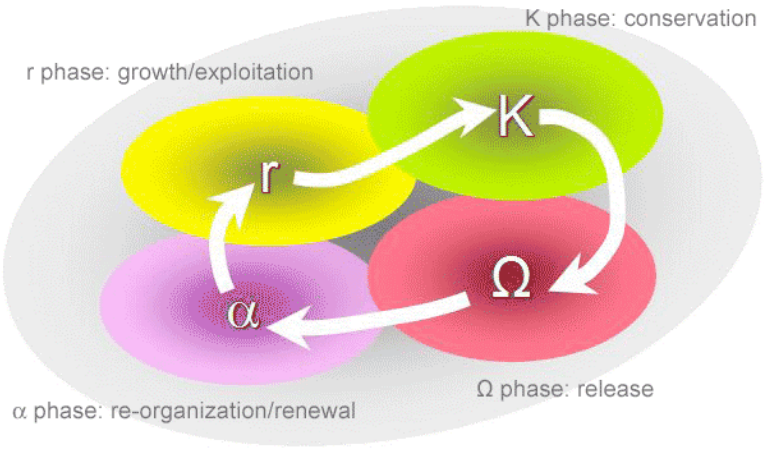

Figure 1. The Adaptive Cycle - a metaphor for change in a social-ecological system.
(Source*: http://www.resalliance.org*)

Most natural systems have been observed to progress through four phases within recurring cycles. These often occur in the order of rapid growth or exploitation, conservation, release, and reorganization. We can apply the adaptive cycle to this case to observe that conventional management approaches to Thai shrimp farming have focused only on the front loop of growth and conservation phases with costly environmental and social results. This can be contrasted with the back loop of release and reorganization phases which is where adaptive management strategies can take advantage of the crossroads of the system now to move towards increasing adaptive capacities and long-term sustainability. Table 1 (below), references the three central aspects of the concept of resilience as a property of a social-ecological system.

DEFINING CHARACTERISTICS OF RESILIENCE AS A PROPERTY OF A SOCIAL-ECOLOGICAL SYSTEM
1. The amount of change the system can undergo and still retain the same controls on function and structure
2. The degree to which the system is capable of self-organization
3. The ability to build and increase the capacity for leaning and adaptation

Table 1. Defining characteristics of Resilience in an integrated system of people and the natural environment - a linked social-ecological system. (Source: *http://www.resalliance.org*)

2.2.5 The Precautionary Approach

Complex social-ecological systems characterized by risk and uncertainty, and with threats of serious or irreversible damage, require management to exercise careful prudence to reduce or avoid undesirable outcomes. The lack of complete scientific knowledge is not adequate reasoning to postpone the enactment of cost-effective measures to prevent environmental and social degradation. The Precautionary Approach is Principle 15 of The Rio Declaration of 27 principles intended to guide future international sustainable development.

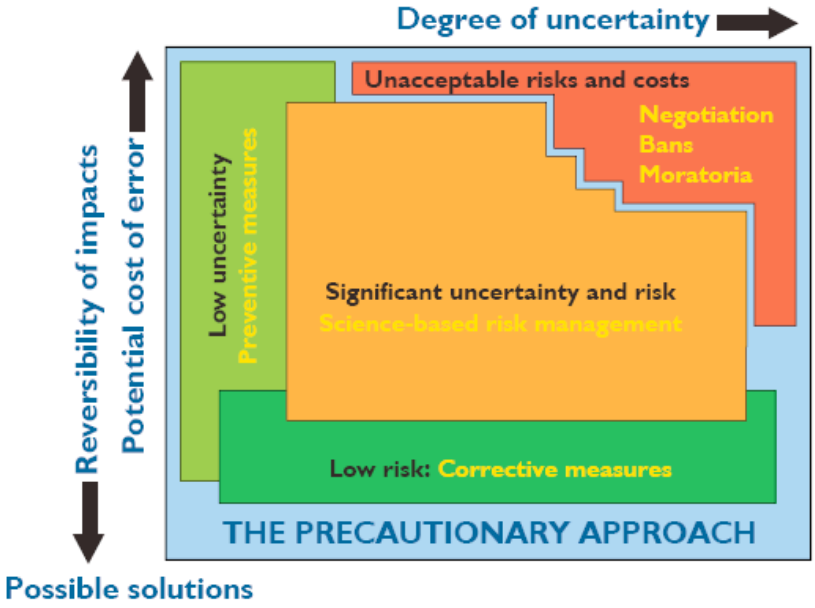

Figure 2. The Precautionary Approach. (Source*: FAO: Fact Sheets, 2007:* *http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=13302*)

2.2.6 The Ecosystem Approach

The Ecosystem Approach (EA) is a method for the management of living natural resources and biodiversity conservation, which views humans as important and integral components of ecosystems. It is an approach that has been endorsed by the Parties to the Convention on Biological Diversity (CBD), which has provided an important institutional context for its development and elaboration. The Ecosystem Approach (EA) strategy requires adaptive management that facilitates dialogue between relevant stakeholders and the creation and maintenance of complex, redundant, and layered institutions (Dietz et al., 2003).

Principles of the Ecosystem Approach (EA), revised from the Convention of Biological Diversity (CBD)

Number	Principle Text
1	The objectives of management of land, water and living resources are a matter of societal choice involving all relevant sectors of society.
2	The ecosystem approach should seek the appropriate balance between, and integration of, conservation and sustainable use of biological diversity as well as the fair and equitable sharing of benefits.
3	Ecosystem management must ensure the sustainable provision of ecosystem goods and services.

4	In order to maintain the provision of ecosystem goods and services, the conservation of ecosystem structure and function is a priority target.
5	Ecosystem management should be decentralised to the lowest appropriate level taking into account the linkages with other levels.
6	Management decisions should be based on all forms of relevant information, including that from all scientific disciplines as well as indigenous and local knowledge, innovations and practices.
7	Ecosystem management must consider the relevant economic values, impediments and opportunities including: (a) the reduction of those market distortions that adversely affect biological diversity; (b) the alignment of incentives to promote biodiversity conservation and sustainable use; (c) the internalization of costs and benefits to the extent feasible.
8	Ecosystem management should be undertaken at spatial and temporal scales appropriate to the objectives taking into consideration effects on adjacent and other ecosystems.
9	Ecosystem management should set objectives for the long term recognising the varying temporal scales and lag effects that characterise ecosystem processes.
10	Ecosystem management should adopt adaptive management strategies recognising the inherent dynamics of change and uncertainties in ecosystems.

Table 2. Principles of the Ecosystem Approach (EA).
(Source: *Adapted from the Convention on Biological Diversity, UNEP, 1992*)

The EA is meant to utilize the best available scientific information, however Day (2007-08-21) emphasizes that management must begin now with the knowledge we have, and adapt and change as we learn more. This is concurrent with Dietz et al. (2003) who recognize that inherent unpredictability of systems will always lead to uncertain scientific understanding of coupled human-biophysical systems.

2.2.7 The Ecosystem Approach to Aquaculture

The broad nature of the Ecosystem Approach (EA) is characterized in the generality of its principles. This is necessary as is intended to be applied in a wide range and variety of circumstances, but it also raises important questions about the exact meaning of its principles and the applicability of their implementation. The framework of the Ecosystem Approach to Fisheries (EAF) is further developed, and therefore has been used by the FAO as a basis for defining the Ecosystem Approach to Aquaculture (EAA) as:

"*An ecosystem approach to aquaculture (EAA) strives to balance diverse societal*

objectives, by taking into account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems including their interactions, flows and processes and applying an integrated approach to aquaculture within ecologically and operationally meaningful boundaries. The purpose of the EAA should be to plan, develop and manage the sector in a manner that addresses the multiple needs of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by aquatic ecosystems" (FAO, 2007).

The FAO is the focal proponent of the EAA, leading in efforts to develop a consensus framework as a foundation for sustainable development.

2.2.8 Adaptive Governance

The overall approach underlying all activity is a focus on the management of natural resources and ecosystem services through experimentation and learning among people, and the promotion and development of institutions and organisations for collaboration, collective action, and conflict resolution.

2.2.9 Adaptive Co-management

Folke et al. (2002) describe adaptive co-management as a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organised process of learning-by-doing. Consensus achievement is through a transparent multi-stakeholder dialogue process of identifying key impacts, developing baseline data, focusing on desired results and identifying best management practices. Flexible systems of resource management are those that develop tailored to specific places and situations and supported by, and working with, various organisations at different levels (Olsson, et al., 2004). In effect, a combination of adaptive, cooperative, and collaborative management come together as a means to operationalize adaptive governance (Dietz et al., 2003).

2.2.10 Institutions

Institutions are the formal or informal rules and norms influencing how humans organize themselves and their activities, with resultant effects on the resilience of social-ecological systems (Dietz et al., 2003).

Institutional infrastructure - areas such as research, social capital, and multi-level rules, are important in the coordination between local, regional, and global scales of governance. Institutions that are designed to plan for change and be responsive to change are proposed by Olsson et al. (2004) to be adaptive. This concept of allowing for adaptation is a central tenant of governance and management strategies that increase the resilience of social-ecological systems (Folke et al., 2005; Olsson et al., 2004).

Dietz et al (2003) acknowledge the difficulties of developing methods of governing ecosystems that support diverse life, including a reasonable quality of life for humans, under uncertainty, complexity, and substantial biophysical constraints as well as conflicting human values and interests. Inherent conflicts necessarily require tradeoffs at different temporal and spatial scales. Gaps in knowledge exist in identifying and understanding the characteristics of institutions that contribute to or weaken socio-ecological systems under particular conditions.

2.2.11 Redundancy

Redundancy in governance systems in the context of adaptive management of social-ecological systems refers to the duplication or overlap in authority and capabilities of systems of governance that exist and function across multiple levels (Hahn et al., 2006). These modest overlaps can be examined and understood as organizational redundancies, as well as institutional redundancies, of which cross-integration is important.
How actors, or the organizations existing within social systems use these institutions in governance is directly related to the degree of flexibility and openness to learning and change that has been developed within them. Redundancy can play an important role in the creation and maintenance of adaptable organizations and learning institutions through the promotion of diversity in the levels of vulnerability - promoting multiple agents with a broader capacity and range of responses to change.

Organizations of different types or social hierarchical levels often tend to have varying degrees of adaptability related to their structure. For example, community-based organizations, NGO's, non-profits, and co-ops can have redundant functions relative to larger bureaucracies, however, their organizational structures likely to allow them to be more adaptive and able to accept new information and respond more effectively to change (Danter, 2000). Redundancy can foster building of social capital as individuals and organizations can work together to overcome a common environmental problem. The resulting increased intersectoral communication and collaboration at different levels act to create social networks, trust, and increased social capital, which can result in benefits far greater than the solution to the problem that produced them (Cumming et al., 2006). Redundancy also creates a buffer in case of loss or ineffectiveness of actors in a system.

Folke et al. (2005) refers to polycentric institutions as "*nested quasi-autonomous decision-making units operating at multiple scales.*" Through redundancy across vertical links from centralized to decentralized control, such institutions increase diversity of response options for dealing with uncertainty and complexity of social-ecological system dynamics at different scales. Governance in the context of the EA is a process of learning-by-doing, and thus a flexible learning approach focused on long-term sustainability is paramount. Such social learning is essential for resolving mismatches between the scale of environmental change and the scale of social organization in which the responsibility for management resides (Cumming et al., 2006). Scale mismatched problems require the development of redundant organizations and institutions that can respond to ecosystem uncertainty and change through adaptation and reorganization. Redundancy in governance systems can be criticized for being less efficient, time consumptive, and messy in the structure of organizations and institutions. It also increases costs, as it is more expensive to encourage and maintain overlapping structures and mechanisms. Increased conflicts can be another negative aspect of redundancy. These downsides of redundancy however are often related more with conventional natural resource management, which aims for control and stability. Redundancy would

not be nearly as important if systems were not so dynamic and had only one equilibrium state. A more relevant shortcoming of redundancy to adaptive governance is the blurring of responsibility, which can lead to blame and scapegoating when things go wrong (Stoker, 1998). The integrated EA however, recognizes that the downsides of redundancy in governance systems are most often outweighed by the beneficial contributions to learning and adaptation through the collaboration of diverse stakeholders operating at different scales in continually evolving multilevel institutions and organizations.

3. CASE STUDY DESCRIPTION

3.1 Thailand Coastal Shrimp Aquaculture

The specific case under examination is delimited by the political-geographical boundaries of the nation of Thailand (see Figure 3), its coastal zones, and the human governance systems (institutions and organisations) related to its adaptive management.
The actual and relevant boundary for a complete and meaningful analysis in this context is however much larger, including global markets and interconnected ecosystems.
The vast majority, over 90% (FAO, 2006) of aquaculture takes place in Asia, with Thailand a dominant force as the world's largest producer and exporter of farmed shrimp. This has not always been the case however, as from the mid 1930's through to the early 1970's, extensive shrimp harvests in Thailand were utilized mainly for domestic consumption and for local market sale. Growing demand from the USA, Japan, and Europe, as well as increased technology for efficiency led to the development of semi-intensive and intensive coastal shrimp aquaculture, aided by government promotion and subsidization. In the late eighties, the collapse of the Taiwanese shrimp farming industry due primarily to disease from overstocking and resource over-exploitation (Kautsky et al., 2000) paved the way for Thailand to assume its authority in this market. The growth and intensification of the industry continued unabated until overstocking, high farm densities, contaminated water, and decreasing availability of undeveloped coastal sites, also lead to the rapid spread of disease (Kautsky et al., 2000, FAO/NACA/UNEP/WB/WWF, 2006), forcing reductions in farming intensity, as well as

movement to non-degraded areas. Formal institutions and government policy were supportive of the unregulated and rapid growth and development that lead to this type of sequential exploitation of mangrove ecosystems (Huitric et al., 2002; Rönnbäck, 2001; Kautsky et al., 2000), and self-inflicted harm to the health and security of the industry.

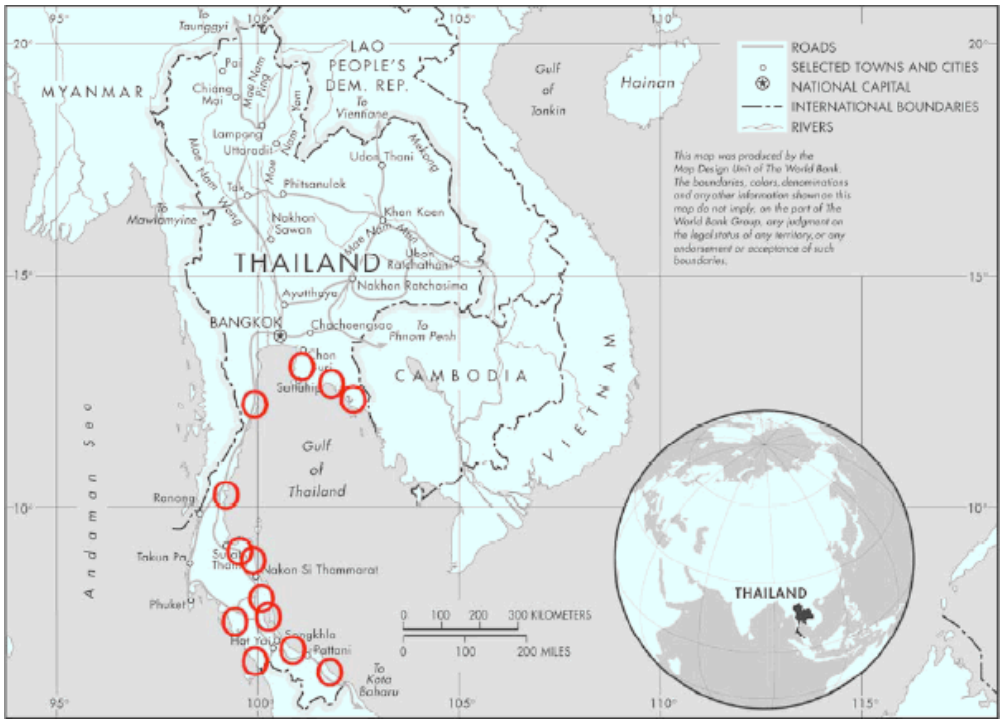

Figure 3. Main shrimp farming areas in Thailand
(Source: Rosenberry, 2001 – Institutional Aspects of Shrimp Farming in Thailand)

Shrimp farming in Thailand and related mangrove destruction and other negative environmental and social aspects have been the focus of significant attention by the media, international NGO's, as well as government, industry and academic research. This study however, emanates from a different perspective than most, focusing on the Ecosystem Approach & Resilience theoretical perspectives to identify and theorize issues of fit and mismatches across multiple scales.

Most shrimp farmers are small-scale producers, as in 2002 there were 31,179 shrimp farms covering 74,391 ha. Total production was 264,923 tonnes (FAO, 2007. The National Aquaculture Sector Overview (NASO)). This region can be seen as a highly important food-provisioning ecosystem and shrimp food production from coastal aquaculture in Thailand is a well recognized essential ecosystem service of this area.

Additional ecosystem services of the seascape environment, including mangrove ecosystems, are carbon assimilation, photosynthesis, nutrient cycling, species habitat, waste assimilation, transport, recreation, aesthetic beauty, cultural value, employment and livelihood, and the maintenance of biodiversity for future supply of these goods and services (MA, 2005).

3.2 The Consortium on Shrimp Farming and the Environment (The Consortium)

The Consortium is an example of an association of International organisations created for a common purpose beyond the capabilities of any single member of the group. Formed in 1999, the mandate of the global program was and continues to be to identify issues around shrimp farming and broadly advise on better management of the shrimp farming sector. The group is a partnership of the following:

1. FAO: The Food and Agriculture Organization of the United Nations – an intergovernmental organization with mandate to build a world without hunger.
2. NACA: The Network of Aquaculture Centres in Asia-Pacific – an intergovernmental organization that promotes rural development through sustainable aquaculture.
3. UNEP: The United Nations Environment Program – a division of the United Nations promoting on the ground partnerships for environment and development.
4. The World Bank – International financial institution with mandate of world poverty reduction, with history of financial backing of environmental and social damaging rapid tropical coastal aquaculture development.
5. WWF: World Wildlife Fund – the largest multinational conservation organization in the world, engaging the aquaculture industry to reduce its negative impacts.

The Consortium's diversity with international membership and focus on endorsing and promoting local voluntary management practices, gives support to its role to act as a bridging organisation for adaptive co-management. The partnership produced the "International Principles for Responsible Shrimp Farming" guideline document in 2006 which calls for improved management via "*strengthening of institutional arrangements, capacity and partnerships*" (FAO/NACA/UNEP/WB/WWF, 2006).
Working with small-scale farmers and promoting increased organisation and development of producer organisations, the increasing result is to be able to advance these local farmers capacities to be active and involved in their own responsible and sustainable shrimp farming practices. The Consortium could be criticized for not having more small-scale farmer participation, but rather than to promote overly broad inclusiveness for its own sake, which could bog down the process and limit effectiveness,

the Consortium aims to promote projects that can play a vital role in promoting the empowerment of local producers, advancing their capacity to be participatory in more meaningful ways when more organised and established.

The rapid development of coastal shrimp farming in Thailand has produced many undesirable outcomes, as well as some potentially successful ones that can possibly be targeted for replication globally. Having gone through several stages of learning, and as one of the countries most advanced in the development of shrimp farming, the importance of understanding and implementing the Ecosystem Approach to Aquaculture in this case therefore has much further potential reach and likely global-reaching implications.

4. METHODS

The material presented within this thesis is based on a literature review of published scientific articles, reports, books, internet sites, and published documents from the Network of Aquaculture Centres in Asia-Pacific (NACA), and the Food and Agriculture Organization of the United Nations (FAO). A meta analysis, a technique of collective analysis of disparate studies, was conducted. This method poses challenges to data interpretation, but recurring patterns do tend to shed light and clarification on the issues (Kvale, 1996). Additionally, the aim is to present and synthesize relevant existing information for this case study and the analytical framework being applied to it, as well as provide some additional new data to increase knowledge and understanding and further develop theory. This primary qualitative data was acquired through questionnaire surveys and semi-structured interviews with key informants that were selected for their relevant knowledge and experience. The snowball method was also used to identify and contact additional individuals for personal communication. Key informants were generally targeted due to their positions as leading people in the field of aquaculture, with the opportunity to advise on policy. The intention here was twofold - to utilize their knowledge and experience, as well as to lay an important foundation for the practical application of the outcomes of this study.

A case study approach, detailed in the preceding section, was utilized to take a detailed analysis of a particular defined case with the intent of demonstrating generalizations applicable to the broader areas beyond the delineated case boundaries. As Yin (2003) suggests, each case is unique and can be utilized as a framework for analysing events and reasons to shed light on both detailed and exploratory research questions.
Adger (2006) and Berkes and Folke (1998) describe the concept of a social-ecological system to reflect the idea that human action and social structures are integral to nature. This inspiration was influential to the methodological and epistemological background to this study which employs an ecological approach to the analysis of the case as an acknowledgement of the inherent complexity and interdependence. This contradicts reductionist management approaches of this system with conventional emphasis on resource yields that take poor account of ecosystem dynamics and often continue to influence governance towards simplistic and in fact, further damaging policies.

5. RESULTS

5.1 Aspects of Coastal Shrimp Aquaculture

Aquaculture comprises many diverse activities that impinge on natural resources at the heart of most legal regimes (Van Houtte, 2001), and therefore raises multiple legal and institutional issues. Development of Thailand coastal shrimp farming has been associated with various positive attributes including provision of employment, rural development and diversification, and significant national export earnings. These benefits have however, been accompanied by major costs in terms of widespread negative environmental and social damage (Primavera, 1998).

5.2 Imperative for Management

Many negative environmental and social aspects of tropical coastal shrimp aquaculture exist, and a discussion of them all in depth is beyond the scope of this study. The loss of vital ecosystem service provisioning mangrove ecosystems is therefore given as an example and a very significant factor for the support of adaptive management strategies.

5.2.1 Mangrove Habitat Loss

Mangroves are tropical intertidal forests that can contribute significantly to the well-being of coastal communities through their provision of a wide array of goods and services (Saenger et al. 1983, Rönnbäck et al. 1999, Primavera 1993, 2001). Besides the direct utilization of forestry products (e.g. wood for fuel and construction materials, forage for livestock, honey, medicines, etc.) mangroves also support high production of seafood through their role as important nursery grounds and breeding sites for various fish, crustaceans and other shellfish (Boesch and Turner 1984, Robertson and Duke 1987). A positive correlation between mangrove area and shrimp/fish catches has been documented for the Philippines, Malaysia, Indonesia and Australia (Primavera, 1995, 1998a and references therein). The mangrove forest also provides services like protection against floods and hurricanes, reduction of shoreline and riverbank erosion, maintenance of biodiversity, etc. (Saenger et al. 1983, Rönnbäck 1999).

Development of aquaculture has been a major factor for deforestation and degradation of mangroves in many countries, especially so during the last two centuries (Hamilton et al. 1989, Primavera 1993, Spalding et al. 1997, Primavera 1998). Other factors like urban development, upstream land degradation, salt mining, and overexploitation for timber has also played a significant role (Saenger et al. 1983, UNEP 1995), argued by some authors to have contributed more to mangrove destruction than shrimp farming (Hambrey 1996a, Fast and Menasveta 2000). Due to acidic soils mangroves do not constitute optimal sites for aquaculture ponds. However, the benefits from ready access to water, natural food and larvae by the tidal movement, together with cheap land or historical low protection status of mangroves (Martinez-Cordero et al. 1999), has resulted in the systematic establishment of farms. The inability among economists to recognize and value the many natural products and ecological services produced by mangroves has been argued to be one important reason for the massive loss of mangroves during the last decades (Barbier, 1994, Rönnbäck, 1999, 2000, 2001, Primavera and Rönnbäck 2002).

5.3 Spatial Scales

Cross-scale interactions (see Figure 4), are demonstrated by a multi-level stakeholder system of layered operational levels and activities involved in coastal shrimp farming.

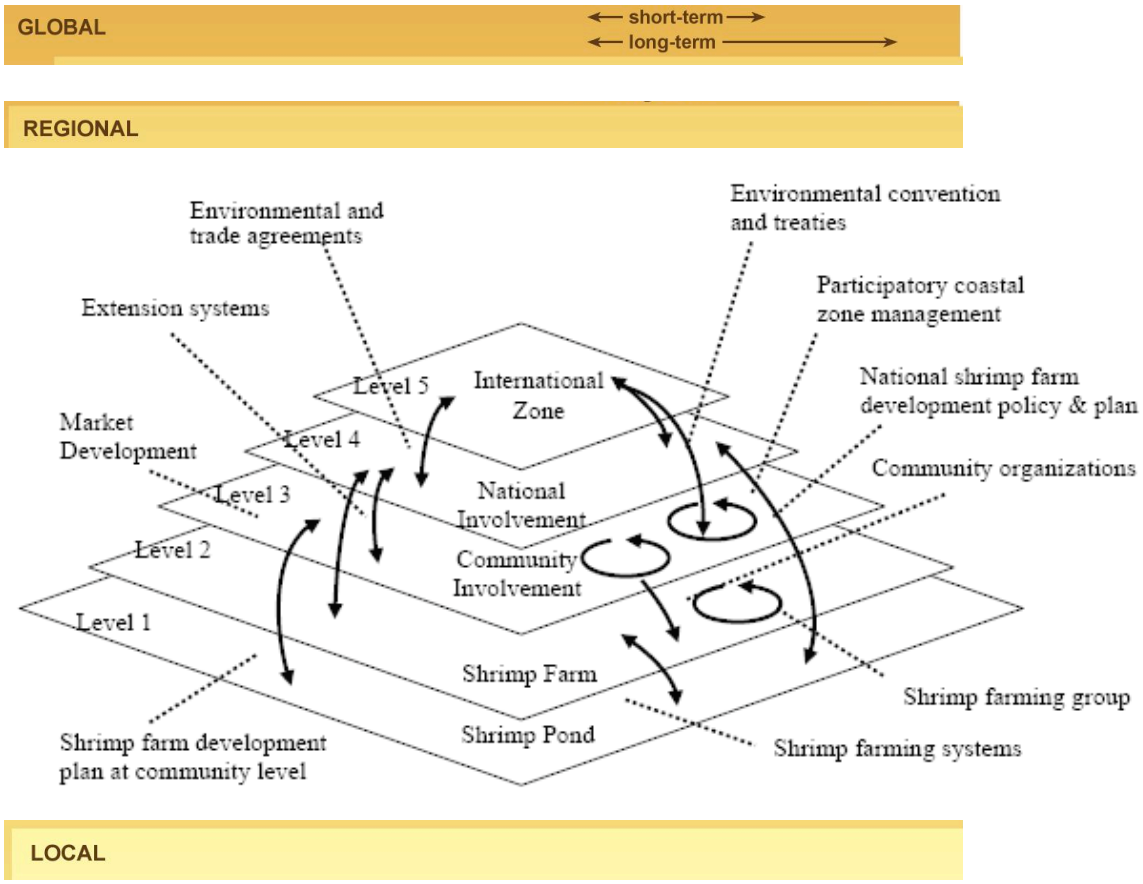

Figure 4. Operation Levels and Activities in a Multi-level Stakeholder Approach to Sustainable Shrimp Farming Development (with addition of different levels of ecosystem scales).
(Source: Modified by author *from Food and Agriculture Organization of the United Nations (FAO), Fisheries and Aquaculture Dept. Fact Sheets,* http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=1330)

5.3.1 Global Scale

International forces have the power to be major drivers of change of this system. Fluctuating market demands, international shrimp prices, trade policies (such as increasing trade barriers of importing regions as in the case of the EU for Thai shrimp), lack of international legislation, and competition from other country producers are some of the important high level factors of influence. The three major international markets for shrimp exports are Europe, Japan, and the U.S.A. Despite the EU being the largest market of the three, Thai shrimp exports to the EU remain low due mainly to strict EU food safety regulations and high tariffs. Additionally, it is widely accepted that global climate change is leading to increased frequency and severity of storms and other weather

events. Changing climatic patterns are also resulting in reduced quality of seed stocks, adding an additional element of difficulty to shrimp farming (Nissapa et al., 2002). Vast changes in the expected future direction of tropical coastal shrimp aquaculture, where production moves to large closed recirculation (Flock) systems (Rosenberry, 2006), will also have powerful effects, particularly for small-scale producers in Thailand.

5.3.2 Regional Scale

Coastal shrimp aquaculture in Thailand is formally regulated by two departments in the Ministry of Agriculture and Co-operatives (Huitric et al., 2002). An apparent conflict of interest is evident as both the regulation and promotion of shrimp aquaculture fall under the responsibility of the Department of Fisheries. The Royal Forestry Department handles the regulation of the use of mangroves. Huitric et al. (2002) have suggested that national legislation and associated government policy were some of the driving forces behind the rapid development of shrimp farming in Thailand from the 1940's to 1997. Here we see an example of possible tradeoffs between short-term political goals at the expense of long-term provision of ecosystem services. Initially, the government whole-heartedly supported and promoted the growth of an increasingly lucrative industry, and took a highly conservative management approach with very little regulatory aspect: promoting general awareness and advice for environmentally-oriented farming practices. Increasing international awareness of the negative impacts of coastal shrimp farming influenced the formation of government regulations. These were implemented in a top-down manner, primarily to protect local rice farmers and villagers, as well as shrimp farmers themselves, from the negative effects of shrimp aquaculture activities.

Government regulations and planning areas can be generally summarized as follows:

1. Regulated shrimp farming area
2. Regulations according to the Fisheries Act
3. Strengthening the hatchery and farm registrations
4. Monitoring programme and antibiotic residue inspection
5. Seawater irrigation system
6. The code of conduct
7. Research programmes and priorities
8. Disease and prevention
9. Ban on inland shrimp farming (1998)
10. Ban on groundwater pumping

11. The RAMSAR convention
12. Prohibition against trawling and the use of push nets
13. Ban on the construction of shrimp farms in mangroves (1996)
14. No Environmental Impact Assessment (EIA) required for aquaculture
15. Division of mangrove forests into three zones
16. Chemical regulations

Limited resources for monitoring and enforcement however constrain the effectiveness of many of these regulatory measures (Tacon, 2007-08-14).

5.3.3 Local Scale

"*Any belief that a legal prohibition of unacceptable behaviour will solve an environmental concern is erroneous*" (Van Houtte, 2001)
Codes of Conduct (COC) and Better Management Plans (BMP) and Certification Standards are methods to assure that operations comply with predefined goals. These methods are typically used to assure that environmental impacts are limited, although they may also include social and economic aspects. The development of COC's, BMP's and Certification Standards is a rapidly growing area of aquaculture (FAO, 2006).

Codes of Conduct (COC)
The Code of Conduct for Responsible Fisheries was adopted by FAO member countries in 1995, and Article 9 deals entirely with aspects relevant to responsible aquaculture (FAO, 1995). Such codes are guidelines that are becoming more common and more developed with the increasing growth and widespread impacts of aquaculture.
The FAO COC is an extensive framework based on international and national legislation and stakeholder consultation (Ackefors, 2002)

Better Management Practices (BMP)
General guidelines of a more local and technical nature are increasingly being developed and adopted as voluntary methods of putting into practice the more general principles of responsible shrimp farming.
Coming out of a central FAO document in 1995 – Code of Conduct for Responsible Fisheries, COC's and BMP's for shrimp farming are captured in the document

"International Principles for Responsible Shrimp Farming" developed by the Consortium. These principles are highly technical in nature and local in focus, and are broken down into farm sitting, farm design, water use, broodstock and postlarvae, feed management, health management, food safety, and social responsibility (FAO/NACA/UNEP/WB/WWF, 2006). In essence, they are intended to support producers to increase efficiency and productivity, reduce or mitigate the negative impacts of farming on the environment, improve food safety and quality, and improve the social benefits and social acceptability of shrimp farming.

COC's and BMP's are voluntary practices, but may have some value being utilized as the basis for strengthening local regulations or certification programs.

FAO (2006) report that the adoption of BMP's by an increasing number of farmers in India and Vietnam has been shown to lead to an increase in shrimp yields and a reduction in disease outbreaks. Implementation of similar practices in Thailand may be slower and more difficult due to the special constraints and limited adaptability of the majority small-scale producers (Hambrey, 2007-08-15, Lee, 2007-08-15). A key challenge is the long-term sustainability of producer organisations such as small-scale farmer cooperatives, which have shown a poor track record globally. In Thailand this is especially the case, as farmers are well known for their individualism (Edwards, 2007).

Certification Standards

Driven by food health safety concerns, as well as environmental and social sustainability issues, attempts are being made to respond to public perceptions and market requirements with certification standards. An aquaculture scientist suggested (2007-08-23) that the certification and labelling process for consumer acceptability could drive the farmers to implement COC's and BMP's.

5.3 Temporal Scales

The FAO have realized that to side-step long-term temporal issues, they need to avoid using the word "Sustainable", and so have changed their wording to "Responsible" (Kautsky, 2007-08-20). In this way the long-term scale of sustainability is traded down to the short-term scale of "*we do as good as we can, but not more than we can afford"*

responsible practices (Kautsky, 2007-08-20). The focus on Responsible aquaculture is evident in short-term, local, and technical-fix COC's and BMP's, but does not equate to the FAO's promotion of the long-term, multi-scale, adaptive Ecosystem Approach to Aquaculture (EAA).

6. DISCUSSION

6.1 Broad Perspectives

Ecosystem services are referred to in the MEA as services provided "by nature to humankind" (MA 2005). The formulation of this assertion implies a degree of natural ownership or direction, rather than the more actual appropriation of these goods and services by humankind in their affirmation of dominance over the planet.

The second half of the twentieth century has seen the increasing effects of the Anthropocene (Crutzen et al., 2000), the current time period denoted by human interference with the biological processes of the planet that are unprecedented throughout human history.

In a period of such rapid growth and change, there is a danger that the scale of management will continue to be too limited to match the growing scale of complexity of environmental and social problems.

Man-made non-natural systems are limited in their complexity when compared to the natural systems which they are dependent upon. My findings thus suggest that there is an inherent risk with the management of aquaculture, such that its focus becomes directed towards simple understood systems of limited complexity (non-natural systems) and conventional management approaches, rather than the broader natural complex adaptive systems on which they are based and ultimately reliant on. Table 3 below highlights the contrasting aspects of conventional and ecosystem approaches to management.

Major Aspects of Conventional Management vs. The Ecosystem Approach

Conventional Management	The Ecosystem Approach (EA)
Focus only on single scale, such as species, local, and short-term	Holistic and integrative approach focusing on entire ecosystem including humans
Command and control focus on specific resources for economic or social production	Adaptive management and planning with learning aspect

top down rigid, focused on efficiency & optimization expert-focused locked-in limits options	multilevel approaches flexible experimental evolving creates options
Short-term focus	Long-term focus for sustainability
View systems as understandable, predictable and controllable	Understands that ecosystems and social systems are extremely complex and dynamic adaptive systems
Assumes changes are incremental and linear	Realizes that the systems we live in and depend on are usually configured and reconfigured by extreme events
Unresponsive to critical changes in ecosystems	Expects and plans for uncertainty in complex ecosystem dynamics (buffer from surprises)
Limited or passive public consultation	Stakeholder involvement and partnerships (brings human behaviour in as central management component)
Peace-meal or disjointed policies	Integrative policies including ecological, economic, and social realms
Monitoring for the sake of monitoring	Active monitoring for understanding and response

Table 3. Major Aspects of Conventional Management vs. The Ecosystem Approach.
(Source: *Concepts compiled and adapted by Robert Johnson, 2007*).

Global marine and coastal areas including Thailand are feeling the negative repercussions of coastal shrimp aquaculture with the degradation of their natural and social systems. The capacity to continue to absorb such disturbances in the future without a change of function and structure, underpin the resilience of the underlying social-ecological system. The governance and management of coastal shrimp farming is poised at a crossroads to exacerbate this problem, or alternatively contribute with proactive responses to it.
The resilience of social-ecological systems (see Figure 5), is dependent on the slow moving variables underlying the system, such as market forces, climate, resource use, and human values and policies. Management in the case of coastal shrimp aquaculture in Thailand has so far been focused on being reactive only to the fast changing variables. Resilience in social-ecological systems includes the added capacity of humans to anticipate and plan for the future and can be operationalized by learning-by-doing and

through flexible experimentation promoting adaptive and transformational capacity (see Figure 5 below).

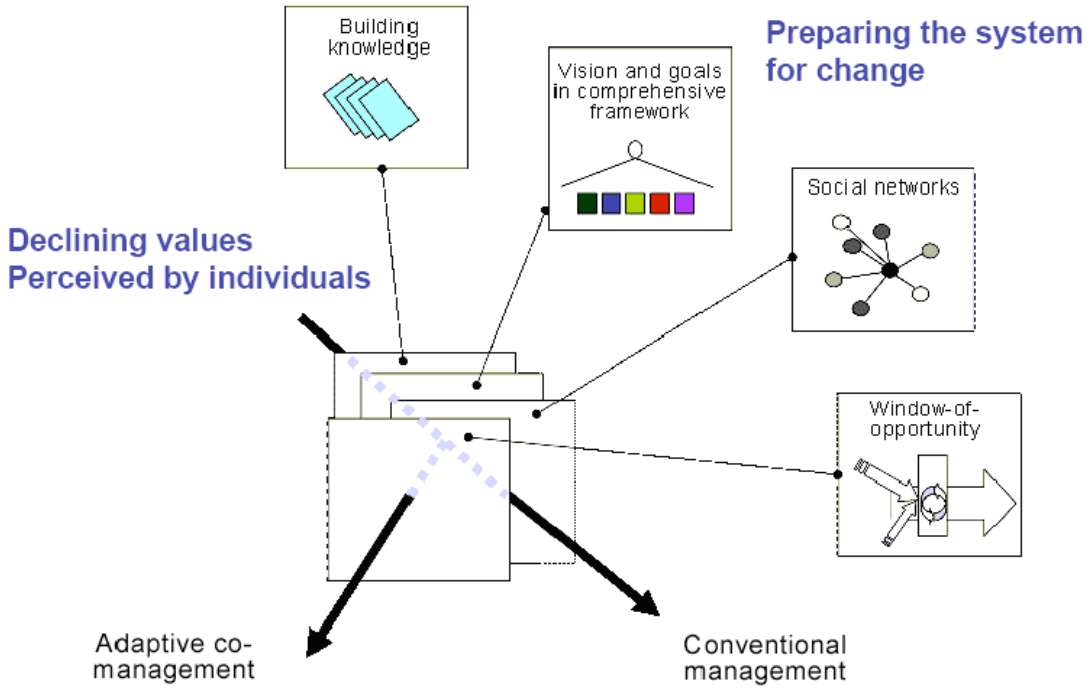

Figure 5. Transformation of the social-ecological system.
(Source: Olsson, Folke, Hahn. 2004. Ecology and Society)

6.2 Temporal and Spatial Scales

Cumming et al. (2006) espouses that mismanagement of natural resources and the related decrease in human well being (and overall decrease in social-ecological resilience) are often contributed to by mismatches of scale. In this case, my findings point to a scale mismatch between COC and BMP management tools for the local scale of small-scale Thai coastal shrimp farmers, and the scales of the Ecosystem Approach to Aquaculture which is meant to be the underlying foundation for all aquaculture governance.
This problem of fit relates to the temporal scale mismatch described in section 5.3 of the results, and is demonstrated in Figure 5 below:

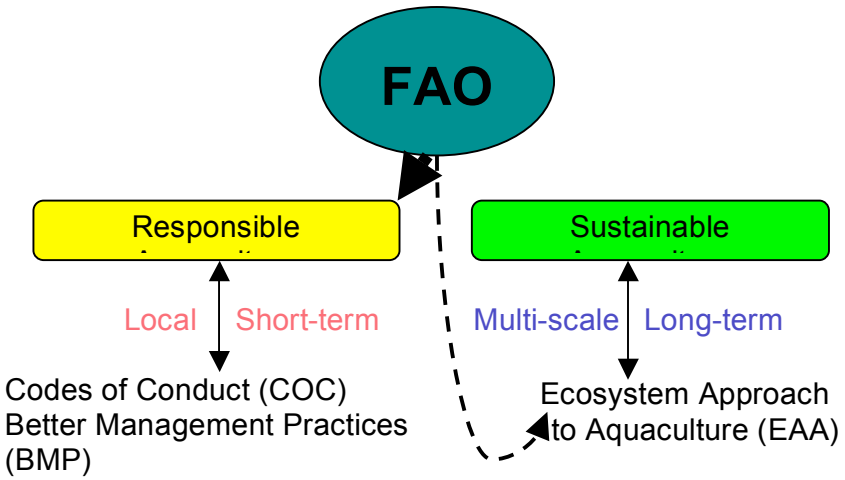

Figure 6. 'Problem of Fit' between the Ecosystem Approach to Aquaculture (EAA) and Codes of Conduct (COC)/ Better Management Practices (BMP). (Source: Robert Johnson, 2007)

An Asian aquaculture researcher (2007-08-23) stated: "*COC, BMP, GAP* [Good Aquaculture Practices] *etc. are well known in Thailand. I don't know much about EAA yet.*" This is mismatch of scales is likely a significant factor that gave rise in this case to the mobilization of an international partnership such as The Consortium, which aims to better fit the scale of management to the scale of the issues, and may increase adaptability through building support for organisation of producer groups for self-management.

6.2.1 Global Scale

This study is an excellent example of a social-ecological system that is tightly linked to global pressures such as foreign market demands and climate change, necessitating the requirement for governance with cross-scale interactions from the global down to the local.

This is supported by Dietz et al. (2003) who emphasizes that "*global markets reshape demand for local resources in ways that swamp the ability of locally evolved institutions to regulate their use.*" Citing the example of global climate change, we can expect it will likely lead to dissimilar levels of impact on different farms, as small scale farmers with less resources and capacity to adapt may become more vulnerable and less resilient as they are forced to operate in the outer coastal zone. Large companies on the other hand will likely be able to operate in more inland locations as well as invest in more infrastructure, protecting them from such external forces.

A scenario can be used as a tool for envisioning change (Peterson et al., 2003; Resilience Alliance, 2007). The aforementioned future scenario of widespread development of large scale, low environmental impact, recirculation Flock systems could flood the market leading to reduced world prices for shrimp. Small-scale shrimp farmers would be unlikely to compete with this technology as it is high-cost and high-maintenance, and would grow increasingly vulnerable in the face of diminished livelihood options. Perhaps an adaptive strategy to help increase the capacity of small-scale coastal shrimp producers would be to diversify their production with integrated aquaculture, such as farming more than one species together (Neori et al., 2007). This is an important area for coastal aquaculture research and development with promising potential to both reduce environmental impacts and social vulnerability.

6.2.2 Regional Scale

Governments are in fact the only legitimate authority to regulate aquaculture practices, but regulations are often inconsistent, and either lacking or unenforced. Therefore the aquaculture industry, with others, need to be proactive and work towards developing and implementing systems of environmental management based on an ecosystem approach that is wider reaching than a primary aim on prevention and mitigation of adverse environmental impacts. An enabling framework should be established by national policy to promote the utilization of COC's and BMP's, but their substance must be broadened to include more than just issues of local and technical nature, and rather to take into consideration all aspects of the entire social-ecological system.

As now developed, COC's and BMP's for the Thai coastal shrimp farming industry are primarily focused on increases in productivity, efficiency, profit, etc., with added side benefits of reductions in negative environmental and social impacts. The industry, particularly coastal shrimp aquaculture has an inherent responsibility, as well as a vested interest, to contribute to improve the damaged image of aquaculture, which has been propagated by issues such as mangrove destruction, coastal waste effluents, and social and development conflicts.

Olsson et al. (2004) identifies enabling legislation as a contributory condition to promoting adaptive management and building resilience of a social-ecological system. The following are suggested strategies for Thailand's national government:

1. Fostering participative policy formation
2. Providing an conducive legal and investment framework – facilitate co-management
3. Establishing public-private partnerships
4. Strengthening of organizations and institutions
5. Providing basic infrastructure support
6. Promoting self-regulation
7. Providing a research platform
8. Undertaking zoning for aquaculture
9. Providing monitoring and evaluation support
10. Promote local ownership
11. Help define the roles and responsibilities of the different stakeholders involved, and support good linkages among participating stakeholders.

6.2.3 Local Scale

Rigid laws with little flexibility have limited chances of success with small-scale producers who don't have the resources or capacity to make sudden and costly changes. It has been suggested that COC & BMP may be the key to successful management of small-scale coastal shrimp aquaculture in Thailand. Boyd & Schmittou (1999), suggest that BMP's can serve as the basis for future government regulation in many nations. The Consortium's programs show potential to develop such cross-scale fertilization. COC's and BMP's necessarily need to be adapted and made applicable to local activities and circumstances (keeping in mind the very diverse nature of aquaculture); however, this should not limit the scope of the regulations. We lose a central aspect of the EAA when these voluntary regulation mechanisms become too focused on only local concerns, as well as primarily technical issues. While the local level of these voluntary measures is a more appropriate fit to the small-scale producers of this industry compared to more cumbersome national legal instruments or broader global forces, the substance of the codes and practices must be developed with the broad foundation of cross-scale interactions (spatial and temporal) to be able to support a broader social-ecological system vision of management in line with EAA principles.

Even so, the burden of compliance with regulations or standards may also fall disproportionately on small suppliers, as the costs incurred are relatively higher, and for whom these increased expenditures push them past their ability to be profitable or competitive.

Kautsky (2007-08-20) stresses the importance of the dissemination of good information at local levels, both about the ecological processes being managed, as well as the interactions between humans and the environment that affect those systems. This knowledge however, as stressed by Dietz et al. (2003) must not overload the capacity of users to assimilate it. The scope of influence of the farmers from a practical perspective is primarily local (Hambrey, 2007-08-15) with understanding of multi-scale processes and interactions not plausible.

6.3 Resilience and Vulnerability in Ecosystem Management

Resilience theory points out that resource crises (shrimp industry boom & bust cycles brought about by environmental and social issues) have the potential to result in important contributions to institutional social learning and renewal of management institutions. This however is not to be expected as a natural or automatic outcome. The analysis of this case has demonstrated that the influential impacts of varied relevant stakeholders show that temporal and spatial scales of this linked social-ecological system are very important factors. Resource management systems such as this are therefore multi-scale, with effective sustainable management only achievable when it is managed at different scales simultaneously. Developing and implementing adaptive strategies increase the capacity for preparedness to expect the unexpected (Folke, 2006-10-23). Three types of adaptation identified by Pretty (2003) are bonding, bridging, and linking, and are important for developing social capital through social networks and trust building. Practices that encourage these types of institutions need to be developed and implemented through the guidance of the principles of the EAA. Hahn et al. (2006) have found that investing in trust-building costs a lot of effort, but the outcome is increased social capital which reduces later transaction costs.

Alternative livelihood options reducing the vulnerability of local rural communities are often cited as positive aspects of increased coastal aquaculture development, however, market saturation (competition), increased risks for diseases, a narrow monoculture approach investing too much in one livelihood option (i.e. shrimp farming), and negative externalities from aquaculture activities combine to create great risks.

Heterogeneity, or the diverse nature of the system helps maintain redundancy of function (Folke et al, 2005). In this case study, the previous absence of significant duplication or overlap in authority and capabilities of systems of governance that exist and function across multiple levels has been a significant challenge in the context of adaptive management. Structures and processes aiding in the development of polycentric institutional arrangements are required to provide balance across different levels and scales to promote the transition to more adaptive and flexible livelihood strategies and institutions.

6.4 Implementation

Development and understanding of the principles of the Ecosystem Approach to Aquaculture are necessary for its implementation. Harwood (2007) asserts that there is widespread *"confusion and uncertainty about terms and concerns about promoted concepts*". Kautsky (2007-08-20) and Hambrey (2007-08-15) suggest that the Ecosystem Approach is good for understanding the system, but going down to management is a process that requires a narrowing down of questions to solve problems step by step. The results from this case suggest that the often referred-to concept (Nissapa et al., 2002) of full or complete implementation of an inclusive participatory approach (whether labelled EA or ICZM) is a limited and misguided notion. Consistently apparent in my findings are the conclusions that implementation, along with the approach itself, must also be a multi-level process employing top-down government control measures and local bottom-up approaches.

Aquaculture poses inherent challenges to the implementation of the ecosystem approach as much of its focus and activity revolves around the optimization and efficiency for

maximum production yields by control of specified variables. The crucial importance is to maintain understanding that these man-made non-natural systems are inherently dependent on natural, social, and economic systems, with processes on multiple scales. Effective management for responsible and sustainable resource use needs this orientation in its development and implementation to be successful.

The results from my case also suggest that social-ecological systems are fully integrated and interdependent systems of (humans and nature), and not simply connected by linkages. I found no discernable temporal or spatial scales, or institutional or organizational levels, that support the theoretical assertion that these are merely linked systems, and although the term of social-ecological systems was first applied by Berkes and Folke (1998), what should be highlighted is their original emphasis that "*the delineation between the social and the ecological is artificial and arbitrary.*"

7. CONCLUSIONS

Social-ecological systems are complex adaptive systems that require flexible governance with the adaptive capacity to react to environmental and social feedback.
The analysis of this case study demonstrates how lack of effective governance institutions at the appropriate scale creates problems of fit between principles and policy, with disadvantageous effects on the management of the underlying natural resources.
The problem of fit between the overarching framework of the Ecosystem Approach to Aquaculture (EAA) and the action policies of local and technical Codes of Conduct (COC) and Better Management Practices (BMP) highlights the limited scope and therefore limited value of these potentially adaptive management instruments.
This research also helps to elucidate the global problem of linear and reductionist management that constrain the social-ecological resilience of complex adaptive systems. This is supported by Miller (2004) who emphasizes that while conventional management can improve social wellbeing and economic development, the focus is often on controlling key aspects of the environment for the purpose of improved productivity for narrow sectoral interests at the cost of more adaptive and flexible approaches.

This is an important case study area to illustrate how resource crises such as the massive outbreaks of disease that affected Thailand coastal shrimp farming growth and development have the potential to result in important contributions to institutional social learning and renewal of management institutions. In addition to increasing progressive local level ecosystem management and governance through networks and organizations, international organisation such as The Consortium can operate at higher scales and assist to develop adaptive capacity of institutions that exert pressure to try to bend the current governance system, and develop flexibility to this system in this way. Perhaps this is an adaptive approach in itself that we can draw from this case that will result in transformative and adaptive capacity leading to effective change to a more resilient and less vulnerable state for the ecosystem and the human systems that are supported by it and have governance over it.

The implementation of the EAA must be executed in a transdisciplinary manner by varied actors comprised of relevant local and external stakeholders. This importance needs to be stressed for the utilization of both science and local knowledge to reach consensus on barriers and opportunities for collaboration and adaptive management strategies promoting responsible and sustainable development.
Important are the development and implementation of multi-level adaptive management strategies with collaborative and adaptive cross-level governance approaches to be able to address important issues of temporal and spatial scales. The analysis of this case study supports the broader assertion for the need to reconcile temporal scales, as governance capabilities are seen to be evolving more slowly than the growth and development of the aquaculture industry.

Scale is an important theme proposed by Cumming et al. (2006) for the unification of different disciplinary perspectives, which is paramount for increasing transdisciplinary development of research and collaboration. The aim here is not just to have different disciplines working together (multi-disciplinary), but the true dissolution of boundaries, which like those across social-ecological systems, are indeed artificial and arbitrary.

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GLOSSARY

Adaptability
Adaptability is the capacity of actors in a system to influence resilience. In a social-ecological system, this amounts to the capacity of humans to manage resilience.

Adaptive capacity
The capacity to adapt to and shape change.

Bridging Organization
An integral part of adaptive ecosystem governance, a bridging organization provides an arena for trust-building, sense-making, identification of common interests, learning, vertical and/or horizontal collaboration, and conflict resolution.

Ecosystem
A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Humans, and their ability have governance are considered an integral part of the ecosystem.

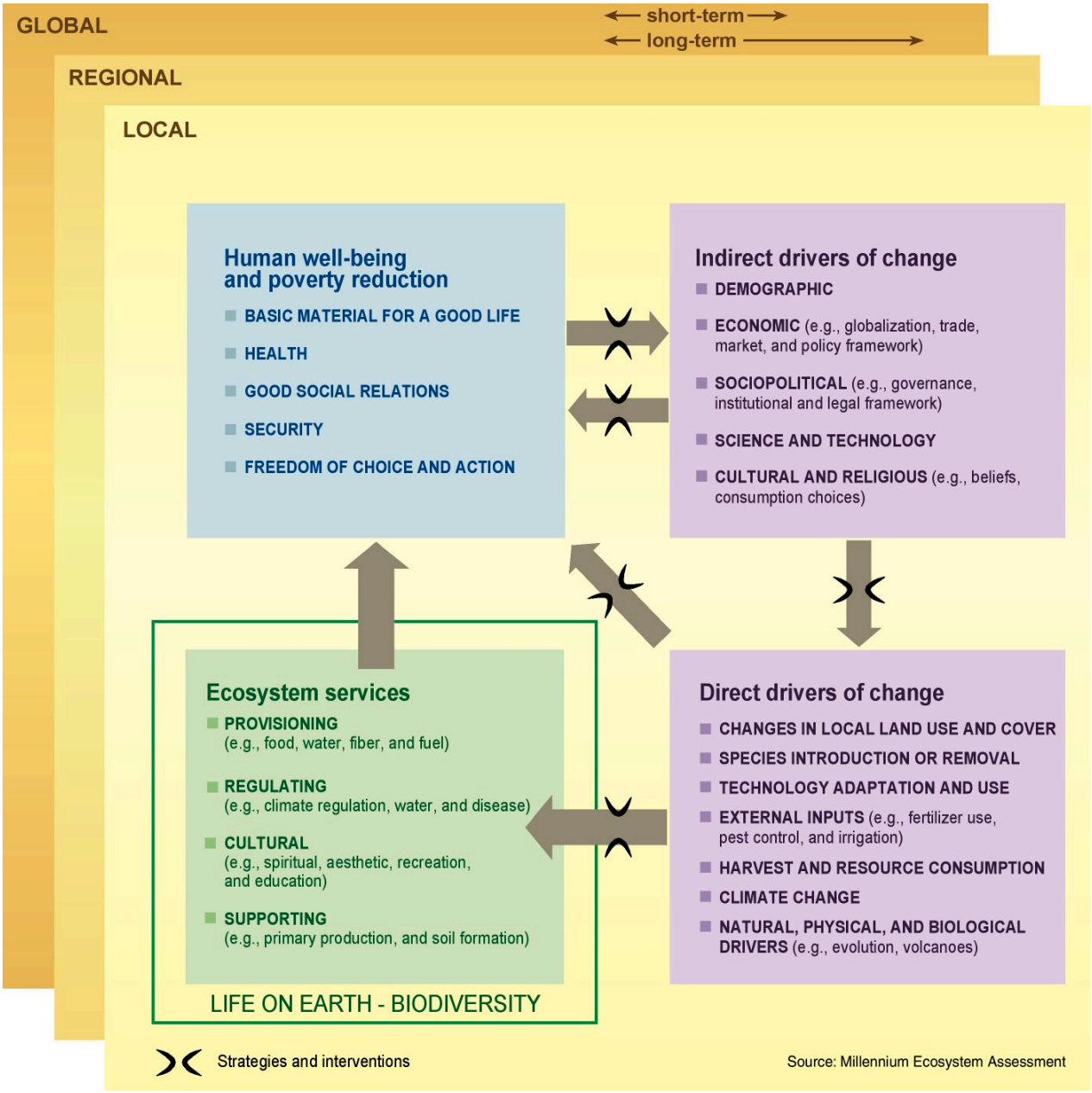
Governance
The structures and processes by which people in societies make decisions and share power.

Polycentric Institutions
Institutions that are self-organizing (without central authority or top-down organizational structure) and operate at multiple organization levels without formal regulation.

Scale
Scale is the spatial and temporal frequency of a process or structure, and therefore a dynamic entity. For the purposes of resilience assessment, a focal scale of the social-ecological system of interest is usually determined from among: landscape/local scale, sub-continental/sub-regional, continental/regional, and global scale, over a specified period of time.

Social Capital
Social capital refers to the aggregate of actual or potential resources that can be mobilized through social relationships and membership in social networks.

APPENDIX 1: Conceptual Framework of Complex Interactions



Conceptual Framework of Complex Interactions among Biodiversity, Ecosystem Services, Human Well-Being, and Drivers of Change (Source: *Millennium Ecosystem Assessment*, 2005).

APPENDIX 2: QUESTIONNAIRE/ INTERVIEW GUIDE

QUESTIONNAIRE ON MANAGEMENT OF THAILAND COASTAL SHRIMP AQUACULTURE

Thank you for your interest and contribution to this important area of research.
Your responses to any or all of the ten questions on this questionnaire may be used in a Masters thesis as valuable input into creating further understanding towards the development and implementation of responsible and sustainable management and governance strategies for this industry.
Your confidentiality can be assured if you would like to remain anonymous with your input. Please just check the box at the end of the questionnaire if you would like your name and personal details to remain confidential.

Please contact the author to arrange an interview time to discuss, with any questions or comments, or to return your answers by email as soon as possible to:
Rob Johnson
Email: rob222johnson@yahoo.ca
Phone: +46 73 7889408 (mobile)

Please respond to any or all questions as per your knowledge and availability:

1. What are the most significant management challenges/ negative aspects of tropical coastal shrimp aquaculture in Thailand today? What are the most promising aspects?

2. Mangroves – Is mangrove loss/ degradation continuing?
To what extent?
What factors are involved?

3. What are special difficulties/ challenges/ opportunities for low-income countries such as Thailand?
- In capacity building?
- In institutional development and strengthening?
- In implementation of the FAO Code of Conduct?

4. How do cultural aspects of individualism and hierarchy affect the long-term sustainability of farmer cooperatives and inclusive participatory approaches to decision-making and self-management?

5. What is the relationship between shrimp aquaculture and export to developed countries, and food security and nutrition for Thailand?

6. What relationship is there between increased demand and production of high-value seafood like shrimp and production of low-priced fish for local consumption?

7. Is the Ecosystem Approach to Aquaculture (EAA) a known and understood concept in Thailand? At what levels? How does this relate to the Codes of Conduct (COC) and Better Management Practices (BMP)?

8. What are the most useful indicators to measure the feedbacks of specific areas of the COC's and BMP's?

9. What are your views on the partnership of The Consortium on Shrimp Farming and the Environment?
- It's objectives, development, stakeholder involvement and interactions, and its successes and challenges?

10. What in your opinion are the most important areas of need for developing effective management and governance strategies for responsible and sustainable coastal shrimp farming in Thailand?

☐ Please treat my responses with confidentiality.

Thank you very much for your help!

Sincerely yours,
Rob Johnson, Master's student, Stockholm University
CTM – Centre for Transdisciplinary Environmental Research
Stockholm Resilience Centre, Stockholm, Sweden