Conservation of the Dugong (*Dugong dugon*) along the Andaman Coast of Thailand: An Example of the Integration of Conservation and Biology in Endangered Species Research

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ABSTRACT

This project investigates the integration of scientific methodology with community and other locally relevant management issues using dugong research on the Andaman coast of Thailand. I examine the role of science, the scientist, government, and the community in wildlife conservation issues. I then make recommendations for an integrated conservation management process for marine mammals and their habitats that are directly endangered by human activities.

The dugong (*Dugong dugon)* is classified as vulnerable by the World Conservation Union (IUCN) based on declines in occurrence and quality of habitat, as well as human exploitation. The dugong was once common along tropical coasts from East Africa to Australia, but is currently considered rare over most of this range. In Thailand, dugongs are now largely confined to seagrass areas off the Andaman coast. The dugong is close to extinction in Thailand, and has been declared a reserved and protected aquatic species under the Thai Fisheries Act since 1947. Although the overall population consists of small groups scattered along the coast, I observed up to 89 animals in aerial surveys at Muk and Libong Islands in Trang province. In 2000 and 2001, I carried out aerial surveys using strip transects in areas with known dugong presence based on interviews, as well as previous aerial and seagrass surveys. The estimated minimum abundance in Trang is 123 animals, with a maximum of 13 calves. The largest group seen is 53 dugongs in the seagrass beds southeast of Libong Island. I also completed seagrass surveys at 10 sites along the Andaman coast.

Interviews were conducted with 146 villagers along the coast to determine the

modern and historical role of the dugong in the areas that border populations. While interviews showed an awareness of conservation issues in the various communities, the dugong is caught in the middle of a conflict between small-scale coastal fishers and commercial trawlers that deplete local fishing resources and destroy seagrass beds. These commercial trawlers are also responsible for a high rate of incidental catch of dugongs. It is estimated that at least 10 dugongs are killed each year by being trapped in various types of fishing gear. Only a small percentage of these incidents are reported. While sample size and frequency is not sufficient for statistical population trend analysis, it is reasonable to assume that this level of mortality is unsustainable to a population this small. Australian researchers have estimated that dugongs can only afford to lose 1% of adult females per year if they are to survive.

If problems of incidental catch, habitat destruction, and the use of dugong body parts as medicine and amulets are not resolved, the extinction of dugongs along the Andaman coast is a strong possibility. This is an example of the imminent need for integrated conservation planning that includes communication and collaboration among scientists, government, management, educators, and the community.

In any conservation process, it is necessary to understand the historical and socioeconomic perspective interactions between people and nature. For example, in Thailand, historical conflicts between small-scale and commercial fishers have created a level of desperation and environmental degradation that places the dugong at risk. Local non-governmental organizations (NGO's) have played an important role in educating communities about the near-shore environment. Focal species concepts and the designation of marine protected areas can be used as tools in a conservation process.

Effective use of focal species such as indicator and flagship species can create a structure to combine biological assessment with an awareness of socio-economic context. The use of marine protected areas has been shown to be most effective when based on a foundation of ecological knowledge as well as the support of the surrounding community. Communication between scientists, government, and the community is crucial for effective conservation planning. Scientists can be a catalyst for social change by communicating the importance of the implications of their research, and collaborating with agencies, users, educators, local scientists, and NGO's.

Examiners:

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I had just started my Masters courses in San Diego, when I attended a workshop on conservation biology with my advisor. I heard presentation after presentation from scientists who were working on complicated issues of wildlife conservation. Paul Beier talked about freeways and cougars, and then Michael Soulé got up to speak about the vanishing canyons in his native San Diego County, and the wildlife disappearing as a result. Their passion and knowledge infected me that day, and I pray it never leaves. Since then, I have been fortunate enough to have met few others who care that much. Dave Duffus is one of them. I am grateful for his guidance.

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Research is easy; conservation most decidedly is not." (George B. Schaller 1992, p. 47)

1.0 INTRODUCTION

1.1. General Background

In *The Last Panda*, Schaller (1993, p. 191) writes that at a certain point in his research, due to the increasing impact of humans on the panda's habitat, he decided to shift the emphasis of the project from biological assessment to conservation. While research to establish baseline information about the species was not complete, Schaller judged that "...a master plan for the conservation and management of the panda and its habitat..." was crucial at this time. It was also considered important that this plan consider the "...ecological, social, and economic influences on the panda both inside and outside of reserves."

While these concerns are universal for endangered species in both terrestrial and marine systems, the focus of this dissertation is on marine mammals that are endangered by the proximity of their distribution and habitats to human coastal populations. Pressures on coastal and marine regions in developing countries, due to a rapidly rising human population, have had a significant impact on marine resources (Hinrichsen 1998, Aragones *et al.* 1997). Marine mammals are threatened in these areas by incidental takes in fishing operations, habitat loss, pollution, direct take, dams, and coastal development (Perrin & Brownell 1994, Reeves & Leatherwood 1994, Perrin & Brownell 1989). As in Schaller's case of the panda, the often cumulative impact of anthropogenic activities on marine mammals is largely unknown (Aragones *et al.* 1997).

To assess these impacts accurately, the complicated and intertwined events, both modern and historic, that cause wildlife extinctions should not be ignored. The global loss of species is no more local than it is recent (Domning 1999). Fossil records show extinctions since animals have existed. At present unprecedented rates of extinction are believed to be occurring, and it is projected that they will accelerate over the next 25-30 years (IUCN 2000, Domning 1999, Holdgate 1994, Meffe & Carroll 1994, Lovejoy 1986, Norton 1986). The growth of an environmental conscience about species extinctions has happened primarily within the last century (Domning 1999). The demise of Atlantic gray whales in the seventeenth and eighteenth centuries was only noted historically (Mead & Mitchell 1994). Domning (1999, 1982) found warnings of species depletion in government reports on Steller's sea cows and Amazonian manatees in the late 1700's, though these kinds of admonitions were not considered important enough to change policies or activities until much later.

Though endangered species legislation and policy exists today in some jurisdictions, they alone will not prevent extinctions. To mitigate current threats of extinction, many researchers maintain that awareness of the social and political reasons for these events, as well as knowledge of the natural and life history of these animals, needs to become integrated into conservation-oriented strategies (Orr 2001, Cork *et al.* 2000, Ehrenfeld 2000, Richter & Redford 1999, Roebuck & Phifer 1999, Clark & Wallace 1998, Maguire 1996, Mangel *et al.* 1996, Meffe & Viederman 1995, Schrader-Frechette & McCoy 1994). These strategies, or programs for the recovery of endangered or threatened marine mammals, need to address not only traditional biological and ethological research, but also to consider the ambiguities of communication, the realities of economic and cultural limitations, inadequate resources, the frustrations and insecurity of politics, departmental complexities and conflicts, and the sluggishness of social change

(Ralls 1997, Wallace 1994).

Accounts of scientists who have become involved with conservation efforts due to the threats to, and endangerment of, the animals they work with show how they have been thrust into a realization of these issues (Katona & Kraus 1999, Oates 1999, Perrin 1999, Reynolds 1999, Reeves & Leatherwood 1994, Schaller 1993, Rabinowitz 1991, Marsh 1980-81). The number of incidents where wildlife populations and habitat are threatened by direct conflict with human needs can only increase (Holdgate 1994). What then is the role of the conservation-oriented scientist? When the science of conservation biology was first conceived, there was much discussion of the need to work with other disciplines, to expand both those with whom one worked, and one's own knowledge as well (Moffatt 1994, Gibbons 1992, Soulé 1985, Soulé & Wilcox 1980).

There is a need for biologists, ecologists, geneticists, geographers, and social scientists to reshape their disciplines for the sake of a conservation-oriented and applied field. This realization is growing amongst conservation scientists who realize that the problems faced by endangered wildlife cannot be solved with biology alone (Domning 1999, Meffe *et al.* 1999, Mangel *et al.* 1996, Holt & Talbot 1978). Especially in marine mammology, a science concerned with many of the most globally impacted species, there is an urgent need for the inclusion of conservation into traditional science. An expansion of training, theory, and technique is required in order to develop conservation strategies that include consideration of whatever factors are influencing the species of concern.

The dugong (*Dugong dugon*) is an example of a marine mammal whose survival is critically endangered by the proximity of its habitat to nearshore human settlements. Outside of Australia, the country with the largest estimated dugong population, dugongs only survive in fragmented population groups in the Eastern hemisphere. Neither the number of dugongs remaining in these groups nor the range of its habitat is known outside of incidental sightings and the reports of fishers (Marsh *et al.* 1999). In Thailand, the endangerment of the dugong is a matter of concern to scientists and the government; the dugong has been under Federal protection since 1947 (Humphrey and Bain 1990). This research on dugongs along the Andaman coast represents the first effort to perform systematic population surveys in Thailand.

In the context of my research on dugongs in southern Thailand, I develop a framework for an integrated conservation strategy for an endangered marine mammal. Scientific knowledge of the behavior and ecology of the dugong along the Andaman coast will play a crucial role in any conservation and management plan. However, the survival of the species here will depend on the consequences of the depletion and degradation of marine resources, economic insecurity, complicated government jurisdictions, uncertain funding for research, a rapidly increasing human population, and changing social roles within human communities.

How does this research fit into the field of geography? The science of geography is traditionally that of an "...integrating discipline..." (Stoddart 1965, p. 242), one that "...bridges the gap between the physical and social sciences" (Veblen 1989, Watts 1978, Fosberg 1976, Morgan & Moss 1965, p. 339). Geographers have called their field a science of life, containing the "domain of systematic botany, zoology, and anthropology" (Morgan & Moss 1965, Edwards 1964, Merriam 1889, p. 160). Watts, in his 1978 review of definitions of biogeography (p. 327) concluded, "All consider that biogeography should deal with the changing distributions of organic life within space and time, and as they relate to the environment." The study of human impacts on wildlife and other natural resources is an integral component and concern of biogeography (Sauer 1981, Vale & Parker 1980, Langdon 1979, Fosberg 1976, Bennett 1960, Anderson 1951, Hesse 1937). Recent biogeographical research includes studies concerning:

- how recreational use of wildlife has created a need to formulate management planning incorporating both social and biological concerns (Duffus & Dearden 1990),
- public attitudes towards the reintroduction of wolves in Yellowstone National Park, US, and New Brunswick, Canada (Bath 1989, Lohr *et al.* 1996).
- using geomatic technologies to map habitat and potential translocation procedures for endangered birds in Polynesia (Franklin & Steadman 1991),
- examining the role of science and protected areas in the protection of cetaceans (Duffus & Dearden 1992),
- the integration of scientific information in developmental planning (Dearden 1995),
- the biology and conservation of Irrawaddy dolphins in Lao, PDR (Stacey 1996),
- using a sensitivity analysis to ascertain how possible map errors from geographic information system and remote sensing image processing could affect the accuracy of habitat mapping for endangered California spotted owls (Hines 1997),
- possible effects of whale-watching on whales (Duffus 1996, Bass 2000, Hines *et al.* in progress), and
- the role and influence of wildlife scientists in conservation planning (Campbell 2000).

Morgan & Moss (1965, p. 340) define the role of geography in the context of a science linking biotic communities to the environment as follows:

> "It is the authors' view that there is a geography of living things which…is directly concerned with problems of relationship such as those between man and environment…concerned…with all forms of relationship affecting the distribution, location, and space organization of living things as they appear on the surface of the earth. The study is concerned with reality and not with phenomena in isolation or even in part isolation."

In consideration of the above definition and examples, this research is firmly within the traditional realm of a geography concerned with the myriad forms of relationships between living beings and their environment.

The goal of this dissertation is to contribute towards environmental science through development of a framework to guide the interactions necessary for an integrated system of conservation-oriented scientific planning for endangered marine mammals. I propose this framework by first examining, in chapter 2, examples of research on endangered species where conservation processes essential to the survival of the species have involved scientists in social issues beyond their usual roles and concerns. Then I use the case study to refine the theoretical framework proposed at the end of chapter 2. In chapter 3, I give specific objectives for the field study, as well as detailed descriptions of the background, the study area, dugong population surveys, seagrass surveys, and interview methodology. Chapter 4 presents the results and a discussion of the case study.

Chapter 5 re-examines the issues identified by the dugong research project and discusses them within the larger context of the proposed framework, processes, and issues common to the conservation and management of marine mammals and their habitat directly threatened by human activities. The framework addresses several issues, such as the social and temporal context surrounding an endangered species, the position of the scientist in collaborations and negotiations with government agencies, non-government organizations, other scientists and academics, educators, and local communities, and the use and effectiveness of designated protected areas for marine mammals.

Another consideration in endangered marine mammal conservation planning is the function of marine mammals within the larger marine environment. In the context of conservation planning, the relationship of the animal to other local ecosystem components (e.g. fish, seagrass) can have direct or representative effects on the health and biodiversity of a coastal or marine system. These species are defined as focal species, and they can have various roles within a biological community (Zacharias & Roff 2001). Even though determination of these roles is uncertain, realization of these possible roles can be a significant tool for management. In chapter 5, from the example of the dugong in Thailand, I examine the utility of focal species designations in this framework.

In the conclusion of chapter 5, I present a refined framework as a template for integrated natural and social conservation strategies. This template is especially applicable to those who study marine mammals in developing countries or subsistence dominated settings, whose research by necessity crosses those fine lines between biophysical and social sciences. Chapter 6 is a summary of this document.

2.0 THE INTEGRATION OF CONSERVATION AND BIOLOGY IN ENDANGERED SPECIES RESEARCH: A LITERATURE REVIEW

2.1 Nature of the Problem

Problems pertaining to the conservation of endangered animals are not going to be effectively resolved by traditional measurable, technical methods alone (Lélé & Norgaard 1996). As fundamental natural laws themselves are imprecise, how precise can measurement in natural science be? Biologists have not even agreed on definitions of such commonly used terms as "species" and "community" (Shrader-Frechette & McCoy 1994). Especially given the magnitude of the problems in endangered species conservation, biological knowledge by itself will never be complete (Meffe & Viederman 1995). The practice of conservation-oriented biology is weakened without consideration of an underlying wildlife ethic by both scientists, and the surrounding social community (Roebuck & Phifer 1999, Barry & Oelschlaeger 1996, Kellert 1996, Meffe & Viederman 1995). Leopold, in 1936, first described a wildlife ethic in scientific wildlife management as the interrelationship of science and aesthetics. He contended that plant and animal communities had ethical and intrinsic rights to their continued existence in a natural state (Hargrove & Callicott 1990, Leopold 1990). To scientists, as well as to the general public, a successful realization of these ethical and intrinsic rights demands a mix of biological science and ethics that transcends the largely utilitarian and economic values previously placed on wildlife (Sagoff 1996, Kellert 1985, Rolston 1985).

The goal of conservation-oriented biology is "...to provide principles and tools for preserving biological diversity" (Soulé 1985, p. 727). Here both a biological and social focus is demanded; any relevant information should be integrated and used (Meffe & Viederman 1995, Soulé 1985). As Meffe & Viederman (1995, p. 328) state:

> "It is quite acceptable (in fact unavoidable), in our opinion, to hold values as a scientist and try to influence the policy process, as long as the scientific process of objective hypothesis testing is not compromised. Thus, the first answer to how scientists can affect the policy process is to agree that they should, and must...recognizing that they are both scientists and citizens."

The goal of conservation science is not value-neutrality, however; all value judgments are not good ones (Shrader-Frechette 1996, Brussard *et al.* 1994). Shrader-Frechette (1996, p. 912) asserts:

> "Without methods for assessing alternative value judgments, science runs the risk of throwing out the baby of objectivity with the bathwater of positivism."

What value judgments are justifiable for scientists, and when are they relevant? Brussard *et al.* (1994) draw their line at political advocacy that could possibly undermine the working relationships between scientists and all stakeholders in a specific situation. Their example is a scientist who sides with an activist group against ranchers and policy-makers over grazing rights. In Brussard *et al.*'s opinion, scientists should stop at informing decision-makers about technical issues, and vote for appropriate government representatives, saving advocacy as an activity outside professional life. There is a fine line here. Advocacy can be defined as the use of knowledge to promote action on environmental issues (Tracy & Brussard 1996). Advocacy can be seen as zealotry at one extreme, and apathy at another. Between these two extremes there is advocacy supported by objective science (Tracy & Brussard 1996).

While discretion has to be used not to damage working relationships, there are times when scientists can be effective advocates for specific values and positions. The first possible role of scientists as advocates is that of serving the search for scientific truth by debating between alternating opinions. In such a situation, scientific debate based on values can be seen as a checkpoint for objectivity. Second, by advocating change, scientists can serve the common good by declaring themselves against economic and political interests that are harmful to the environment, rather than serving the most powerful player. Third, scientists have special knowledge that can considered to be crucial information in an environmental decision-making process. Scientists who believe that participation in such a process is outside of their professional venue could be considered to be complicit in decisions causing environmental damage (Shrader-Frechette 1994, 1996, Maguire 1996, McCoy 1996).

In this chapter, I review examples of projects in which researchers have been confronted with situations where the conservation of the animal in question demands that their usual practice of science be expanded. Relevant factors and concerns that are brought forth in these examples are reviewed at the end of the chapter, and summarized into a preliminary framework for an endangered species conservation and management process integrating biological and social issues.

In this next section, I describe research on endangered terrestrial mammals. After that, I write about projects on threatened cetaceans. Following is a discussion of conservation strategies for the extant Sirenia. I first write about research on manatees, and then more specifically on dugongs as a preface to the case study.

2.2 Conservation Research for Terrestrial Mammals

Conservation of the tiger (*Panthera tigris*) is one of the most complicated examples of the need for integration between researchers and local communities. Tigers and humans have interacted closely since before recorded history. In the consciousness of people throughout its range, the tiger has been a spiritual and cultural image (Jackson 1999). Tigers have killed people throughout history, as well as currently, and people hunt tigers for meat, skin, and the medicinal benefits of their bones and other body parts (Seidensticker *et al.* 1999). The tiger is the largest terrestrial carnivore in Asia, able to adapt to various climatic regimes from tropical rain forests to steppe, surviving wherever there is large prey (Seidensticker *et al.* 1999).

In the late 1960's, researchers estimated that a maximum of 600 tigers remained in all Asia, and a conference to address this near-extinction was sponsored by the IUCN in 1969. Operation Tiger was begun by the International Union for the Conservation of Nature (IUCN) with the World Wildlife Fund for Nature (WWF) to raise money for tiger conservation in India and Southeast Asia in 1972 (Matthiessen 2000, Thapar 1999).

In the next year, Indian Prime Minister Indira Gandhi sponsored the inception of Project Tiger, establishing tiger reserves, sponsoring research, mapping of habitat, and monitoring of tigers in India (Matthiessen 2000, Thapar 1999, Kenney *et al.* 1995). Fifty percent of all wild tigers live in India (Thapar 1999), with a population of between 2500 and 4750 animals (Seidensticker *et al.* 1999). At first, Project Tiger was considered successful. However, that optimism has been tempered by realistic assessments of declining habitat and increased poaching since the 1990's (Karanth & Stith 1999, Kenney *et al.* 1995). Currently there are 23 Project Tiger reserves, with an area of 30,000 square kilometers, only a handful of which are equipped with forest rangers that actively patrol against poaching. Half of these reserves are within areas with internal insurrection or where the government is too weak or poor to assure adequate protection. Other parks are less effective, as recent freezes on funding have left 40% of all forest ranger positions unfilled (5 Tigers News 2000).

One of the major strategies of Project Tiger is the relocation of villages from the reserves. This has created numerous hardships for local people and generated resentment and rebellion. Local animosity has led from poaching to tiger poisoning from villagers who were inadequately compensated for their relocation, and have had both livestock and community members killed by tigers (Saberwal 1997). Tiger researchers and conservationists in India confront an immense challenge in dealing with such complex and opposing interests. However, not to consider the issues of the local communities living in and around the reserve would render any management solutions useless.

Throughout the rest of Asia, tiger conservation is plagued by war, poverty, mining, logging, corruption, increasing population pressures, loss of habitat, and the most insidious threat, poaching for the use of body parts in Chinese medicine (Dinerstein *et al.* 1999, Galster & Eliot 1999, Rabinowitz 1999). Miquelle & Smirnov (1999) identify the need for "co-existence recipes" in the Russian Far East. Only 7% of tiger habitat in this area is included in protected areas as unprotected tiger habitat areas are exploited by villagers for timber, hunting, and non-timber forest products (Miquelle & Smirnov 1999). Any conservation scheme here has to include management systems in unprotected lands. Potential issues that need to be addressed include the impacts of humans on tigers, such as poaching, logging, and habitat destruction, and the adverse effects of tigers on humans, for instance, attacks on humans by tigers, tiger depredation on livestock, and competition with humans for ungulates.

Tiger researchers in Nepal's Royal Chitwan National Park found that ecodevelopment schemes were not effectively involving or employing local villagers. Consequently, areas adjoining the park were being degraded as people gathered thatch and cut down wood for firewood. Poaching was only being controlled by strict enforcement (Dinerstein *et al.* 1999). More community-based ecotourism was initiated and local guards were hired, and nature trails and a wildlife-viewing tower were constructed. Thatch and firewood regeneration areas were designated, and guarded by village watchmen. No poaching has been reported in regeneration areas since the project began, and habitat is currently regenerating. As these areas regenerate, tiger attacks on local livestock are also reduced. The authors conclude that as quality of life improves for the villagers, the chances of a successful management scheme increase. They caution that planning should not be based solely on increasing economic incentives, but primarily on raising public concern for an area (Dinerstein *et al.* 1999).

The example of the tiger illustrates the problems that epitomize most cases of species endangerment. In this case, the relationship between local people and tigers is life-threatening to both. In India, the forced relocation of villagers without consideration of their social and economic well-being does not address the major issues of declining habitat for the tiger, or the importance of co-existence between the tiger and villagers. As is seen by the examples in Nepal and Russia, management strategies there include increasing habitat quality for the tiger as well as the quality of life for the public so that direct hunting is less of an option for either.

For the African elephant (*Loxodonta africana*), Armbruster & Lande (1993) write about demographic analysis as only one of the components necessary for successful conservation. They cite a further need for management approaches to be established that are sensitive to local ecological, social and economic conditions. More specific suggestions include communal game management adjacent to parks, including locally run safari hunts and other tourism, to create a financial advantage for villagers to preserve elephants. They include a caveat for this plan, alluding to the potential danger of relying on exploitation of wildlife to support a human population that is increasing so rapidly. Ambruster & Lande (1993, p. 609) believe:

> "...that such management schemes would facilitate the integration of a sustainable wildlife management ethic into African society, which is ultimately the only real hope for effective species conservation in Africa."

Oates (2000) discusses his experiences researching wildlife in Africa with much the same conclusion about the necessity for a wildlife ethic here to be based on more of an intrinsic value for wildlife than economic worth.

Numbers of giant pandas (*Ailuropoda melanoleuca*) in China have decreased rapidly in recent decades. There are two major reasons, habitat destruction and fragmentation from logging, and poaching (Zhou & Pan 1997, Schaller 1993). Past conservation strategies have either ignored sociological aspects that contribute to panda endangerment or simply suggested that people emigrate from panda habitat (Schaller 1993). Schaller (1993) suggests that local people should be involved in conservation efforts that are based on their interests, skills, self-reliance, and traditions. In order for management planning to be successful, programs need to offer spiritual and economic benefits to villagers. As in the cases of the of the tiger and elephant, pressures of a growing human population will only increase the endangerment of the panda unless the needs of local people are somehow addressed.

In Langtang National Park in Nepal, research on the ecology and conservation of the red panda (*Ailurus fulgens*) includes not only biological studies, but also ancillary studies of village economics as they affect red panda habitat (Yonzon & Hunter 1991). Approximately 30,000 villagers in nearby rural communities use the park for livestock grazing and fuelwood collection (Fox *et al.* 1996). Grazing is the most damaging activity to the red pandas, and the local cheese industry from the grazing livestock supports a majority of the villagers. Intensive grazing has disturbed 62% of local panda habitat (Fox *et al.* 1996). Conservation of the panda in this area depends on the ability of residents and park managers to find a balance between natural resource use and habitat preservation (Fox *et al.* 1996, Yonzon & Hunter 1991). The local cheese industry was increasing the level of economic sustainability for the village. However, in this example, research has shown that grazing to support the cheese industry was responsible for the habitat decline endangering red pandas. Therefore, any successful resolution will depend on the cooperation and concern of villagers.

The lion tamarin (*Leontopithecus sp.*) in Brazil has been the focus of an integrated ecological research and social conservation program both in the wild and in zoos since 1969. Conservation efforts included long-term field studies, artificial breeding in zoos, and a reintroduction program using zoo-bred animals (Kleiman & Mallinson 1998). International recovery and management teams work with the Brazilian government and non-governmental organizations (NGOs) to coordinate research and conservation efforts (Kleiman & Mallinson 1998, Dietz *et al.*1994). The tamarin has been declared a flagship species, or a species that can serve as the representative of environmental conservation in educational processes (Simberloff 1998, Dietz *et al.* 1994). Kleiman & Mallinson (1998) consider this long-term collaborative approach successful in increased habitat protection, growth of educational programs, and scientific achievements.

Koala (*Phascolarctos cinereus*) conservation in Australia is an example of the complications confronting researchers in more developed countries. While research has generated a substantial amount of valuable information on koala biology and ecology, knowledge of the cultural and organization processes necessary to implement conservation management is lacking (Stratford *et al.* 2000). While habitat and population models have been created, they alone are inadequate to resolve land use disputes and develop policy (Cork *et al.* 2000). Political and cultural influences on decision making need to be (Stratford *et al.* 2000, p. 610)

> "...more explicit in research, management, and policy-making forums...Ultimately, the koala symbolizes conflicting land-use values and illustrates the need for greater collaboration, cooperation, and trust among social and natural scientists in the conduct of koala conservation research, management, and policy."

One of the larger problems in implementing such an explicit decision-making process for koala conservation is the polarity of views both about scientific issues, such as the regulation of urban development and management of eucalyptus forests, and disagreement and mistrust among interest groups, government, universities, and the public as to one another's credibility and motives (Cork *et al.* 2000)

The researchers in these examples all have the tools of biological and ecological analysis, and the solutions that these approaches subscribe to. What these cases illustrate is that these solutions will not be successful without consideration of the overall economic, political, and cultural factors effecting local villagers or concerned citizens. Suggestions for management schemes include strategies for co-existence, ecotourism, locally run enforcement, local involvement in conservation planning, education and social conservation planning, and collaboration between natural, social scientists, and other stakeholders.

2.3 Conservation Research for Cetaceans

Interactions between humans and marine mammals have been responsible for bringing species to dangerously low levels, and at times, populations to extinction. Even though marine mammal endangerment as a whole is as critical and widespread as any of the terrestrial species in the previous section, generally, marine mammal scientists have not crossed the line of scientific detachment in the service of conservation. While suggestions for education and enforcement are often seen in both scientific journals and popular literature,

> "Surprisingly few titles are available...that focus on conservation issues and the interplay of science and management that leads to formulation and achievement of conservation goals." (Twiss and Reeves 1999, p. 1)

In this section, I review examples of cetacean literature where the researchers go beyond suggesting solutions to working towards them, and focusing on methods to integrate social concerns for successful conservation.

The vaquita (*Phocoena sinus*), a small porpoise in the northern Gulf of California, has been called the most endangered cetacean in the world (D'Agrosa *et al.* 2000, Perrin 1999). Vaquitas have the most limited spatial distribution of any marine cetacean, and approximately 39 animals per year are caught and killed in local gillnet fisheries (D'Agrosa *et al.* 2000, Vidal 1993). D'Agrosa *et al.* (2000) and Vidal (1993) write about current plans for a protected zone in which gillnetting would be prohibited. Both he and D'Agrosa *et al.* (2000) call for enforcement of these areas to be reinforced by an integrated program with public participation programs, and the development of alternative sources of income for local fishers.

D'Agrosa *et al.* (2000) cite research on the Hector's dolphin (*Cephalorhynchus hectorii*) by Dawson & Slooten (1993) as an example of a successful integrated conservation management plan. The Hector's dolphin is another endangered small cetacean with a limited distribution, found only in New Zealand. This animal is also vulnerable to entanglement in gillnets, which are used both commercially and recreationally (Dawson & Slooten (1993). A process to create sanctuary areas for the dolphin was begun in 1988, with public meetings and documents explaining both dolphin biology and the magnitude of the entanglement problem. Five options were suggested, including alternatives to do nothing, to put acoustic sound emitters on nets, to establish seasonal closures, and to exclude gillnetting year-round. The public, on the basis of information from scientists and managers, voted unanimously in favor of establishing the sanctuary, and 61% voted for year-round exclusion of commercial fishing and limited recreational gillnetting. A review process was then created, involving researchers, government agency representatives, fishers, conservationists, and Maori. Documents from the reviewers were submitted at meetings for public discussion (Dawson & Slooten 1993).

In the Gulf of Maine, incidental catch of harbor porpoises (*Phocoena phocoena*) in fishing weirs and gillnets poses a serious threat to the viability of that population (Read *et al.*1993). Research is conducted both to understand the behavior and spatial patterns of porpoises that cause entanglement, as well as net and fishing practice modifications to reduce incidental catch rates (Dawson *et al.* 1998, Westgate & Read 1998, Kraus *et al.* 1997). Satellite telemetry and time-depth recorder studies are beginning to show temporal and spatial patterns of porpoise migrations that can be incorporated into management planning (Westgate & Read 1998). Acoustic pingers are also being investigated as to their effectiveness in reducing porpoise bycatch (Dawson *et al.* 1998). Researchers have been attending public meetings with local fishers and participating in debates about the use of acoustic deterrent devices and the implementation of various management strategies (Read pers. comm. 1999).

The Indo-Pacific humpbacked dolphin (*Sousa chinensis*) is widely distributed throughout the western Pacific and Indian oceans. One population group is found in the waters around Hong Kong Special Autonomous Region (SAR) (Jefferson 2000, 1998). The economic success and growth-oriented policies of the government have led to a lack of commitment to environmental protection (Liu & Hills 1997). Local environmentalists became aware of the humpbacked dolphins in the late 1980's (Jefferson 2000). A sightings' study was begun in 1989, as part of the 'Dolphin Awareness' campaign of the World Wide Fund for Nature Hong Kong (WWFHK), who also commissioned a study to document possible effects of a sewage outfall (Porter *et al.* 1997). In the early 1990's, a new international airport was planned for the middle of the dolphins' habitat. The Agriculture and Fisheries Department of the Hong Kong SAR government funded projects to study the dolphins and make recommendations for conservation and management (Jefferson 1998, Porter *et al.* 1997). Among the proposed strategies were large-scale public awareness campaigns, creation of a marine reserve, and inclusion of dolphin conservation and management into a multi-disciplinary coastal zone management strategy (Jefferson 1998, Porter *et al.* 1997). Researchers also recommended that educational curricula at primary and secondary school levels be revised to include information on dolphin and marine conservation. A successful 'Adopt-A-Dolphin' scheme was begun in 1994, with participation by researchers (Porter *et al.* 1997). Jefferson (2000, p. 54) calls for the input of "the full range of knowledge from the natural and social sciences" in any decision-making process. In their review of the issues surrounding humpbacked dolphin conservation in Hong Kong SAR, Liu & Hill (1997, p. 366) note:

> "The case of Hong Kong's Chinese white dolphins also demonstrates that environmental policy making cannot operate effectively in isolation from sound scientific knowledge and informed judgments."

Until recently, the number of humpbacked dolphins in the waters surrounding Hong Kong SAR was thought to be less than one hundred, and in imminent danger of extinction (Liu & Hill 1997). However, recent research has shown that there are at least 1000 dolphins. While researchers have shown evidence of some population decline, this trend could possibly be reversed if an integrated economic, political, and social program for humpbacked dolphin conservation is given a high priority (Jefferson 2000).

River dolphins throughout their distribution in Asia and Latin America are endangered as the result of a variety of anthropogenic actions. These include directed and incidental catches, local use of body parts (oil and meat) as products, food and fish bait, pollution, sedimentation, the construction of dams and barrages, and noise (Leatherwood & Reeves 1994, Reeves & Leatherwood 1994, Reeves *et al.* 1993).

The baiji, or Chinese river dolphin (*Lipotes vexillifer*), in the Yangtze River is believed to be approaching extinction (Perrin 1999, Reeves & Leatherwood 1994). 'Rolling hook' fishing gear is the most direct cause of baiji mortality, as well as the use of electricity and explosives for fishing (Perrin 1999, Renjun 1990). Riverbank construction and sewage discharge are also factors, as are noise and collisions as a result of increased commercial boat traffic (Perrin 1999, Renjun 1990). The construction of the Three Gorges Dam, begun in 1994, and scheduled to be finished in 2003, will also affect baiji habitats and may increase incidental deaths due to a redistribution of villagers along the river (Zhou *et al.*1998). Conservation of the baiji has centered on legislation outlawing rolling hook and destructive fishing methods, semi-captive breeding and the establishment of protected areas. Local and international scientists and agencies have contributed to knowledge of the dolphin, and the baiji was declared a heritage species in China (Zhou *et al.* 1998). Scientists are also contributing to public education efforts to raise the level of public awareness about the baiji using posters and brochures, as well as articles in newspapers and a book (Zhou *et al.* 1998).

The range of the Irrawaddy dolphin (*Orcaella brevirostris*) extends through the coastal waters and rivers of all coastal countries between India and Australia, and in rivers in Lao PDR (Stacey & Leatherwood 1997). While information on the biology and behavior of the Irrawaddy dolphin is considered incomplete as compared to other cetaceans, what research has been done has shown that numbers throughout its range are declining (Stacey & Leatherwood 1997, Stacey 1996). In Lao PDR, a Community Fisheries and Dolphin Protection Project was initiated in 1992 as a joint conservation project with the Whale and Dolphin Conservation Society out of Britain (Baird 1994).

The overall directive of the project is the entire range of Irrawaddy dolphins in Lao PDR, but the focus is in two villages in the southern part of the country near the Cambodian border (Stacey 1996). The project advocates education and community involvement, holding community meetings with Project workers and local villagers to exchange knowledge. A goal of the project is to raise the environmental awareness of the villagers about dolphin conservation as it is related to destructive fishing, fish stocks declining, dam projects, and local tourism (Stacey & Leatherwood 1997, Stacey 1993, Baird & Mounsouphom 1993). As a result of this Project, villagers have petitioned the government to formally request that Cambodia enforce laws against the use of explosives for fishing. Each of the villages in the area has also designated a reserve area, based on dolphin habitat needs, as a non-fishing zone (Stacey 1996). Stacey & Leatherwood (1997) and Stacey (1996) recommended that this kind of dedicated program be a prototype for community-based conservation efforts throughout the range of the Irrawaddy dolphin.

For cetaceans, the main causes of species endangerment are bycatch and the destruction of habitat by harmful fishing methods and overfishing. In this section, in addition to the activities mentioned by terrestrial researchers, scientists have participated in public review processes towards developing protected areas and strategies to reduce bycatch, in the development of educational materials, and have begun to utilize technology to show habitat patterns and decrease bycatch. Researchers in this section also reported on a community-instigated conservation project.

2.4 Conservation Research for the Sirenia

The Order Sirenia encompasses 3 living species of manatees, and the dugong. Outside of Florida and Australia, the status of the modern Sirenia is generally poorly known (Marsh & Lefebvre 1994). One of the reasons for this is a history of excessive exploitation that caused the extinction of one genus, the Stellar's seacow, in the late eighteenth century, and greatly decreased the numbers of dugongs and manatees (Bertram & Bertram 1973). Dugongs and manatees are particularly vulnerable to human exploitation and habitat destruction as they are large, relatively slowly moving herbivores that are obligate foragers on nearshore or riverine beds of aquatic vegetation (Bertram & Bertram 1973).

For the Florida manatee (*Trichechus manatus latirostris*), a large and complex governmental and non-government organizational infrastructure has been created to support conservation and management. This effort dwarfs conservation efforts in other countries having manatee populations (Reynolds 1999). In the Caribbean, conservation policy and efforts are building, though economic limitations have hindered enforcement (Reynolds 1999, Marsh & Lefebvre 1994). In South America, Brazil has had a long-term research program, but this program has not been connected to development or human activities. Research on West African manatees has been isolated and uncoordinated, and enforcement of hunting laws minimal (Reynolds 1999).

In Puerto Rico, reports of manatee mortality have increased significantly since 1990, but researchers believe that this might be an artifact of the growing interest and dedication of both the public and government to report strandings (Mignucci-Giannoni *et al.* 2000). Scientists and government agencies have created a proactive education campaign to inform the public about the status of the manatee, as well as current conservation efforts and the need to report sightings and stranding events (Mignucci-Giannoni *et al.* 2000).

In Florida, even with recovery plans, management and conservation plans by agencies at all levels of government, the participation of private business, NGOs, zoos and aquariums, plus the involvement of the public, annual manatee mortality has been constant since 1989 (Reynolds 1999, Wallace 1994). Private organizations, from Florida Power & Light, to Sea World, private colleges, and the Save the Manatee Club, amongst others, have funded and participated in manatee rescue, public education programs, and research activities (Wallace 1994). The manatee has become a popular symbol of endangered species problems and is well known both nationally and internationally. The state of Florida has designated the manatee the official state mammal, and in 1992 alone, sales of manatee license plates added more than $1.2 million dollars to the Save the Manatee Trust Fund (Wallace 1994).

Federal and state agencies work with these private organizations to advance the use of scientific findings as tools for conservation. In a state of more than 13 million people, with a rapidly growing population, one of the biggest challenges is developing and implementing plans to accommodate human population growth congruent with the conservation of manatees and other natural resources (Reynolds 1999). Public education is a major component of this strategy. The Save the Manatee Club has over thirty-five thousand members, supports scientific research, and does a great deal of lobbying of politicians. Other federal agencies have also contributed. Rather than using propellers, the National Aeronautics and Space Administration (NASA) devised waterjet propulsion systems for their ships traveling through manatee habitat zones. The Navy installed propeller shrouds on their ships, started manatee awareness programs at Florida and Georgia bases, and created manatee reserves in two Navy bases (Reynolds 1999).

Wallace (1994) judges the constant mortality rates stable and successful in that the mortality rate has stopped increasing in the midst of the quickly escalating human population. He feels that the various non-governmental and private organizations are communicating well with each other, and that scientists at governmental agencies are open to participating and listening to them. Reynolds (1999, p. 285) feels that the Florida manatee conservation program "falls short". Habitat is still being lost and degraded, powerboat numbers are increasing, and the growth of the human population is not well managed. Wildlife scientists should be more active in shaping policy and communicating the results of their research to managers, legislators, and educators. He also asserts that a value system that places a primarily economic value on wildlife devalues the intrinsic importance of an animal independent of its relationship with humanity. As a result, there is an increasing public and political opposition to the changes in human activities necessary to effectively conserve manatees (Reynolds 1999, Reynolds 1995).

The major sources of human-caused mortality to dugongs (*Dugong dugon*), similar to the manatee, are incidental drowning in fishing nets, hunting, habitat degradation, and boat strikes (Preen 1999). Also like the manatee, the distribution of the dugong is spread over a wide range (between East Africa and Vanuatu) with a large proportion of animals in a relatively wealthy, developed country, in this case Australia. While the different manatee species have more localized distributions, dugongs are found in scattered relict populations (Marsh *et al.* 1999). As in the examples of all the animals in this section, enforcement of regulations that protect dugongs and their habitat is problematic (Marsh & Lefebvre 1994). Research outside of Australia is sporadic, and I found few examples of dugong scientists integrating conservation into their research plans beyond proposing integrated management and more effective enforcement.

In Papua New Guinea, Hudson (1986, 1981) conducted interview surveys in 1977 and 1979 to collect information on the numbers of dugongs in the area, the current level of hunting, and the attitudes of local people towards dugongs. She used the interviews not only to obtain information about dugongs and their relationship with local people, but also to get to know villagers and educate them about conservation and management strategies for the wildlife in their areas. Provincial officers known to the villagers accompanied the interviewers. Talks were given in local schools while badges, posters, and pamphlets were distributed. The interviewers also showed films about wildlife management and local animals in the evenings. As a result, she states (Hudson 1981, p. 671):

> "...it is hoped...that all the people in the area will assist to successfully manage this resource for the good of the people and the dugongs...".

In Australia, there are two major dugong conservation issues that have forced an integrated approach upon researchers concerned about dugong endangerment. The first is the tradition of Aboriginal dugong hunting. Researchers are concerned about the low reproductive rate of dugongs and unsure about the numbers of animals that can be hunted without endangering the sustainability of local groups (Marsh *et al.* 1997*a*, Ponte *et al.* 1994, Smith & Marsh 1990). At the same time, dugong meat and oil are among the most valuable traditional foods for coastal Aboriginal groups, who traditionally hunt the animal, and include the dugong as an integral part of their culture (Marsh 1997, Ponte *et al.* 1994).

Major hunting areas include the international waters in the Torres Strait between Australia and Papua New Guinea as well as within the Great Barrier Reef Marine Park (GBRMP)(Marsh *et al.* 1997*b*, Smith & Marsh 1990). The issue of Aboriginal hunting rights in the GBRMP has been a source of controversy among environmentalists. Sixty-one percent of non-Aboriginal people interviewed feel that traditional hunting in parks discriminates against non-Aboriginals and conflicts with the concept of parks as wildlife sanctuaries (Ponte *et al.* 1994). Dugong researchers in Australia are involved in public educational campaigns about the threat to the survival of dugong populations from traditional dugong hunting. Scientists also work with Aboriginal communities to inform them about dugong conservation needs and to facilitate a co-management process where community Councils of Elders issue hunting permits (Marsh & Lefebvre 1994, Ponte *et al.* 1994).

The other major issue in dugong conservation in Australia centers around the incidental catches of animals in commercial and recreational gill nets within the GBRMP (Marsh 2000, Preen 1999, Marsh *et al.* 1995*a*). Marsh (2000) reports that dugong numbers have declined significantly along areas included in the GBRMP since the mid-1980s. Dugong protection areas were established in 1997, with restrictions on fishing gear, net attendance rules, and local closures (GBRMP Information Services). Researchers are not certain that these regulations or their enforcement are adequate in the long run to protect dugongs from incidental catch or increasing boat traffic (Marsh 2000, Preen 1999). Local scientists are involved with initiatives and negotiations that comprise all issues of dugong conservation. They have been forthcoming with the inclusion and interpretation of scientific information for management and education through formal reports and articles in popular media (Preen 1999, Marsh 1997, Marsh *et al.* 1997*b*, Preen & Morissette 1997, Marsh *et al.* 1995). They have also been participants at meetings like the recent discussion convened by the GBRMP Authority, in May of 2001, to develop a Wildlife Conservation Plan on how best to protect dugongs in the park. Input was from researchers from James Cook University in Townsville, Queensland, park representatives, government agencies, and representatives from Aboriginal bands (GBRMP Information Services).

For Sirenians in developed countries, there are extensive collaborations between scientists, government agencies, and NGOs. In Florida, even with the help of private and public organizations, and technology, the challenge of a rapidly increasing human population has highlighted problematic enforcement of laws and an inability to protect animals from large-scale recreational boating. Dugong scientists in Australia negotiate with fishers to reduce bycatch, and with aboriginals to limit indigenous hunting to a sustainable level.

2.5 Summary

For all these animals, the major threats are similar: declining and or degraded habitat is found in all cases. Hunting is a common threat, as are incidental catch and boat strikes for marine mammals. Researchers in these instances have confronted frustrating situations where wildlife is endangered by the all too common struggle between economics and natural resources. The examples show scientists who have gone beyond acknowledging a need for community education or suggesting enforcement of legislation, to contribute in various ways to the overall recovery process. The contributions seen in these cases varied from actual participation in public and political process, advisory roles, and education, to the invention of technologies to assist in reducing the number of fatal interactions.

In some of these examples, scientists have become intricately involved in the search for long-term solutions. Miquelle & Smirnov (1999) combine their scientific research with work in communities, living in villages and hiring locals. Schaller (1993) was instrumental in formulating national legislation for pandas, as well as bringing their endangerment to the attention of the international community. Scientists have been involved with all aspects of lion tamarin conservation, from captive breeding to community education and training local people as grassroots researchers (Kleiman & Mallinson 1998). Hector's dolphin researchers worked with the public by presenting biological information as part of the sanctuary process (Dawson & Slooten 1993). Researchers in this chapter have built acoustic pingers to prevent bycatch, attended meetings with politicians or local citizens, collaborated with local scientists or NGOs, dressed up in dolphin costumes in downtown Hong Kong, written educational materials, and worked closely with indigenous peoples. The body of conservation research can be classified according to general aspects of the work (Table 1). All of the examples involve collaboration in various ways with local residents, government officials, or local or international NGOs. The last three cases include researcher participation in an educational process.

Table 1. A summary of the activities by which researchers have contributed to endangered species conservation processes, as seen in the examples in this chapter.

Activities	**References**
Communicate situation to the international community	Schaller 1993 Zhou *et al.* 1998 Thapar 1999
Involved in public process to create sanctuary areas	Dawson & Slooten 1993 Schaller 1993 Marsh *et al.* 1999 Reynolds 1999
Scientist input in formulating regulations	Zhou *et al.* 1998 Marsh *et al.* 1999 Preen 1999 Reynolds 1999 Jefferson 2000
Involvement in meetings with park, government, and indigenous or local representatives to find conservation/management solutions	Schaller 1993 Vidal 1993 Baird 1994 Ponte *et al.* 1994 Miquelle & Smirnov 1999 D'Agrosa *et al.* 2000
Involvement in public debate process on management & co-management strategies	Dawson & Slooten 1993 Westgate & Read 1998 Marsh *et al.* 1999 Reynolds 1999 Stratford *et al.* 2000
Help to establish flagship species as representatives in an educational process	Dietz *et al.* 1994 Kleiman & Mallinson 1998 Reynolds 1999
Research alternative sources of income for local fishers	Vidal 1993 D'Agrosa *et al.* 2000
Create innovative technology to lessen incidental take or harm	Dawson & Slooten 1993 Westgate & Read 1998 Reynolds 1999
Involvement with non-governmental and other private organizations	Baird 1994 Porter *et al.* 1997 Reynolds 1999
Lend assistance to community-based ecotourism	Baird 1994 Dinerstein *et al.* 1999
Training of local residents as field researchers	Kleiman & Mallinson 1998
Participating in raising public concern by education, such as writing educational materials	Porter *et al.* 1997 Kleiman & Mallinson 1998 Zhou *et al.* 1998 Marsh *et al.* 1999 Reynolds 1999 Mignucci-Giannoni *et al.* 2000

The interactions involved in species recovery are still seen as outside the technical concerns of most biologists. Participation in the human factor of endangered species conservation is "often labeled as politics or advocacy and dismissed as outside of recovery professionals' immediate concerns" (Clark & Wallace 1998, p. 2). The researchers discussed here have been compelled by circumstance to understand that endangered species will be saved only if social processes sustain the same goal. Meine & Meffe (1996, p. 917) define "Conservation (as)...a collective term used to embrace our diverse efforts to make the people-nature relationship an enduring one." Therefore, successful conservation demands that scientists be concerned about social and environmental conditions beyond the laboratory (Meine & Meffe 1996).

Figure 1 suggests an idealized conservation decision process that incorporates the input and cooperation of researchers, managers, community members, government representatives, and NGOs. I outline this process in the form of a conceptual framework. It is conceptual, in that the structure of such a framework in reality has to be general enough to be relevant in diverse situations. The goal of the framework is to outline and organize the key elements in a progressive course of action that is widely applicable to endangered species conservation planning.

The problem stated in the center of the figure asserts that habitat and population decline is caused directly or indirectly as a result of human values, beliefs, and practices. The process around the center begins with the gathering of scientific information, both about the animal and the social considerations that helped to create habitat and population threats. NGOs, local people, and government agencies also contribute other information. Based on this information, and public debates, conservation-based management and educational planning is created with an alliance of all parties, and implemented. These strategies, such as the creation of sanctuary areas, educational planning, exploring alternative sources of income, investigating innovative technology, establishing community-based ecotourism, training of local residents as researchers, and creating alliances with local and global NGOs, are open to review and further participation from all concerned groups in a continual information gathering process.

The case studies described in this chapter all incorporate pieces of this framework. For example, in the case of the lion tamarin in Brazil, the problem of habitat and population decline could be described as originating due to human values, beliefs, and practices. Information was therefore gathered not only on tamarin biology, but also on the socioeconomic factors that were causing tamarin endangerment. While there was not open debate between all stakeholders, consequent development of conservation planning included recognizing the tamarin as a flagship species in order to mobilize community support and education. Management planning also included training of local villagers to assist in the research. Collaboration and input into continued research and management included government representatives, scientists, and national and international NGOs.

Conservation efforts around the Aboriginal hunting of dugongs in Australia also address several elements of the framework. Aboriginal beliefs and traditions that result in hunting are possibly contributors to dugong population endangerment. Researchers contribute their knowledge of dugong biology and population sustainability to educate the public and develop conservation and management planning in collaboration with Aboriginals.

The example of Hector's dolphins in New Zealand most closely exemplifies the framework. The original problem of habitat and population decline came from the human practice of gillnet fishing, which traps and drowns the dolphins. Scientists gathered the initial information on the dolphins' biology, and then communicated their results in an open debate process with all concerned stakeholders created to develop conservation planning. The stakeholders voted unanimously on management actions and created a review process involving scientists, government representatives, fishers, conservation advocates, and indigenous Maoris.

In the next chapters, I describe a case study that demonstrates further an endangered species whose conservation process demands attention to social and economic issues as much, if not more, than scientific ones. The case study aims to accomplish two tasks: the first is to gather information and contribute to the conservation planning for a little known and highly endangered species, the second, to use this information to further refine the conceptual framework as suggested in Figure 1.

Dugongs in Thailand, are, like all Sirenians, endangered by their need for a nearshore habitat that brings them into direct conflict with humans living along the coast. Neither hunting, as in Australia, nor boating accidents, as in Florida, are presently major threats. However, the destruction of seagrass beds caused by coastal development, and incidental take by both small-scale and commercial fishers are placing an already diminished population in danger of extinction. As in the other examples in this chapter, both biological and socio-economic information is needed for effective dugong conservation. I will show through this case study that the development of conservation-based management and education planning is beginning for the dugong in Thailand through collaborations between local and international NGO's, international and local scientists, small-scale fishers, and the Thai government. The implementation and sustained success of these policies depends on these collaborations continuing through the cycle of implementation, review, research, debate, and planning outlined in Figure 1.

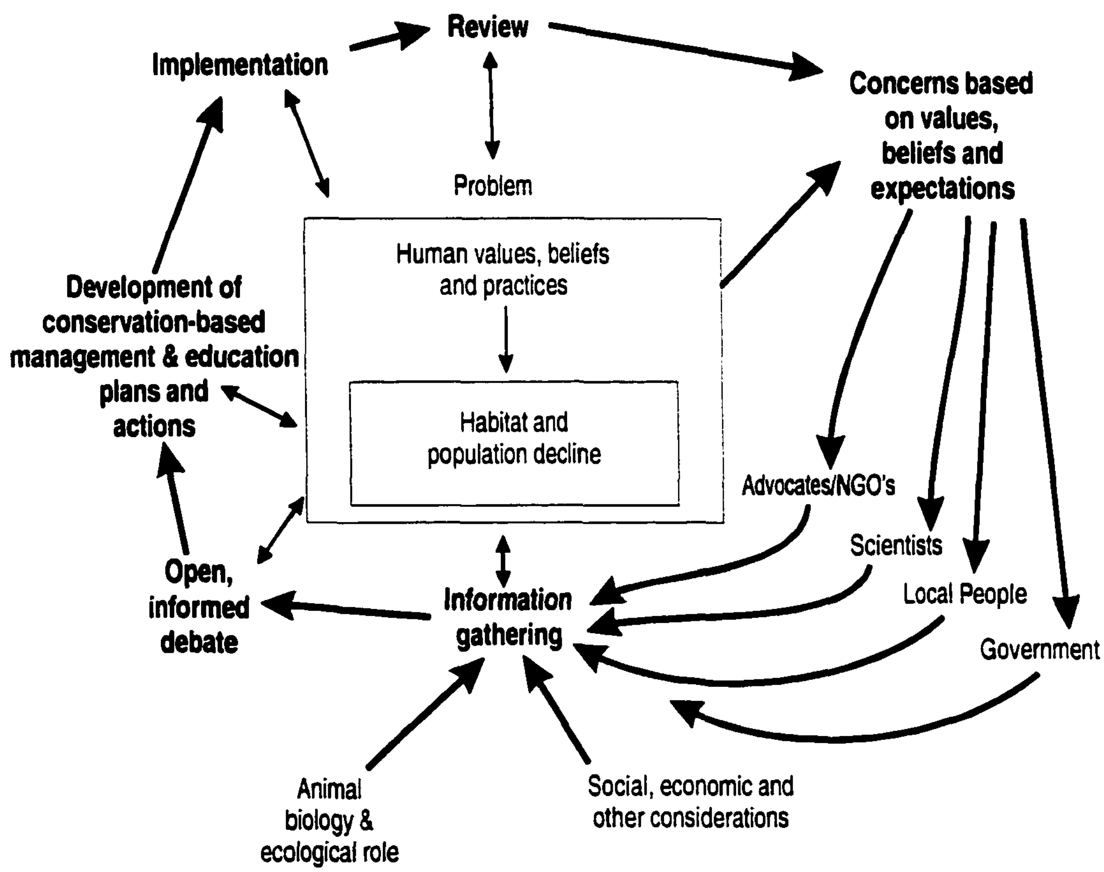


Figure 1. A diagram showing the format of an idealized endangered species conservation process (based on Cork *et al.* 2000).

3.0 THE CASE STUDY: DUGONGS ALONG THE ANDAMAN COAST OF THAILAND

This dissertation examines the integration of scientific methodology with community and other locally relevant management issues using the example of research on dugongs along the Andaman coast of Thailand. In the previous chapter, I presented examples and causes of wildlife endangerment. In this research on dugongs in southern Thailand, as in all the examples in the literature review, population and habitat decline are direct results of human values, beliefs, and practices (Figure 1). In the case study, my purpose is to first initiate, and then in the future, follow the cycle shown in Figure 1, starting with a gathering of scientific data on the dugong combined with information on socioeconomic issues relevant to dugong endangerment. Based on the results of this study, and the examples found in the literature review, further planning of conservation-based management and education planning can be developed, implemented, and monitored for dugongs and their habitats.

First, I outline specific research objectives for the dugong research. In the next section, I discuss background information pertinent to the study, including previous research on dugongs and seagrass in Thailand, as well as legislation relevant to the dugongs' legal conservation status in Thailand and globally. The next section of the chapter contains a review of current events in Thailand of relevance to dugong and seagrass conservation. I then describe the study area and the various field sites of the research. The remaining sections of this chapter outline the techniques for dugong population and habitat assessment, and interviews in fishing villages along the Andaman coast.

3.1 Objectives

The goals of the case study are: 1) to describe the current state of population and conservation of dugongs along the Andaman coast of Thailand and 2) to assemble empirical knowledge about dugongs and relevant conservation issues to refine the conceptual framework proposed in chapter 2 into a format useful as a template for an integrated conservation strategy. Specific objectives include:

1. Determine the present distribution and population of the dugong and the distribution and species of seagrass habitat along the Andaman coast of Thailand.
2. Establish locally applicable, practical field protocols to provide baseline information to monitor the habitat, numbers, and behavior of the species in question.
3. Determine the cultural and economic importance of the dugong both modern and historically in the areas which border populations.

3.2 Project Background

3.2.1 Coastal degradation, fisheries exploitation, and seagrass beds.

Since World War II, increased exploitation of primary resources has been the policy of ASEAN countries (Chua & Garces 1994). Especially since the 1960's, there has been a high birth rate, and accelerated population growth in coastal areas. The population in Southeast Asia grows by 22.5 per cent every 10 years, with 60 per cent of the people (more than 200 000 000) living within 50 km of the coast (Kirkman & Kirkman 2000, Chia 1995). This number is expected to double in the next 25-35 years (Kirkman & Kirkman 2000). Along with this intensified population growth, there has been a remarkable increase in commercial fishing in this area (Pauly & Chua 1988).

In Thailand, commercial fisheries have developed particularly rapidly. In 1950, the annual fish production was 158 000 tons. By the early 1990's, fish production had increased to 3 065 000 tons (Menasveta 1995), and in 1997, total fish production was 3 300 000 (Thai Department of Fisheries 1997). This rise in commercial fishing, most notably trawl net, purse seine, and other mechanical fishing gear, has been the impetus for a growing conflict with traditional small-scale fisheries for fishery resources in coastal waters, especially since fish stocks have been severely depleted by this extensive exploitation (Johnston 1995, Menasvata 1995, Chua & Garces 1994, Kuperan & Abdullah 1994, Flaherty & Karnjanakesorn 1993, Torell 1984, Panayotou 1980). A census on fishers in 1995 by the National Statistical Office and the Department of Fisheries showed that 89.7% of the fishers in Thailand were engaged in small-scale fishing, using 72% of the fishing boats in the country (Federation of Fisher Folk of the South 2000).

From the 1990's however, there has been a growing awareness of the environment, and of the consequences of rampant economic development (Chua & Garces 1994). While coastal areas in Southeast Asia are vital to the needs and livelihoods of local peoples, human activities are, in many cases, degrading these areas. Here, as in other areas, as coastal resources are overexploited; there is a decline in the condition of these coastal ecosystems, and a consequent impoverishment of the people who depend on coastal resources (White 1995, Chua & Garces 1994). Besides fisheries depletion, the subsequent threats as a result of this acute pressure on coastal and marine areas include air and water pollution, and the loss of wetlands and other coastal areas due to increased urbanization, agricultural and aquacultural development (Gomez 1995, Menasveta 1995, Beatley 1991). In Thailand, these challenges are magnified by jurisdictional conflicts, weak enforcement policies, and increasing dependency on aquaculture (Flaherty and Karnjanakesorn 1995, Menasveta 1995).

Coral reefs, mangroves, and seagrass coastal ecosystems in Thailand are economically significant as sources of food and tourism, and ecologically important for coastal protection, nutrient transport and cycling, and as areas of high biological diversity. These areas are also crucial habitat and protection for many marine organisms, functioning as breeding, nursery, and feeding sites (Gomez 1995, Chansang & Poochaviranon 1994).

Seagrasses are one of the most valuable and yet the most vulnerable of these systems, as their dependence on light limits them to a depth of approximately 30 m in shallow coastal and estuarine areas, depending on water turbidity (Kirkman and Kirkman 2000, Fortes 1996, McRoy 1996, Fonseca 1987, Kemp 1983). Therefore, seagrass beds are directly exposed to impacts of coastal development, especially declines in water quality, dredging, fishing gear damage, algae blooms from sewage runoff, and siltation (Kirkman 1996, Fonseca 1987).

In Southeast Asia, seagrass beds have been studied less than other coastal systems, are not well mapped, and little is known of the extent of their degradation (Kirkman & Kirkman 2000, Fortes 1996). Thai researchers have noted this problem, emphasizing that baseline information is urgently needed to assess the distribution and composition of seagrass beds for management (Poochaviranon 2000, Satumanatpan *et al.* 2000, Poovachiranon & Adulyanukosol 1999, Chansang & Poovachiranon 1994, Poovachiranon & Chansang 1994).

Seagrass beds in Thailand are the habitat of the dugong (*Dugong dugon* Müller, 1776). The survival of the dugong is largely dependent on the presence of seagrasses as their major food source (Aragones 1996, de Iongh 1996, Preen 1993). Therefore, dugongs are found in sheltered coastal areas where they are vulnerable to hunting, incidental catch in fisheries, and habitat destruction (Preen & Marsh 1995). For example, the tin mines of Phuket, Phang-nga, and Krabi provinces in western Thailand have damaged seagrass areas by siltation. In Thailand, seagrass habitat degradation also continues from marine pollution and sedimentation from housing and industrial development on land (Nateekanjanalarp & Sudara 1994).

3.2.2 Dugongs in Thailand

Dugongs are one of four species in the Order Sirenia, and the only member of the Family *Dugongidae* (Marsh *et al.* 1997*a*). The dugong is the only existing herbivorous mammal that lives strictly in the sea (Heinsohn 1972). While the dugong was once commonly seen along tropical coasts from East Africa to Australia (Figure 2), they are currently considered rare over most of this range (Marsh *et al.* 1999). The name dugong is from the Malaysian word *duyong* (Nair *et al.* 1975). The IUCN classifies the dugong as vulnerable on a global scale based on declines in occurrence and quality of habitat, and human exploitation (Hilton-Taylor 2000). The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) has banned international trade in dugong products (Marsh 1988).

The largest population of dugongs is found along the west, north, and northeastern

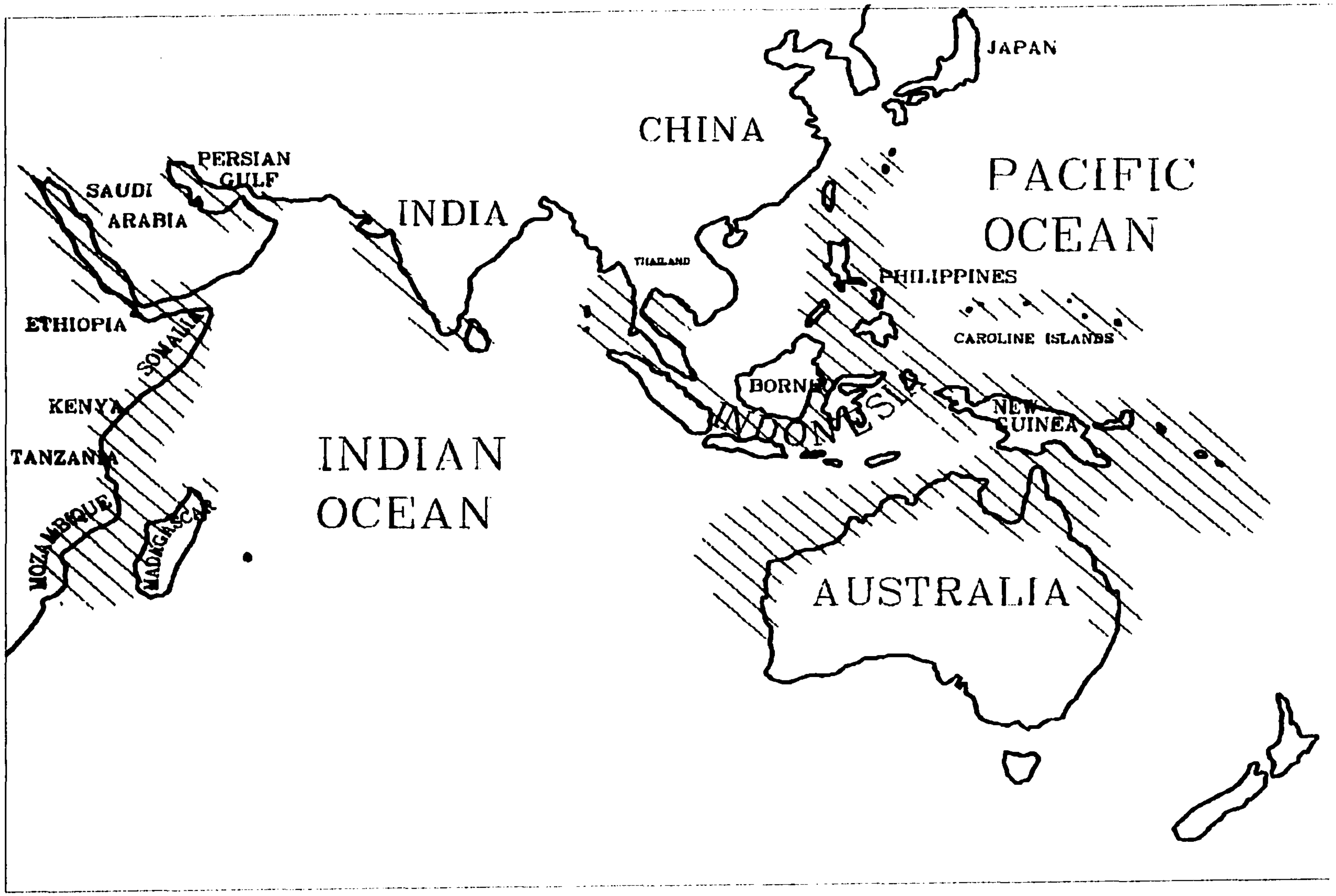


Figure 2. Dugong distribution in the Indo-Pacific region (Reynolds & Odell 1991).

coasts of Australia, where researchers have estimated a population of approximately 85 000 animals (Marsh *et al.* 1999). In Southeast Asia, dugong research has been done primarily in Thailand, the Philippines, and Indonesia. deIongh (1996) found a minimum population of between 22 and 37 dugongs in the Lease Islands, in eastern Indonesia. Aragones (1994) studied dugongs at Calauit Island in the Philippines, sighting a mean of 5 dugongs. Dugongs were considered extinct in Malaysia and Sumatra (Lekagul & McNeely 1977), until 5 dugongs were captured in fish traps and more sighted off peninsular Malaysia (Marsh, as cited in Sirenews, April 1999). Along the coast of Cambodia, dugongs are reportedly extinct (Dearden, pers. comm. 2001). Research has recently begun to assess dugong population numbers and habitats off the northern coast of Sabah, in Malaysian Borneo (Rajamani pers. comm. 2001). I have not heard about dugongs in Vietnam, but in Guangxi province of China, near the Vietnam border, dugongs have been seen and a Dugong Natural Reserve has been established (Chaobing pers. comm. 2001).

In Thailand, dugongs used to be commonly seen along both the Andaman and Gulf of Thailand coasts but are now largely confined to seagrass areas off the Andaman coast (Figure 3) (Nateekanjanalarp & Sudara 1994). Nateekanjanalarp & Sudara (1994) report that some dugongs may still exist on the eastern coast of the Gulf of Thailand, around Rayong, Chanthaburi, and Trat. In interviews by Adulyanukosol in 1998, villagers in both Chantaburi and Rayong provinces reported seeing small numbers of dugongs in recent years. The Marine Endangered Species Unit (MESU) at the Phuket Marine Biological Center (the major center for study of large marine fauna, including dugongs, turtles, and cetaceans, along the Andaman Coast) has 2 records of stranded

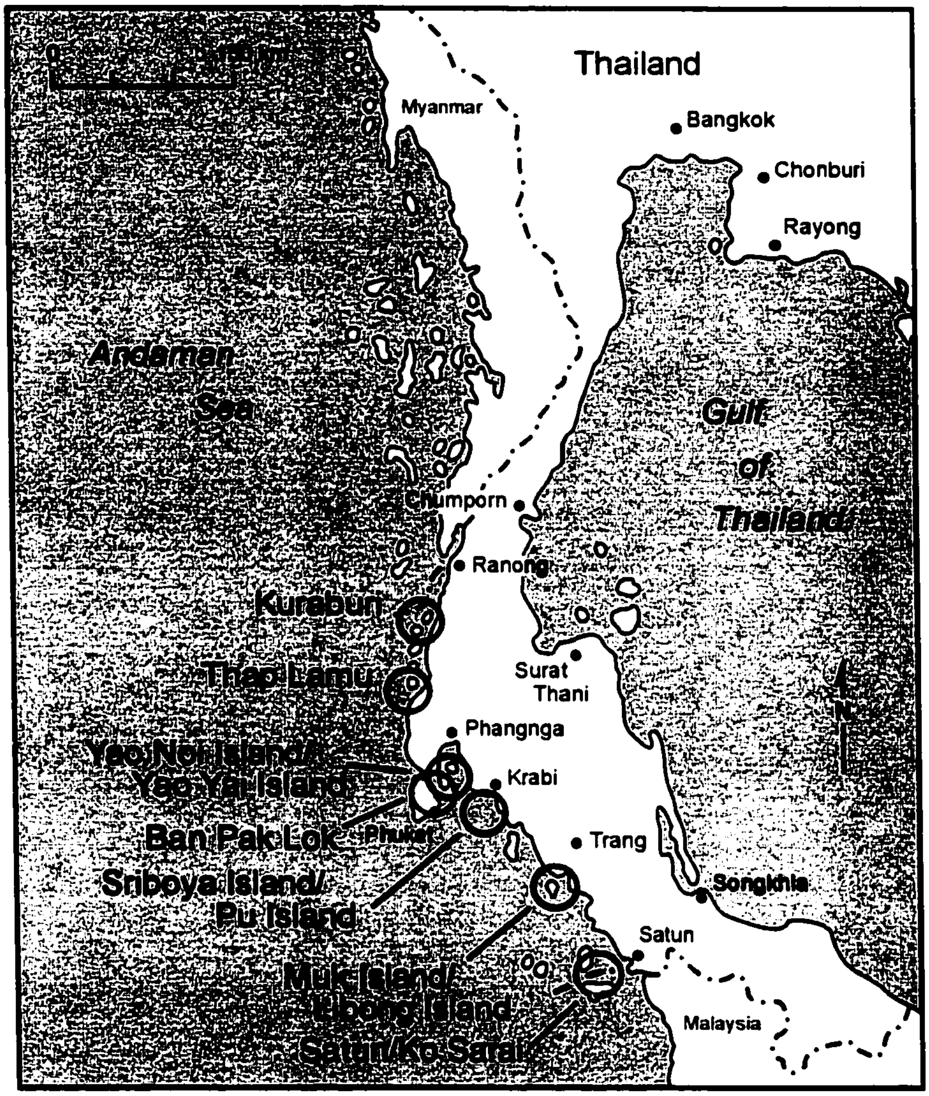


Figure 3. Dugong and seagrass habitat areas along the Andaman coast of Thailand.

animals since 2000 in Chonburi, 13 stranded dugongs from Rayong since 1986, and 6 records from Trat since 1996 (Adulyanukosol, pers. comm. 2001). No live sightings have been reported on the west coast of the Gulf of Thailand since the 1970's (Nateekanjanalarp & Sudara 1994). Recently, the MESU has heard of stranding incidents in Chumpon, Nakhon Si Thammarat, and Surat Thani provinces on the western Gulf of Thailand (Adulyanukosol 1999).

Dugongs are legally protected in Thailand. By law, if dugongs are captured in fishing nets, they must be put back or if hurt, handed over to Department of Fisheries officials. However, several dugongs are found dead every year as a result of incidental catches in fixed fishing nets. Both legal and illegal fishing practices such as dynamite and cyanide fishing, small mesh seines, and push nets can either directly harm dugongs or damage seagrass beds. A major problem along the Andaman coast is the encroachment of large fishing trawlers and push netters into shallow coastal waters. These boats damage seagrass beds and catch dugongs incidentally. They are illegal within 3 km of the coast (Ministry of Agriculture & Co-operatives 1998, 1985), and have been the source of numerous, often violent conflicts, with small-scale fishers in coastal villages.

It is difficult to assess the impact of fishing practices on dugong populations as there is little and incomplete quantitative data on incidental catches in Thai waters. Entanglements in various types of fishing gear that have been reported to the MESU between 1979 and 1999 are summarized in Table 2.

Twenty-seven percent of these reported entanglements were caused by entanglement in the various types of gill nets. In 53% of these cases, the animals were too decomposed to be able to tell the cause of death. In 2000, MESU recorded the deaths of 12 dugongs. So

Table 2: Dugong Entanglements in Southern Thailand with Fishing Gear, and Boat Accidents Reported to the MESU Between June of 1979 and July of 1999 (Letter from K. Adulyanukosol to the Director General of the Thai Department of Fisheries, 23 July, 1999).

TYPE OF INCIDENT	PROVINCE(S)	FOUND DEAD	RELEASED ALIVE	TOTAL DUGONGS INVOLVED
Gill net	Rayong, Chumpon, Phang-nga, Phuket, Krabi, Trang, Satun	21	4	25
Gill net (crab)	**Phuket**	**1**	**0**	**1**
Gill net (sting ray)	Rayong, Phang-nga	3	0	3
Surrounding net	**Trang**	**1**	**0**	**1**
Trawl	Rayong, Surat Thani, Nakom Sri Thammarat, Krabi, Trang	7	0	7
Sting ray net	**Surat Thani, Trang**	**2**	**0**	**2**
Set net or Shallow Wake Pound net	Rayong, Ranong, Phang-nga, Krabi, Satun	4	2	6
Hit by boat	**Phuket**	**1**	**0**	**1**
Caught by hand	Ranong, Satun	0	2	2
Cannot identify fishing gear	**Ranong, Phang-nga, Krabi, Trang**	**55**	**0**	**55**
TOTALS		95	8	103

far, in 2001, only 2 entanglements have been reported to the MESU, one in Trang, the other in Rayong province, with no indication of the type of fishing gear responsible (Chantrapornsyl, pers. comm. 2001). How many strandings are unreported is unknown. Supot Chantrapornsyl, the head of the MESU, estimates that there are 10 dugongs killed per year at Had Chao Mai National Park in Trang alone, by illegal gill nets, long line hooks, and sting ray nets. In a Bangkok Post article on October 5, 2000, Mr. Chantrapornsyl mentions that he believes that the actual numbers are hard to estimate, and is quoted as saying ..."Villagers usually don't get excited with the death of dugongs or turtles...so they don't necessarily inform us." The unknown number of strandings and incidental catches, as well as a general lack of information on the size and location of dugong population groups makes conservation difficult (Preen 1998).

The extent of dugongs along the Andaman coast is largely scattered between beds of seagrass. The small size and isolation of remnant populations places each small population in a higher probability of extinction. The patchy distribution of seagrass meadows makes the dugong especially vulnerable to the effects of increasing habitat fragmentation (Roberts & Hawkins 1999). Currently, the re-colonizing ability and travel distances of dugongs in this region are unknown. It is a common hypothesis in conservation biology that the continued fragmentation of habitat places the remaining populations at further risk of extinction from environmental stochasticity, demographic stochasticity, and eventually the loss of genetic variability. In general, the loss of genetic variability, especially in populations recovering from bottlenecks, or a sudden reduction in population numbers is problematic (Caughley & Gunn, 1996, Preen & Marsh 1995, Fahrig & Merriam 1994, Andrewartha & Birch 1984). Some marine mammal species, such as the Northern elephant seal (*Mirounga angustirostris*), have experienced bottlenecks that have resulted in low genetic variability, but with no bearing on the recovery of their population numbers. However, we have so little information on dugong population structure in Southeast Asia, that the genetic implications are unknown. Seagrass loss due to a cyclone in Hervey Bay, Australia, caused enough damage to seagrass beds supporting approximately 1,753 dugongs that, even though some of those dugongs were able to travel to other areas, the carcasses of at least 99 animals were found dead of starvation. Recovery of the population is expected to take more than 25 years (Preen & Marsh 1995). In Thailand, the locations and populations of dugongs are not sufficiently known to estimate the effects of habitat loss or modification, or incidental mortality, much less stochastic environmental events.

The combination of specialized habitat needs and a low birth rate make the dugong especially vulnerable to anthropogenic disturbances. Dugongs, like other Sirenians, have a low reproductive potential (Reynolds & Odell 1991). The dugong lives up to 70 years, with a 13-month gestation period, a minimum age of 10 years at sexual maturity, and between an 18 and 36-month period between calving. It has been estimated that a dugong population can only afford to lose 1-2% of its breeding females in one year to maintain population numbers (Marsh & Lefebvre 1994).

In many if not all of the other countries within their distribution, the dugong has been or is presently hunted. Reports of hunting are found from East Africa, many of the countries along the Persian Gulf, the Andaman and Nicobar Islands, Indonesia, the Philippines, India, Sri Lanka, Palau, Papua New Guinea, Vanuatu, and Australia (Das 2000, Santiapillai 2000, Baldwin & Cockcroft 1997, Marsh *et al.* 1995, Reynolds &

Odell 1991, Smith & Marsh 1990, Hudson 1981, Heinsohn *et al.* 1979, Bertram & Bertram 1973, Hughes & Oxley-Oxland 1971).

People along the coasts of Thailand consider the meat of the dugong to be delicious, and have hunted dugongs in the past (Boonprakob *et al.* 1983, Sae Aueng *et al.* 1993). Now that the species is considered threatened in Thailand, the public cannot legally hunt dugongs. However, some Thai villagers believe that dugong skin, bones, tears, oil, and tusks have aphrodisiac, protective, anti-rheumatic, and various other medicinal properties, and relatively high prices will be paid for these body parts. For example, a fisher may receive 10,000 Thai baht for a set of tusks (approximately CDN$357.00). To put this amount into perspective, in 1999 the average monthly wage in Thailand was 6600 baht per month (CDN$237.71), and the monthly salary of a farm worker, hunter, or fisher was 3050 baht per month (CDN$109.85) (Bank of Thailand 2001). This situation was exacerbated in 1995, when a Thai newspaper reported on this phenomenon, announcing that tusks are sometimes sold for as much as 100,000 Thai baht (Adulyanukosol, pers. comm. 2001). Sometimes, this trade is done openly through village officials, who buy the tusks from the fishers, and resell them to an amulet-maker. Nateekanjanalarp & Sudara (1994) tell of a legend on Libong Island in Trang Province where a woman became a dugong because of cravings for seagrass pods, only returning to her husband as a mermaid and then only as a dugong. From this legend, it is reported that the tears of a dugong are a powerful love potion. In a later chapter, while assessing the cultural role of the dugong in Thailand, I further discuss variations of this legend, and medicinal uses for dugong body parts heard in interviews in different villages.

Though the use of dugong body parts as medicine and amulets is current in some areas, the image of the dugong as a symbol for coastal conservation is becoming popular. In Trang Province, where the largest population of dugongs remains, the dugong is already a flagship species, symbolizing a growing awareness of the marine environment. A large dugong was painted on the elementary school in Libong Island, (Figure 4) and many people had dugong images on T-shirts and shopping bags. Suwan Pitaksintorn conducted the first aerial survey for dugongs in Trang in 1991 (Sae Aeung *et al.* 1993). After this helicopter survey, the Royal Forestry Department announced that this was the last group of dugongs left in Thailand, and a national mass media campaign was developed to spread awareness of dugong conservation in Thailand. A dugong 'ranger' was created to convey messages of conservation at Trang's Had Chao Mai National Marine Park. Another result of the 1991 survey was the establishment of a seagrass conservation zone in the Non-Hunting area previously set up around Libong Island in Trang Province in 1960 (Figure 5). Education of local communities and buoys marking seagrass areas were implemented, and all destructive fishing techniques were prohibited (Nateekanjanalarp & Sudara 1994).

From interviews with the two major dugong researchers in Thailand, and with Choomjet Karnjanekesorn, the CITES official of the Royal Forestry Department, dugong conservation is an issue of significant concern nationally. Population assessment of this seriously endangered species has been irregular and uncoordinated, done by separate researchers as funding becomes available. Since there is an economic crisis in Thailand at this time, there is currently little funding available for research. In the next section, I summarize research being done on the dugong in Thailand.

Figure 4. Dugong mural at elementary school on Libong Island, Trang Province.

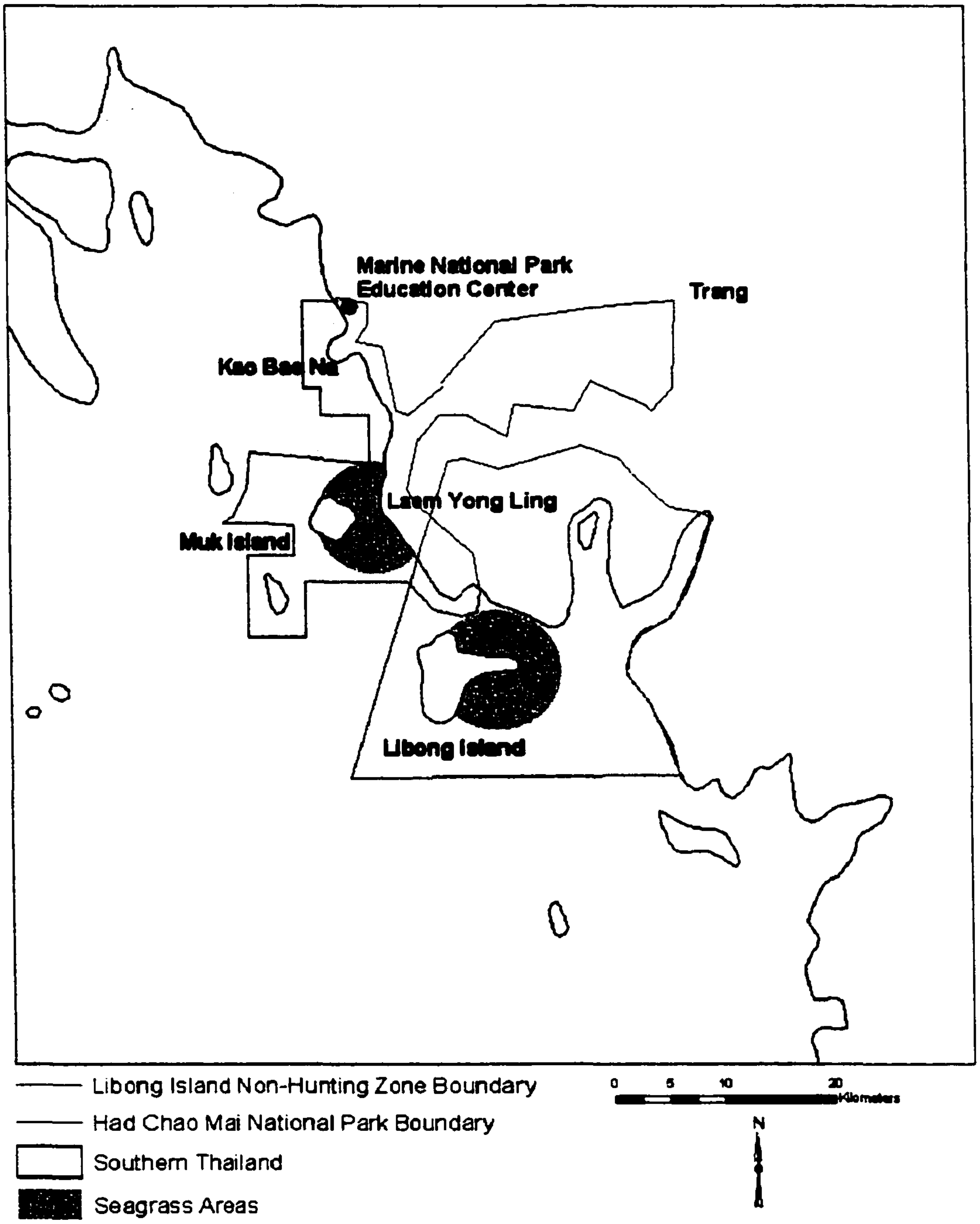


Figure 5. Boundaries of Had Chao Mai National Park and the Libong Island Non-Hunting Zone.
Information courtesy of the Royal Forestry Department of Thailand.

3.3 Previous Research on the Dugong in Thailand

3.3.1 Distribution and Abundance

The first aerial population survey was conducted by Suwan Pitaksintorn of the Royal Forestry Department, who found 61 dugongs in Trang Province in 1991 and 1992 (Sae Aueng *et al.* 1993). Kanjana Adulyanukosol, from the MESU, was the first Thai scientist to systematically interview villagers (Adulyanukosol 1995) and perform aerial surveys between 1997 and 1999. She found a maximum of 48 dugongs in 1997 and 38 in 1999 along the Andaman Coast (Adulyanukosol 1999, Adulyanukosol *et al.* 1999, 1997). In 1997, Adulyanukosol *et al.* surveyed eight stations which had seagrass beds of between 100 and 200 km^2 (Figure 6), finding 3 dugongs at Tung Nan Dam in Phang-nga province, 5 dugongs in Ban Thalane and 5 also at Hang, Pu, and Sriboya Islands in Krabi province, 6 dugongs in northern (Muk Island, Laem Yong Ling, and Khao Bae Na), and 28 dugongs in southern (Libong Island) Trang province, and 1 dugong at the Ko Sarai area in Satun Province.

3.3.2 Other research on dugongs in Thailand

In 1983, Boonprakob *et al.* wrote about four dugongs brought to the Phuket Marine Biological Center (PMBC) between 1979 and 1982. The first and third animals had been accidentally caught in fishing nets, and the others were found stranded in seagrass beds at low tide. After the first dugong was received by the PMBC, people were disappointed in the appearance of the dugong, and began calling it a sea pig, or "moo thalae". They had thought the dugong was actually a 'nguag', or mermaid. One of the dugongs was already dead when brought in. The other animals survived at the Center from between 77 to 153 days.

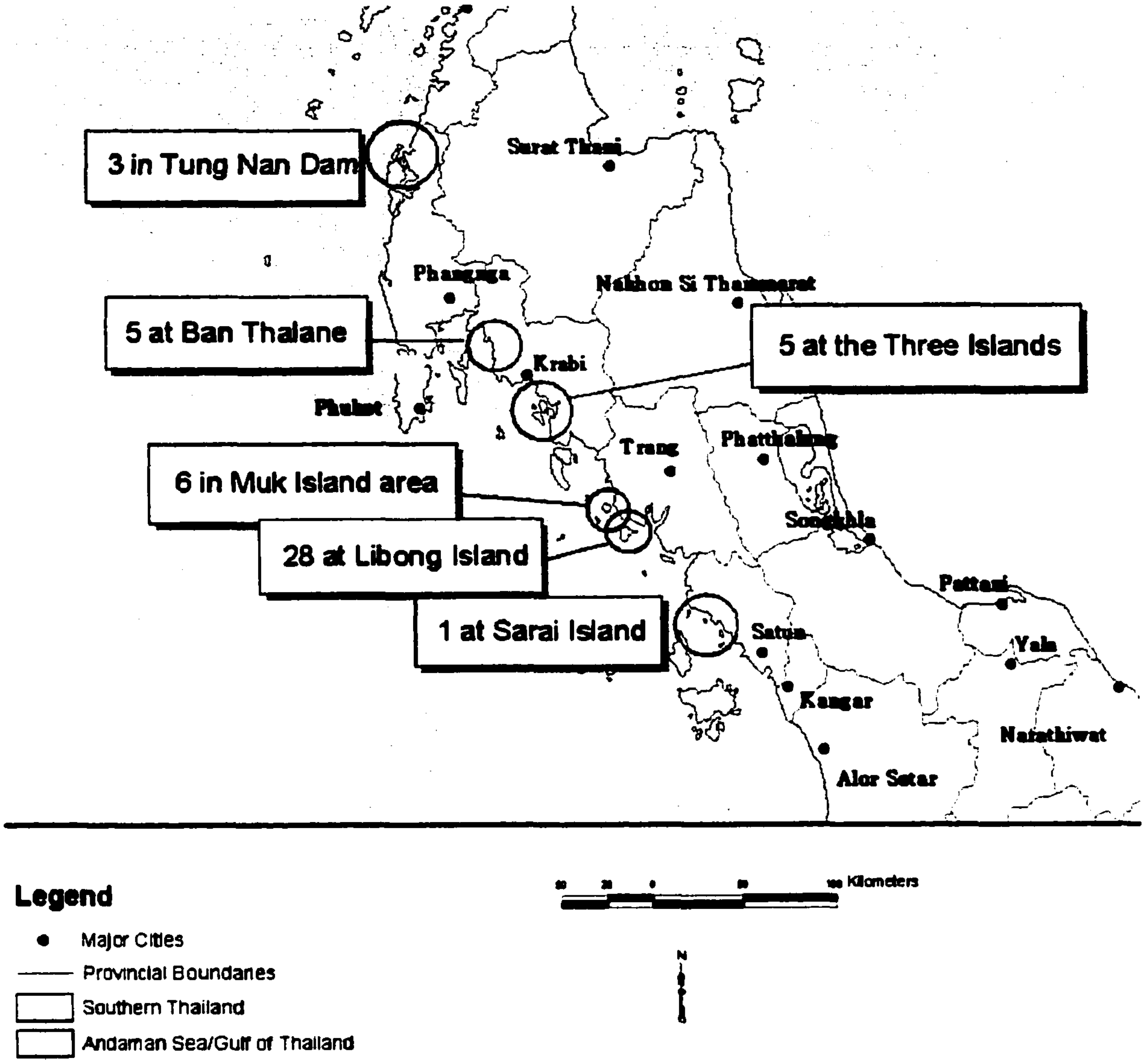


Figure 6. Dugong population group numbers and sightings areas from Adulyanukosol et al. (1997).

Adulyanukosol & Bhatiyasevi, in 1994, reviewed the captivity of the latter described animals, and four others that had been brought to the PMBC between 1982 and 1993. Two of the animals were un-weaned calves. The first was released into the area from which it had been found after 15 days, and the second died after 41 days (Boonyanate 1994). The longest time in captivity for the adults increased to 200 days. The authors cite injuries during handling and transportation, and also infection as probable causes of death. Researchers in Australia have noted the susceptibility of the dugong to capture myopathy, or capture stress after finding that a large percentage of animals will die between hours and several weeks of handling and capture (Marsh & Anderson 1983, Anderson 1981, Heinsohn *et al.* 1976). Another dugong was reared in captivity at PMBC from March to October of 1994. Adulyanukosol (1997) studied and reported on breathing behavior and diving times of this dugong. Other research by Adulyanukosol includes age determination based on the analysis of dentinal growth layers of dugong tusks, and the analysis of dugong stomach contents (Adulyanukosol *et al.* 1998, Adulyanukosol in press).

Thai research on the foraging habits of dugongs has had results analogous to other studies looking at the possibility of dugong cultivation grazing. Supanwanid (1996), from the Faculty of Fisheries at Kasetsart University, studied the recovery period and growth of *Halophilia ovalis*, a species of seagrass seen to be preferred forage of dugongs (Preen 1993), in feeding trails at Had Chao Mai National Park. She dug experimental trails mimicking the patterns created by the foraging dugongs. Within two months, there was no significant difference between seagrass biomass beside and within the simulated feeding trail. In Australia, Perry & Dennison (1996) found increased nitrogen fixation rates and possible elevated phosphorus content in seagrass beds following dugong grazing. Seed production in *Zostera capricorni* was also found to be higher in sites with dugong foraging, leading to pre-grazing densities within 9 months (Peterkin & Conacher 1997). Both Preen (1995) and Aragones (2000, 1996) reported that intensive dugong grazing altered the structure and dynamics of seagrass communities, creating an environment which favors the more rapidly growing, more highly nutritious *Halophilia ovalis* over less nutritious species. They both noticed that the grazed areas were completely recovered within several months. de Iongh *et al.* (1995) in Indonesia also noted this cultivation grazing strategy in beds of *Halodule uninervis* in Ambon Island. They found that the roots and rhizomes of *Halodule sp.* had higher levels of total organic carbon than other surrounding species, and found that the disturbed areas were restored within 5 months.

Intensive research was conducted in 1998 and 1999 at the seagrass beds in Had Chao Mai National Park by a group of Japanese scientists from the University of Tokyo and Thai scientists from the Faculty of Fisheries at Kasetsart University (Koike 1999). Detailed studies were carried out on the immediate physical and chemical environment, the structure and dynamics of the seagrass beds, and the interactions between the seagrasses and associated fauna. Three reports specifically relate to dugongs. The first examined the extent of dugong grazing in a 100 m X 100 m quadrat at Kao Bae Na (Mukai *et al.* 1999). The single dugong observed was estimated to create 14.9 feeding trails totaling 5.1 m^2 per day. Using further calculations of grazing rate, and seagrass biomass, production, and distribution, they estimated a carrying capacity of about 40 dugongs for the entire park area (Mukai *et al.* 1999). These conclusions can only be considered for the year of the research, as the seagrass beds in this area are vulnerable to storms in the rainy season. In 2000 and 2001 the seagrass at Kao Bae Na was largely washed away. The second report (Nakaoka & Aioi 1999) found that recovery of *Halophilia ovalis* in the feeding trails was actually 10 days at this time, a much higher estimate of recovery than Supanwanid (1996). The third paper examined and found no significant effects of dugong herbivory on benthic communities (Nakaoka *et al.* 1999).

3.3.3 Conservation Status and Relevant Legislation

As a result of declining numbers of sightings and reports of occasional killings by fishermen, a variety of laws and policies have been created in Thailand to guard dugongs (Humphrey & Bain 1990). Thailand has two laws to directly protect dugongs. First, the Fisheries Act of 1947, executed by the Department of Fisheries (DOF), proclaimed a Ministerial Regulation to prohibit the killing and taking of dugongs in Thai waters. In addition, as mentioned earlier, the DOF also designated a Non-Hunting Area off the coast of Trang province (Libong Island) by virtue of the 1947 Fisheries Act to protect seagrass beds, dugongs, and other animals. Secondly, the Wildlife Reservation and Protection Act in 1992 executed by both the Royal Forest Department (RFD) and DOF proclaimed in a Royal Decree to list dugongs in the Reserve Endangered Species List (similar to Appendix I of CITES) which prohibits killing, taking, possessing, trading, exporting and importing of dugongs and dugong body parts (Karnchanakesorn, pers comm. 2000). The Department of Fisheries is responsible for fisheries conservation, aquaculture, preservation of aquatic animals, and regulation of the use of fishing gears harmful to aquatic animals. The Royal Department of Forestry oversees protected areas, including marine and coastal areas designated as national parks and non-hunting areas (Thai

Department of Fisheries 2000, FAO 2000).

In Thailand, there are several categories of protected areas, all of which are administered by the Royal Forestry Department, in this case under the auspices of the Marine National Park Division, and enforced by the National Resources Conservation Bureau. The three categories applicable here are (Kitching 1996):

1) National Parks -- Here hunting and collecting are forbidden, as well as any act that will potentially modify the environment. Most National Parks have been chosen not only to protect the environment, but as possible vehicles for education and recreation. Had Chao Mai National Park in Trang was established in 1981 and encompasses 230.9 km 2, of which 59% is an aquatic zone (Marine National Parks pamphlet) (Figure 5).

2) Wildlife Sanctuaries -- Similar to National Parks in size and the level of protection; however with permission, collection of specimens is permitted. Recreational use is not specifically encouraged, but not specifically prohibited. There are currently no marine wildlife sanctuaries.

3) Non-Hunting Areas -- The only activity restricted here is hunting for specifically named species. When the original Libong Island Non-Hunting Area was established in 1960, the dugong was not listed as one of the 108 originally restricted species. Protection of the dugong in this Area was specified after the Wildlife Reservation and Protection Act in 1992. Some Non-Hunting Areas have been upgraded to Wildlife Sanctuaries.

The Ministry of Agriculture and Co-operatives, in 1985, declared that trawlers, purse-seines, and gill nets smaller than 4.7 cm were prohibited in Phang-nga Bay and parts of the coast off Krabi province from April 15 to June 15 of every year (fish egg-laying season) (Figure 7). However, this was soon seen as inadequate, as there were still many fishers using trawlers and push nets in this area both during the prohibited time and all year (Ministry of Agriculture & Co-operatives 1998, 1985).

In response, in 1998, the Ministry of Agriculture & Cooperatives declared that all trawlers, push nets, purse seine, or motorized fishing within 3,000 meters from the coastline were prohibited in Phang-Nga Bay, from Cape Panwa in Phuket to Cape Laem Hang Nark in Krabi (Figure 7). This announcement extended the prohibition throughout the year. The boundaries were expanded into Phuket province and to completely cover the coast along Krabi province, down to the border of Trang province (Ministry of Agriculture & Co-operatives 1998). Under this declaration, nets are not allowed with smaller than 3 cm mesh, and all boats must be registered and permitted. Enforcement of this regulation is problematic and will be discussed later.

Recently in southern Thailand, the Department of Fisheries has begun a policy of buying push nets from both commercial and local fishers to discourage their use and encourage the use of legal and less destructive fishing techniques (Bangkok Post, April 19, 2000). Push nets have been illegal in Thailand for 10 years. This strategy has backfired in various ways. The larger, commercial push net fishers ignore this policy, and some local fishers will build push nets to show fisheries officials so they can get money. Pisit Charnsoh, the director of Yadfon, a Non-government Organization (NGO) based in Trang province, and Ari Watcharat, the local representative for the Andaman Project (another NGO) in Satun province, have heard that other push net fishers will use

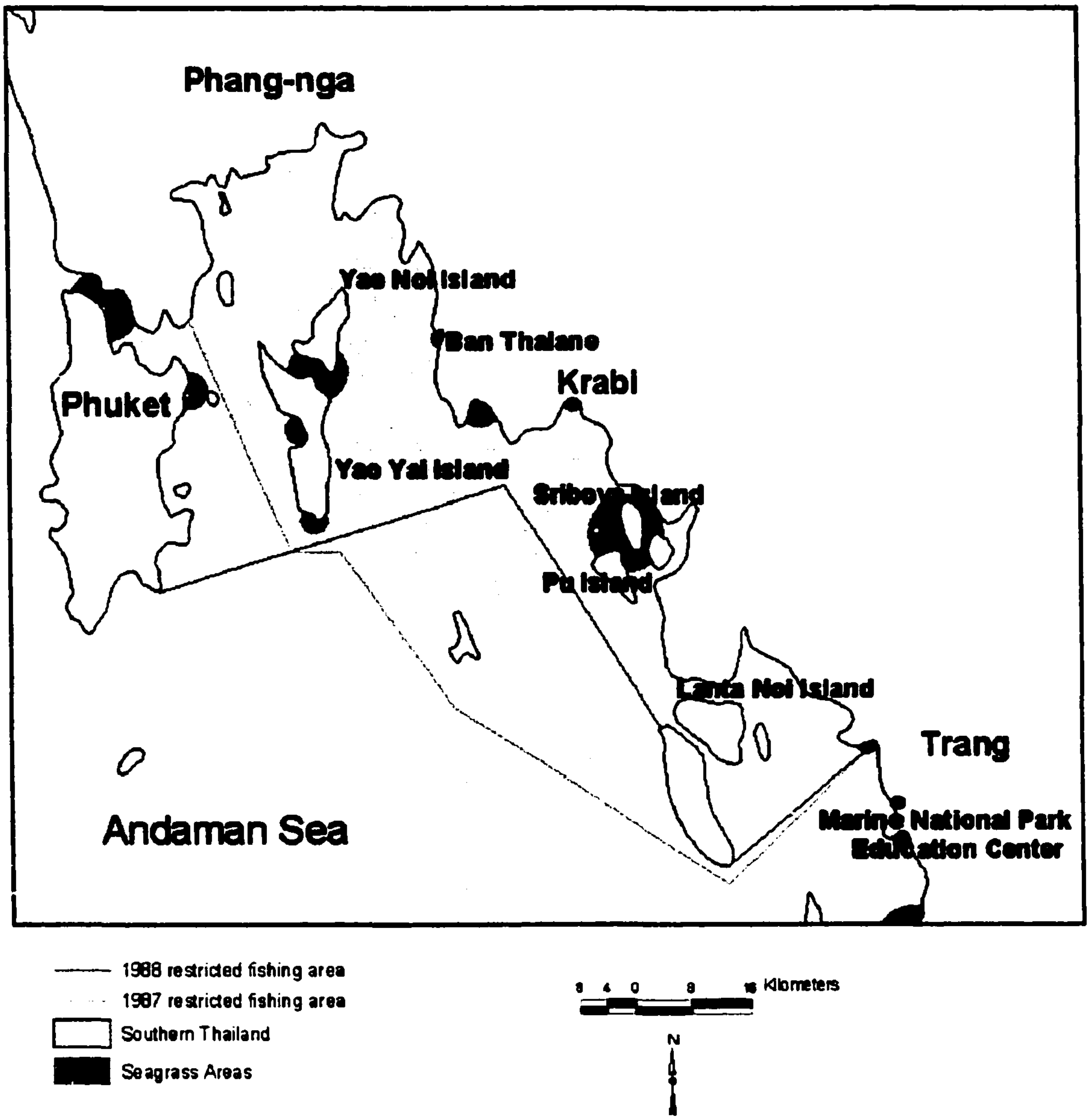


Figure 7. Boundaries of restricted fishing (no trawlers, purse seines, or push nets) areas as outlined by the Ministry of Agriculture & Cooperatives in 1985 and 1998.

the money they receive to buy new and better push nets.

In 1991, according to Mr. Charnsoh and Suriya Weetoonpan, the Chief Provincial Officer for the DOF in Trang, all seagrass areas in Trang were declared as conservation areas by the provincial branch of the Department of Fisheries, and all push nets and drag nets prohibited within them. Before this law came into effect, there were approximately 300 push net fishers in Trang. Now there are around 100 (Weetoonpan, pers. comm. 2001). However, interview respondents believe that the efforts of villagers, who either stop push net fishing voluntarily or band together to patrol local waters, are responsible for this decrease, not the Department of Fisheries.

In 1998, Thailand became a signatory to the Ramsar Convention on Wetlands, and lately has nominated nine wetlands to become Ramsar sites, including Had Chao Mai National Park and Libong Island Non-Hunting Area in Trang province, Phang-nga Bay, and Kuraburi estuary in Phang-nga province. These are all sites with extensive seagrass beds that include reported dugong populations (Bangkok Post, February 4, 2000).

3.3.4 Current Events

In Trang province in March of 2000, two dugongs were found dead, one tied to a mooring buoy, and the other washed up on the beach, both near Had Chao Mai National Park. I sighted the first dugong during a microlite transect and reported the incident to the local Marine National Park Education Center (MNPEC) at Had Chao Mai National Park. The dugong tied to the mooring buoy was a young (under 3 years) female who was caught in a fishing net. Her teeth and tusks, breasts, and part of her tail were cut off. I was told that the Muslim villagers nearby use these items as aphrodisiacs and amulets.

The other animal was a full grown male, also with tusks cut off. Staff at the MNPEC performed a necropsy of the male privately. I was told that the necropsy showed this animal had been struck in the chest. They could not tell if it had been caught in a net beforehand. Kanjana Adulyanukosol of the MESU came down to the MNPEC with her staff to perform a necropsy for the female and take samples. Necropsy of the female showed a well-nourished dugong, but gave no indication of cause of death. Numerous reporters were called to the scene and the events were well publicized throughout Thailand. In the Bangkok Post, March 13 2000, the headline of a resulting article read "Dugong death leads to extinction fears: Local beliefs blamed for falling numbers."

As a result of these deaths, the then director of the MNPEC called a meeting (he has since been transferred and replaced). Scientists, academics, and community leaders attended to discuss raising public awareness of dugong conservation, the possibilities of further laws and regulations, and additional expansion of the present conservation area for dugongs and seagrass. All participants considered the meeting successful, and two further meetings were planned with various government officials, scientists, and community members. The new director has not held any further meetings.

Soon after this meeting, two more dugongs were found dead in the nets of large push net fishing trawlers anchored off Libong Island in Trang. A Bangkok Post article read "Two more dugongs killed in Trang Park: Species threatened by amulet market". The article described that 30 dugongs have been found dead since 1992, 19 of which were found in Trang. The Department of Fisheries published articles in both Thai and English newspapers on April 29 2000, warning of a four-year jail term and 40,000 baht fine (CDN$1428.00) for possession of parts of dead dugongs (Bangkok Post, April 29

2000). A Thai scientist wrote to me on May 10, 2000 that another 2 dead dugongs were found stranded in Trang, with no clear indication of cause of death (Pitaksintorn, pers. comm. 2000). A Bangkok Post article on December 15, 2000 reported a 2m long dugong found dead on the beach in Sikao Bay in Trang province, also with no indication of the cause of death. The Puyi-ban, or headman, of the village mentioned that this was the fifth dugong found dead in this area in the past six years. The Puyi-ban reported the death to the MESU, who came to retrieve the carcass and perform a necropsy.

In the Yao Islands, villagers are quite active in the Phang-nga Bay Small Scale Fisheries Network, established with the assistance of the Andaman Project. Bang Yoo Chamnanrakay, a local fisher, is the president. This organization has formed alliances with similar groups all over Thailand, and representatives have traveled to villages as far away as Chiang Mai in the north. They have begun a network of guesthouses through the islands, where tourists stay in the villages and learn about the lives and concerns of local fishers. Conservation awareness is high in this area, even though the medicinal use of dugong body parts is common. Currently, conflicts with illegal push-netters are getting violent. The villagers have formed a patrol to find and turn illegal push-netting boats into the Department of Fisheries (DOF). They impound the vessels and the DOF fines the fishers 100,000 baht (approximately CDN$3571). However, many of the push-net fishers have powerful backers, who will pay the fine for them, or use their influence to have the fine reversed. Lately, the push-net fishers have been organizing, and stole one of the patrol boats, which had been named the "Payoon Tong" or "Golden Dugong". It was later found in a nearby harbor, burned irreparably.

In January of 2001, I received a letter from Yadfon Association in Trang mentioning an escalation in local conflicts with push-netters. In the opinions of many of the interview respondents, NGO representatives, and scientists I have spoken with, these boats are responsible for both seagrass destruction, and most of the incidental catch of dugongs and dolphins. These fishers come into shallow waters illegally, and the net is literally pushed in front of the boat in a 'V', dragging through the substrate. Villagers told me that when these fishers find a dugong or dolphin, they simply throw it back into the ocean, from which it gets washed up on shore, or is never found. If the dugong has been in the ocean for a while, it is not possible to see marks from nets.

3.4 Study Area

Along the Andaman Sea, the western coast of Thailand is approximately 865 km long (Figure 3). There are over 200 islands along the coast, most of which are steep columns of limestone rock with no inhabitants (Federation of Fisher Folk of the South 2000). Mangrove communities, river mouths, and sandy beaches comprise most of the coastal area, with fringing coral reefs around many of the islands and rocky outcrops (Chansang & Poovachiranon 1994).

There are two seasons, a rainy season under the influence of a southwest monsoon from approximately May to October, and a dry season influenced by a northeastern monsoon from November to April. Tides are semidiurnal, with a tidal range of between 1.1 and 3.6 m (Tide Tables of Thai Waters, Hydrographic Department, Royal Thai Navy 2000, Chansang & Poovachiranon 1994). There are five population centers along the coast, Ranong, Phuket, Krabi, Trang, and Satun (Figure 3).

Ranong, the northernmost city on the coast, borders Myanmar. There are some seagrass beds on the islands just south of Ranong; Chang and Phayam (Figure 8). In 1999 a stranded dugong was received at MESU from Phayam Island (Adulyanukosol pers. comm. 2000). Further down the coast, seagrass beds along the coast and surrounding the islands near Kuraburi, in Phang-nga province, are suitable in size and species for dugongs (Figure 8). Previous surveys mention dugong sightings here (Adulyanukosol *et al.* 1997). Two Thai seagrass scientists have mentioned that they have recently seen dugongs in this area during their field research (Poovachiranon, Supanwanid pers. comm. 2000). Thap Lamu, further south, is another area where seagrass is suitable for dugongs. Other researchers have seen dugongs in this area (Adulyanukosol, Poovachiranon pers. comm. 2000).

The island of Phuket is Thailand's most wealthy province, due to the extensive tourist trade (Cummings & Goncharoff 1998). Many of the seagrass beds surrounding the island have been degraded by coastal development (Poochaviranon 2000). There are still seagrass beds on the northeast side of the island where an adult dugong stranded in April of 2000, and villagers have reported seeing dugongs in early 2001 (Adulyanukosol, pers. comm. 2001) (Figure 9). No previous aerial surveys have seen dugongs in that area.

Krabi, on the eastern coast of Phang-nga Bay, is also the center for a growing tourism industry, which is spreading to the surrounding islands quickly. There are seagrass beds on Yao Noi and Yao Yai Islands in the Bay, also at Ban Thalane, and Sriboya, Pu, and Hang Islands on the eastern coast of Phang-nga Bay (Figure 9). Just outside of Krabi city and on beaches to the west are some seagrass beds, but due to the volume and size of the ships going through the harbor, and the extent of tourism on the beaches, it is doubtful that dugongs use the area (Figure 9). There is some patchy seagrass at the southern end of Lanta Noi Island, but no dugongs have been sighted there by previous researchers (Figure 10).

Trang province is currently being advertised as the new, unspoiled area for tourists in southern Thailand. Advertising campaigns by the Tourism Authority of Thailand and Thai Airways are encouraging both national and international visitors to this area. Trang province has the largest seagrass beds along this coast (two beds equaling 7 km^2 at Libong Island, and 6.36 km^2 in Had Chao Mai National Park) (Chansang & Poovachiranon 1994) (Figure 10). In this area is also the largest remnant population of dugongs in Thailand (Adulyanukosol 1999, Sae Aeung *et al.* 1993). Around Satun province, there are several areas where there is sufficient seagrass to possibly attract dugongs. Adulyanukosol *et al.* (1997) saw one dugong there in her first aerial survey.

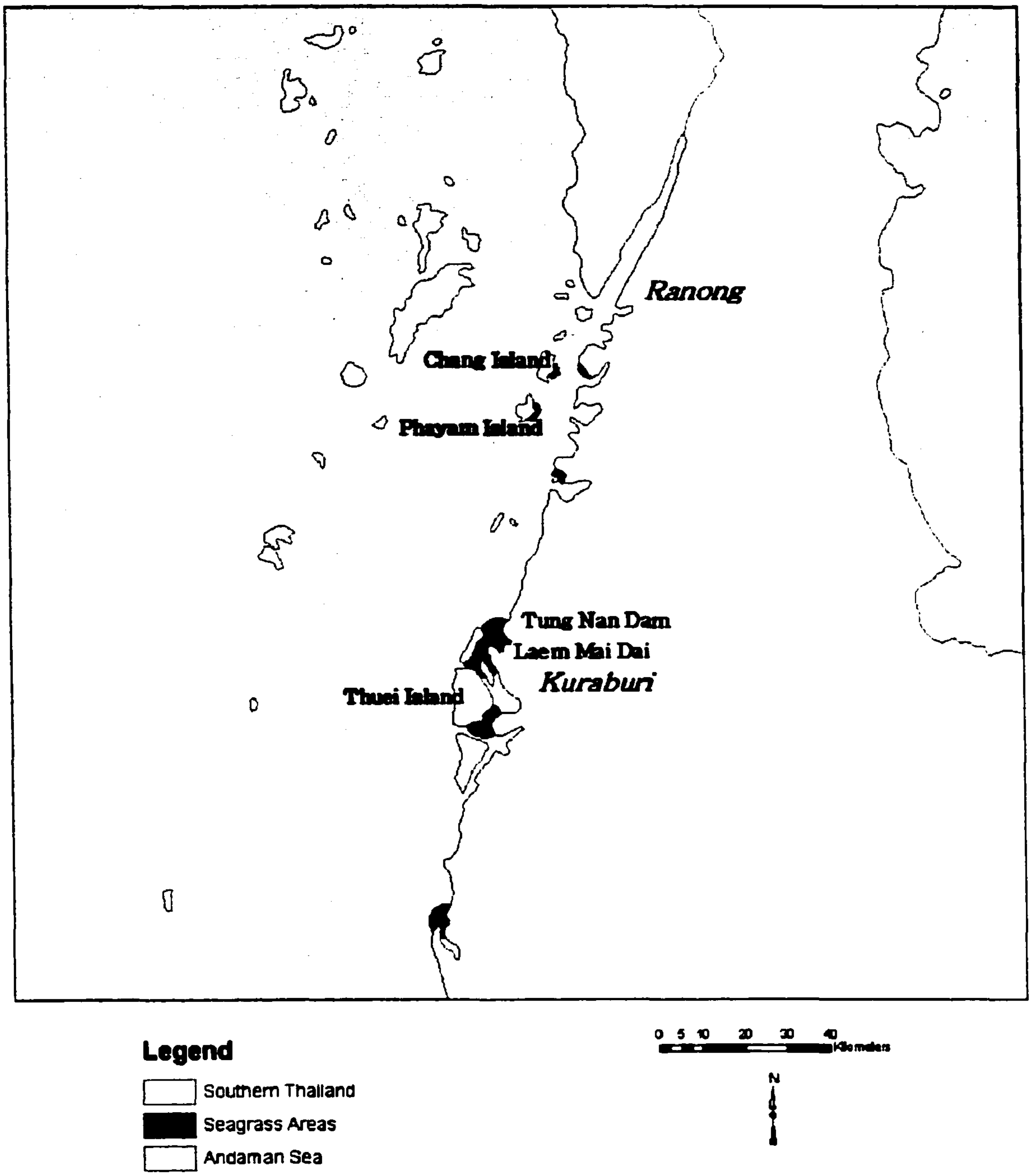


Figure 8. Seagrass beds and possible survey sites between Ranong and Kuraburi.

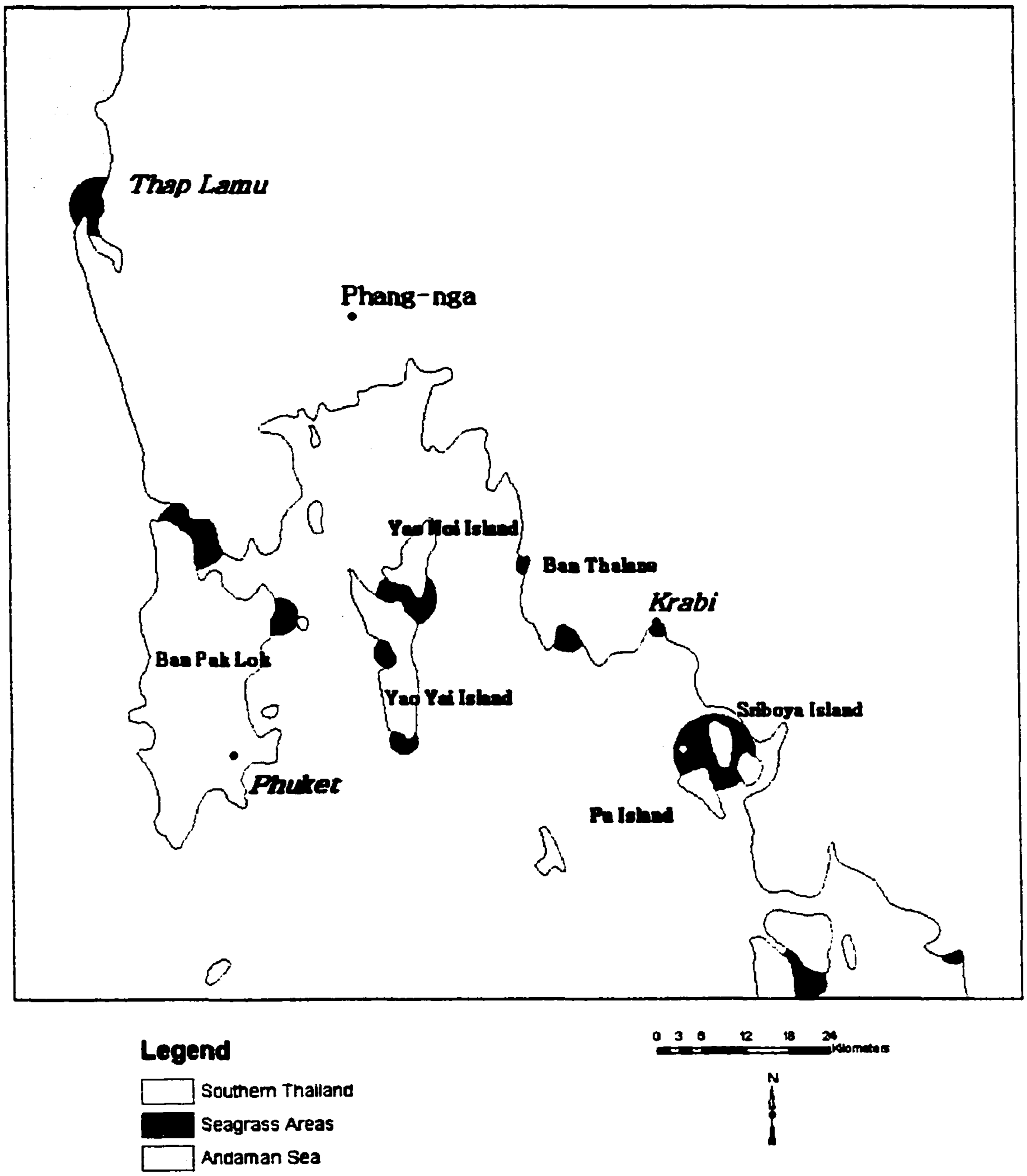


Figure 9. Seagrass beds and possible survey sites between Thap Lamu and the Three Islands, (Sriboya, Pu, and Hang).

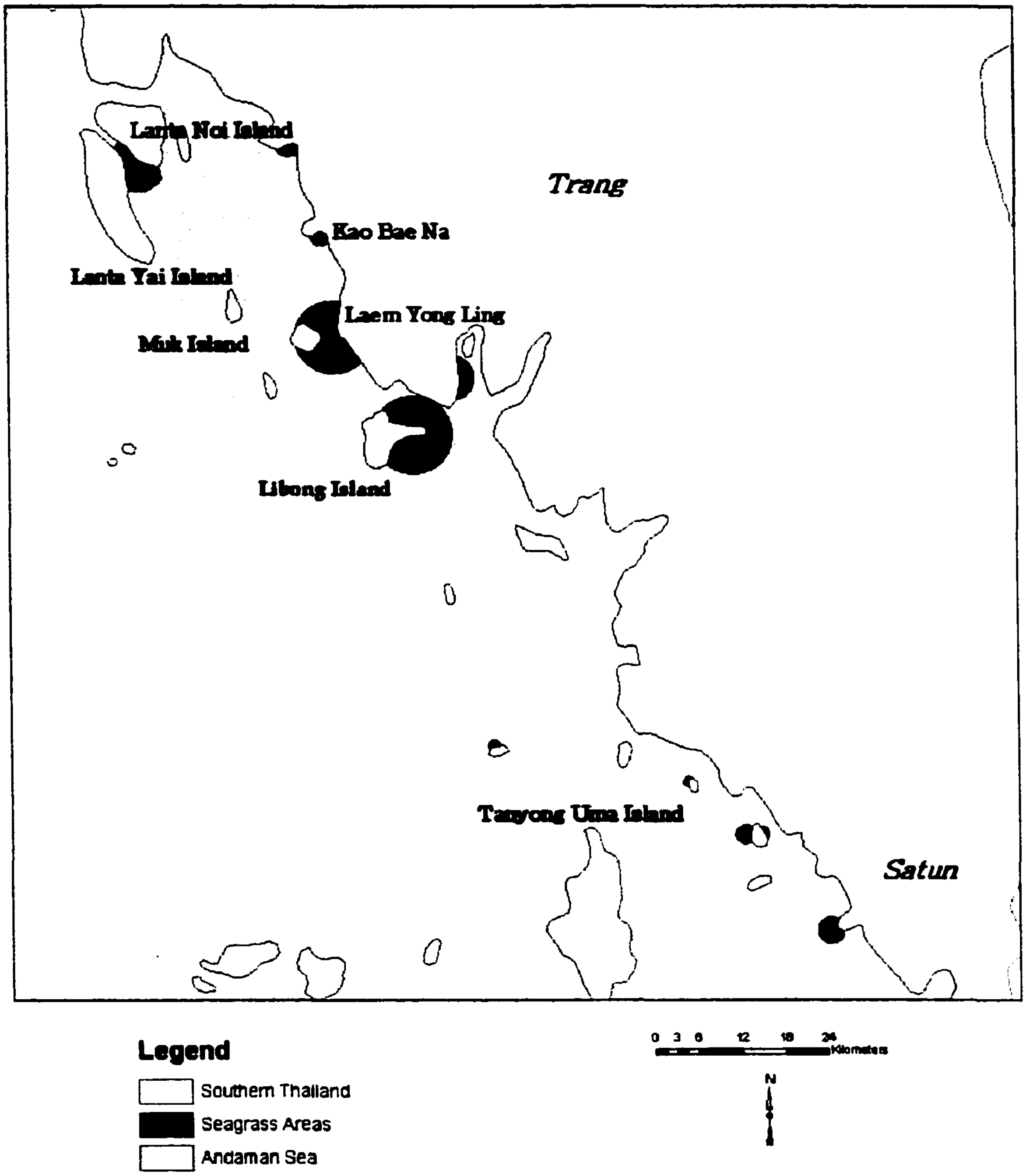


Figure 10. Seagrass beds and possible survey sites between Lanta Noi Island and Satun.

3.5 Research Design

The first objective for this case study was to establish a baseline of information about present dugong population and seagrass species and bed locations and abundance. In order to obtain this information, the second objective, the creation of repeatable and practical field protocols, was necessary to monitor both dugong population groups and seagrass habitat. Systematic transect surveys have not been done for dugongs in Thailand previous to this research. Line and point transect sampling of seagrass species and bed locations has been done along the Andaman coast by several Thai researchers Poochaviranon & Adulyanukosol 1999, Purintavaragul *et al.* 1999, Lewmanomont *et al.* 1996, Supanwanid *et al.* 1996, Chansang & Poovachiranon 1994, Poochaviranon & Chansang 1994, Poochaviranon *et al.* 1994, Pummawan & Deetae 1993, Chansang et al 1989). Specific criteria for establishing my field methods were the creation of field techniques appropriate for the spatial scale and location of the study area, local budgetary constraints, and available logistical support (Aragones *et al.* 1997). For future monitoring, the survey techniques also needed to be straightforward enough that local personnel can be trained in these research methods. Field sites for this project were chosen from both previous dugong and seagrass surveys and from consultations with Thai seagrass and dugong scientists.

In the following sections, I describe in detail the field methods that were created to achieve these objectives. To summarize, in each of these sites, aerial surveys were carried out to detect the presence and abundance of dugongs, and to observe the locations of seagrass beds. Line transects and boat-based seagrass surveys were done in 2000, and point sampling was completed in seagrass beds during the 2001 field season. I interviewed villagers in areas nearby the field sites to discover whether dugongs had been observed by local fishers either in the past or recently. The interviews were also directed towards ascertaining the historical and modern cultural and economic influence of the dugong in the lives of villagers, and local opinions about the importance of dugong and seagrass conservation.

3.5.1 Aerial Surveys

Aerial surveys are the most applicable survey method for dugongs as the animals are (Aragones *et al.* 1997):

1. Easily identified from the air.
2. Mainly aggregated in coastal areas.
3. Difficult to see from boats.
4. In relatively small groups.

The only method available to directly count dugongs is from the air, and the only quantitative information on dugong population size is based on aerial surveys (Marsh 1995*a*, Hudson 1981). Information on manatee distribution and population abundance in Florida is also obtained from aerial surveys, which have been conducted since 1967 (Ackerman 1995, Lefebvre *et al.* 1995). The first aerial survey for dugongs was in Mozambique in 1970 (Hughes & Oxley-Oxland 1971). Most subsequent surveys have been in Australia, the first in the Townsville area of North Queensland in 1974 (Marsh 1995*a*, Heinsohn *et al.* 1976). Aerial surveys for dugongs have been carried out in Kenya, Papua New Guinea, Palau, Irian Jaya and Ambon Island in Indonesia, the Arabian Gulf, Djibouti, and Vanuatu (de Iongh *et al.* 1995, Marsh 1995*b*, Chambers *et al.* 1989, Rathbun *et al.* 1988, Robineau & Rose 1982, and Hudson 1981).

During the two years of aerial surveys for this project, a helicopter was first used to perform extended area surveys along the entire coast to determine the distribution and obtain a qualitative estimate of the abundance of dugongs and seagrass (Aragones *et al.* 1997, Lefebvre *et al.* 1995). The microlite, a single-engine light plane was then used for more detailed surveys in areas that either had the most sightings in the helicopter surveys, or were reported to have groups of dugongs by interview respondents or Thai researchers (Aragones *et al.* 1997).

3.5.1.1 Helicopter Surveys

In both 2000 and 2001, through the efforts of the Department of Fisheries in Bangkok, the Thai government donated to the project the use of a small Bell helicopter, along with a pilot, a co-pilot, and a flight engineer. Each year during the dry season, February through April, I conducted 3 consecutive days of helicopter surveys of the entire Andaman coast from Ranong to Satun Provinces. The purpose of this initial survey was to assess areas with dugong presence based on previous surveys and observed seagrass areas (Whiting 1999). I also flew over previously unsurveyed regions. In this way, I used the helicopter surveys to acquaint myself with the locations and overall conditions of seagrass beds along the coast, and on where to direct more rigorous research efforts.

In 2000 we flew along the coast at an altitude of 304.8 meters and an average speed of 70 knots at times of high tide (Tide Tables, Hydrographic Department, Royal Thai Navy 2000). The average altitude was 121 meters in 2001, and the on-effort speed varied between 45 and 80 knots again at high tide (Tide Tables, Hydrographic Department, Royal Thai Navy 2001). Latitude and longitude positions of all sightings and routes were recorded in a global positioning system (GPS) for later creation of digital maps. When either the three observers or the pilot sighted dugongs, cetaceans, or turtles, the helicopter circled overhead until position, species, and group size were documented. At this time, we did not attempt to fly in transect lines, instead concentrating effort in lines parallel to the coast and around islands

(Figure 11, Figure 12).

3.5.1.2. Microlite Strip Transect Surveys

I used transect surveys to sample representative areas and statistically estimate abundance and densities of dugongs to the total area (Burnham *et al.* 1980). Manatee researchers have established the advantages of transect methods over total coverage surveys for the following reasons (Miller *et al.* 1998, Ackerman 1995, Lefebvre *et al.* 1995):

1. In practice a total count is seldom possible.
2. Lower cost
3. Increased ease of navigation
4. Reduced likelihood of double-counting
5. Reduced observer fatigue

While line-transect sampling is recommended for boat-based and aerial surveys for cetaceans (Forney *et al.* 1991, Barlow 1988), dugongs are more difficult to sight because they are often solitary or in cow-calf pairs, and often in turbid water (Marsh 1995*a*).

Strip, or fixed-width transect techniques are recommended for dugong aerial surveys, and for other marine mammal aerial surveys where the aircraft is moving rapidly. At the speeds required to safely fly aircraft it is difficult to correctly assess perpendicular distances from the aircraft while searching the field of view and counting animals (Miller *et al.* 1998, Marsh 1995*a*, Marsh & Sinclair 1989*a,b*, Barlow *et al.* 1988, Leatherwood *et al.* 1978).

Strip transects are a strip or sampling block of length L and width $2w$. In a formal strip transect the assumption is made that all objects within the census area are detected. In a line transect survey, this assumption is relaxed, and a detection function $g(y)$ is used to assess the probability of detecting an object at a given distance (Buckland *et al.* 1993). Marsh &

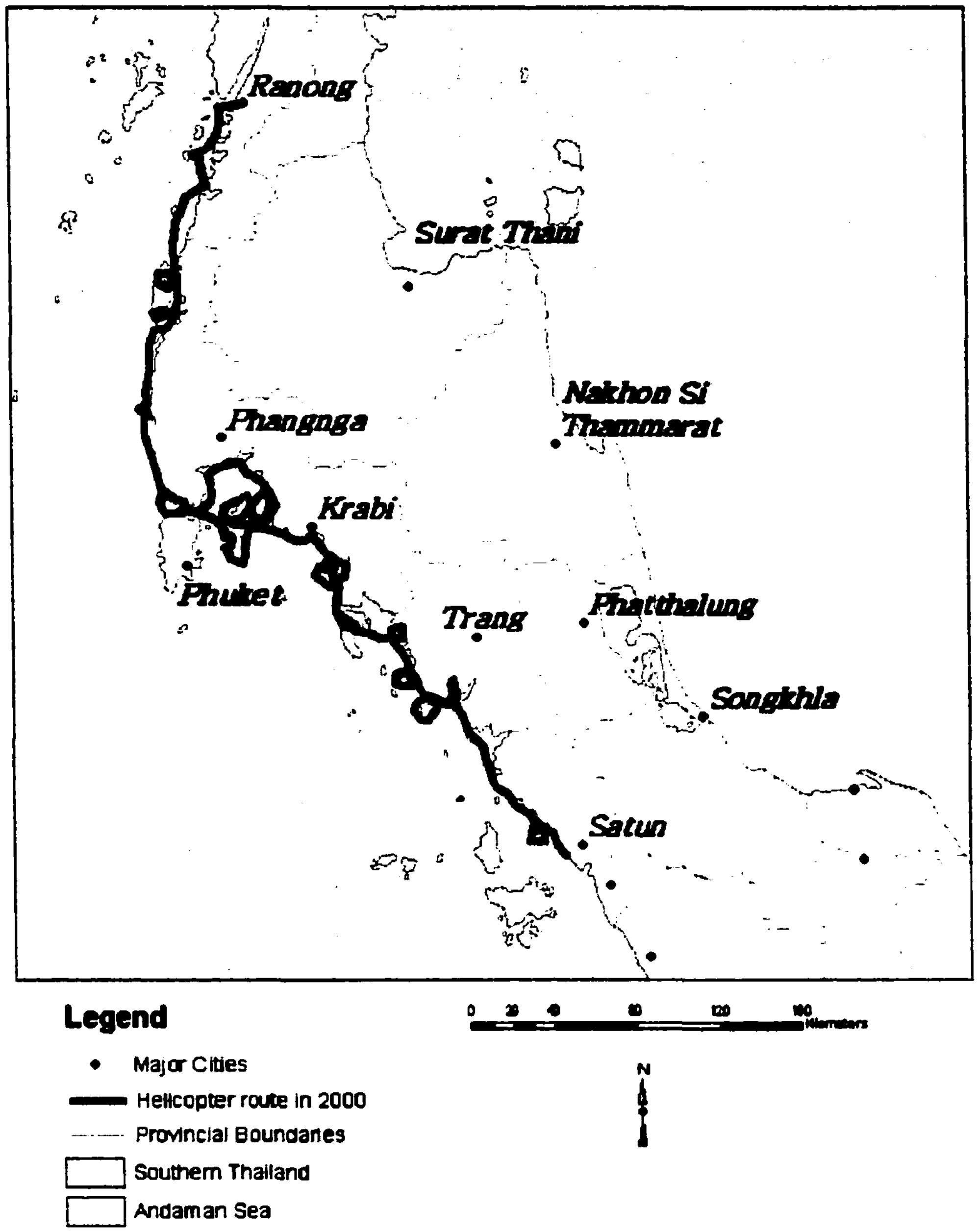


Figure 11. Helicopter survey route along the Andaman coast in the 2000 field season.

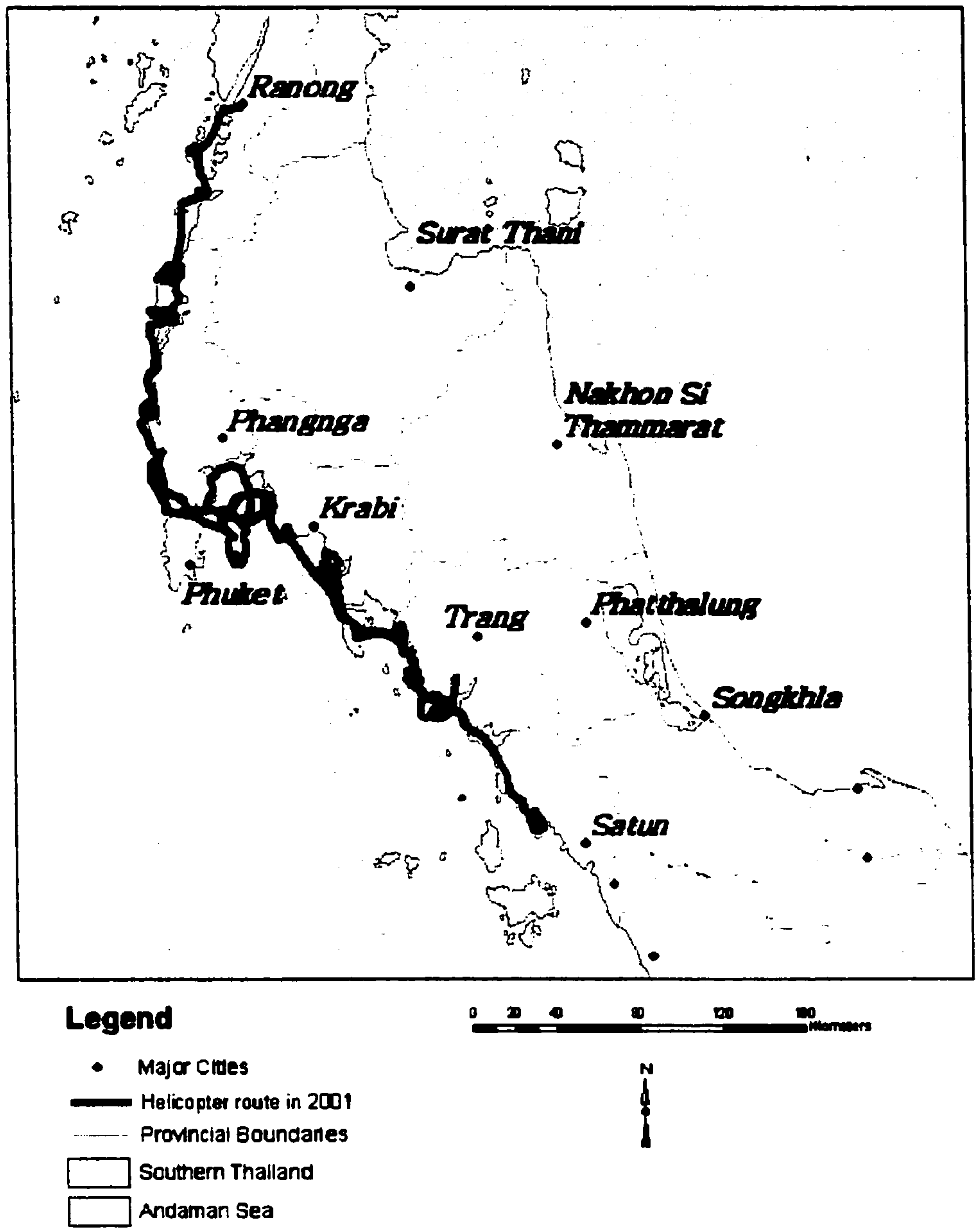


Figure 12. Helicopter survey route along the Andaman coast in the 2001 field season.

Sinclair (1989*a,b*) have created methods to correct for factors in survey conditions that would cause dugongs within the transect strip to not be observed. They have defined perception bias as animals potentially visible that are overlooked by observers, and availability bias as the number of animals unseen by observers because of uncontrollable factors such as water turbidity, glare, group size, and animal behavior (Marsh 1995*a*, Marsh & Sinclair 1989*a*, Bayliss 1986).

I used the microlite to fly predetermined transects to assess population locations and numbers in Trang province in both years, as well as the Three Islands area in Krabi in 2000. In 2001, I flew transects along the northeast coast of Phuket Island in Phuket province, and the Yao Islands in Phang-nga Bay (Figure 3). Transect aspects were chosen a priori for repeatability, to be perpendicular to shore, and to take advantage of visible endpoints both on land and in the water (e.g. buoys, limestone outcroppings).

To reduce the variance between the number of sightings found on transect lines, the transect lines should ideally be placed parallel to the density gradient of the distribution of the group of animals (Yoshida *et al.* 1997). Dugongs are generally found in more shallow waters, and while feeding will be in waters at most 11-12 meters deep, based on the distribution of seagrass (Reynolds & Odell 1991). Therefore, the density gradient is most probably perpendicular to the shoreline and I placed the transect lines in that approximate aspect as well.

I used bathymetric maps from the Hydrographic Department of the Royal Thai Navy to plan the path and bearing of each transect for the various areas. When I created the transect bearings in Krabi province, as well as in Phuket and the Yao Islands, I used a slightly zigzag pattern in order to equalize the effort on all parts of the transect line (Dahlheim *et al.*2000, Buckland *et al.* 1993) (Figure 13 and Figure 14). In Trang for both years, I estimated the time it took to turn the microlite from one transect to another, and subtracted that time from effort calculations (Wade, pers. comm. 2001) (Figure 15). In 2001, I added a small area and 4 more transect lines to the Trang transect to survey a nearby estuary where I observed that the seagrass had increased both in area and cover percentage since 2000, and the microlite pilot had noticed dugongs during the past year (Figure 15).

At least 5 transect lines should be surveyed, with 10 or more being preferred in order to get a more reliable population estimate (Burnham *et al.* 1980). In Trang, in 2000, I flew 45 transects, and in 2001, with the addition of the estuary, 49 transects. In the Three Islands area, I created 20 zigzag transects, and flew a single line over a narrow seagrass area between two islands (Figure 13). In Phuket, I flew 9 transects, as the area of interest was limited in size, and in the Yao Islands, 36 transects (Figure 14).

For more accurate areal estimation of the transect areas, and for subsequent calculation of differences in density, I created blocks, or sampling strata, around each group of transects (Wade, pers. comm. 2001, Marsh 1995*a*, Bayliss 1986) (Figures 13, 14, and 15). Table 3 shows the area of the sampling strata, and the length of transects.

In 2000, the transects were run at a predefined interval of between 400 and 500 meters, at aspects perpendicular to shore, starting from 2 to 2.5 hours before high tide (Tide Tables, Hydrographic Department, Royal Thai Navy 2000). In 2001, transects began at more variable times, from 1.5 to 2.5 hours before high tide (Tide Tables, Hydrographic Department, Royal Thai Navy 2001). The microlite flew at an average height of 152.4 meters, and an average speed of 46.5 knots. Visibility from the microlite was approximately 200 m on each side. I established this measurement by marking an area of the

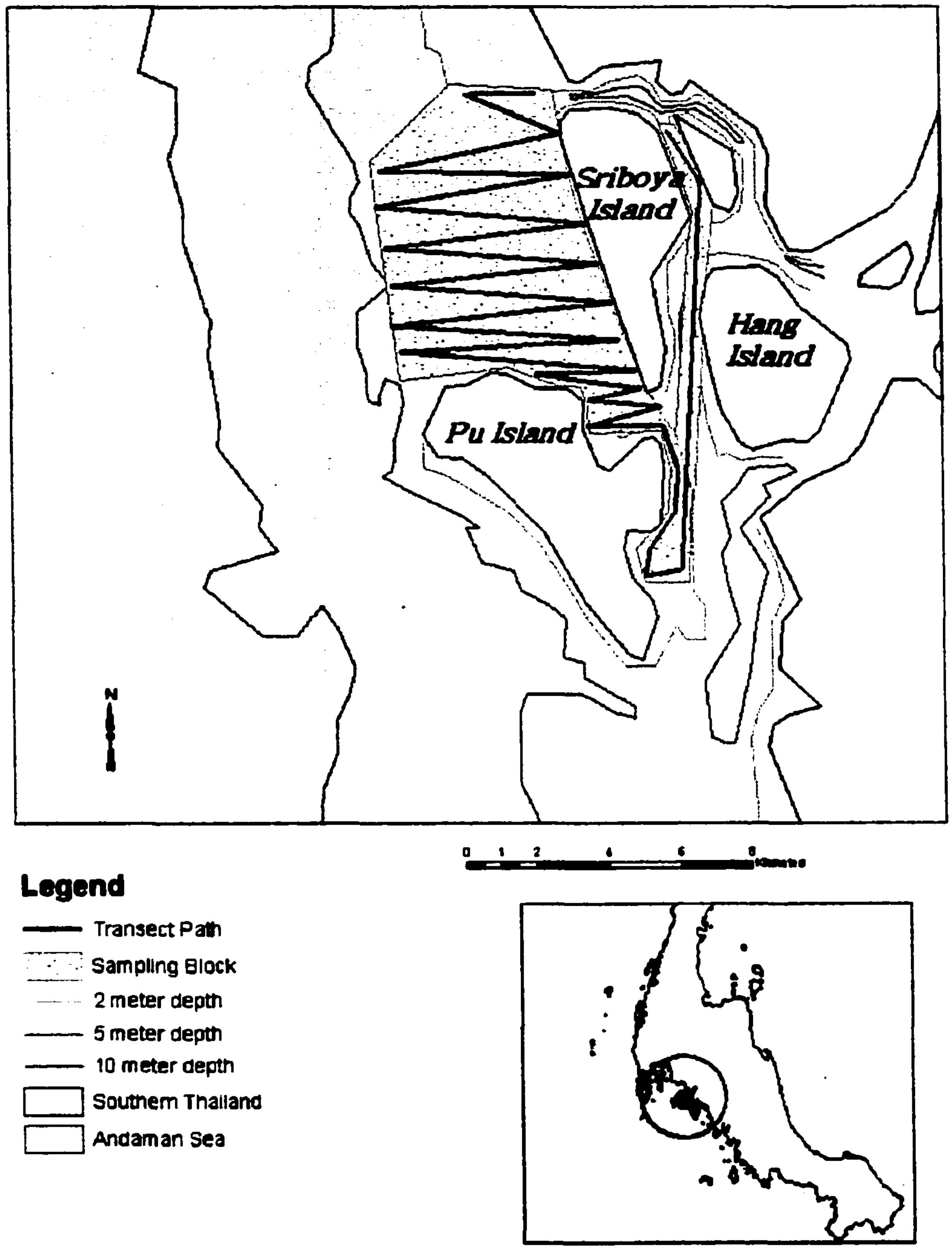


Figure 13. The transect path and sampling block in the Three Islands area, Krabi Province.

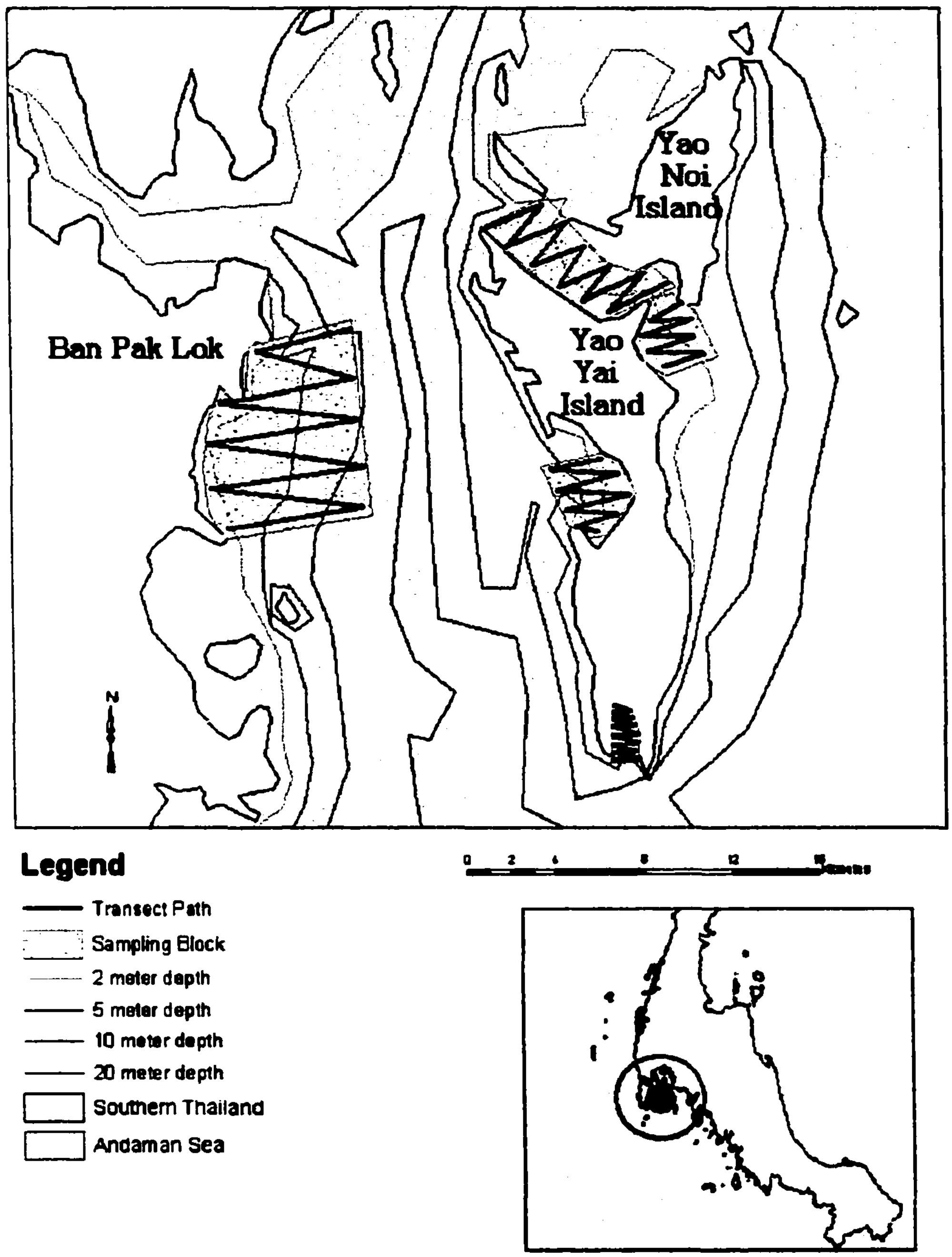


Figure 14. The transect path and sampling block in Ban Pak Lok (Phuket Province) and the Yao Islands (Phang-nga Province).

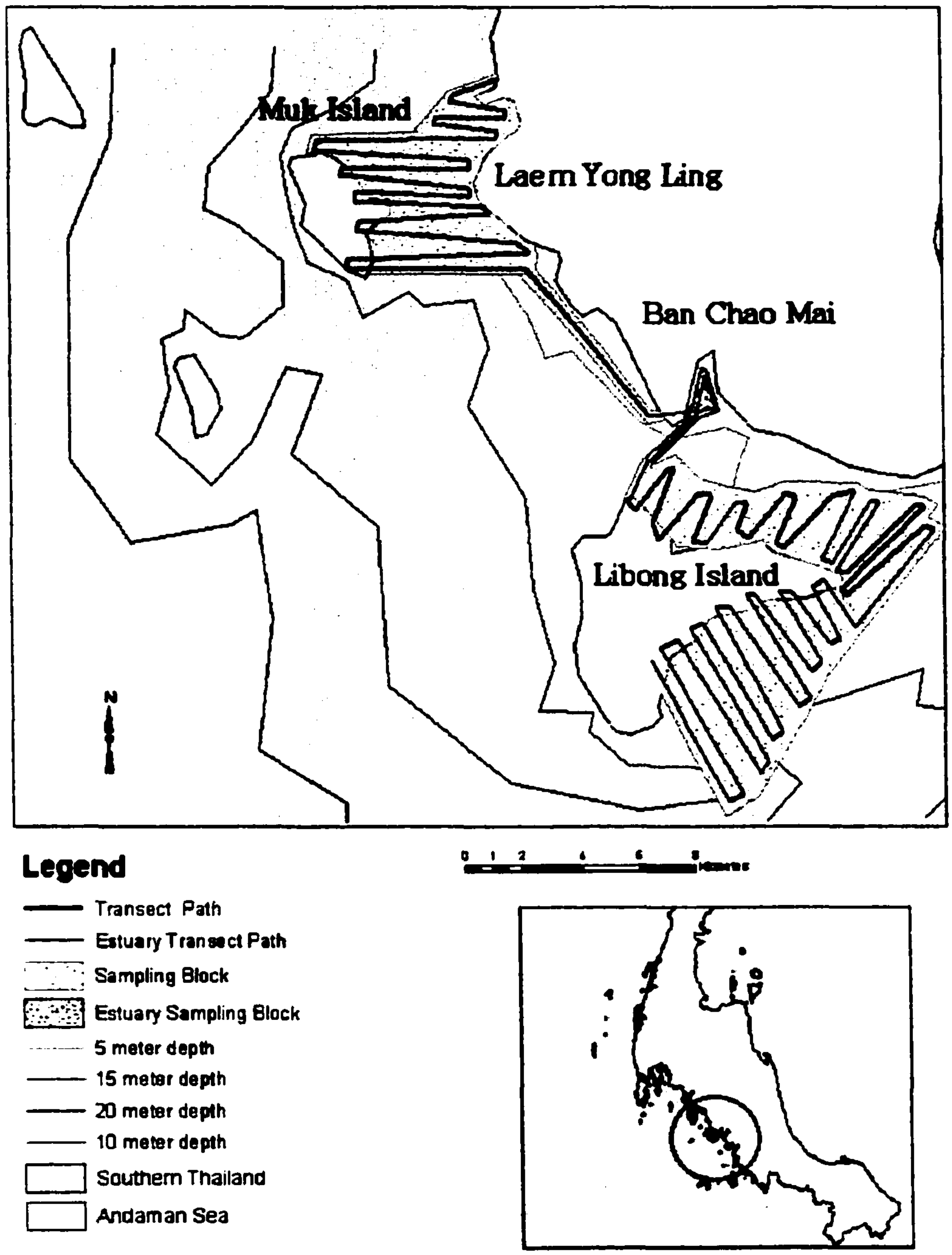


Figure 15. The transect path and sampling block in Trang province.
The estuary sampling block by Ban Chao Mai was added for the 2001 field season.

Table 3: Areas of sampling strata, and lengths of strip transects.

Area	**Year**	**Strata number**	**Area (km^2)**	**Length of transect (km)**
Trang	2000 / 2001	1	29.24	59.11
Trang	2000 / 2001	2	3.25	6.73
Trang	2001	3	1.68	6.02
Trang	2000 / 2001	4	29.29	42.77
Trang	2000 / 2001	5	31.43	53.58
3 Island	2000	1	60.28	105.19
Phuket	2001	1	58.56	55.13
Yao Islands	2001	1	20.01	29.40
Yao Islands	2001	2	8.82	15.10
Yao Islands	2001	3	2.95	14.62

Total area surveyed: 245.51 Square Kilometers

Total length of transects: 387.65 Kilometers

beach using a measuring tape and then placing markers on the sand that could be seen from the microlite at 500 meters. I then noted a place on the struts of the microlite corresponding with that distance. Two hundred meter visibility from an aircraft has been calculated for 137 meters of altitude by Marsh *et al.* 1996, Marsh 1995*a*, Marsh *et al.* 1994, Bayliss & Freeland 1989, Marsh & Sinclair 1989*a,b*, and Bayliss 1986. This altitude is considered sufficiently narrow to prevent repeated sightings while allowing adequate visibility (Marsh 1995*a*, Marsh

& Saalfeld 1990). The extra 15.4 meters in altitude was necessary for safety in the microlite, because of the lightness of the plane.

The elevation and the path of the microlite was slightly variable while on transect because of the wind. However, the field of view from the microlite as well as the generally clear water allowed me to see both sides and the front of the transect area with ease. Due to the maneuverability of the aircraft, when an animal or group of animals was seen, it was easy to circle at lower altitude for further information without the sound of the aircraft scaring the animal (as in the helicopter). When either the pilot or myself sighted dugongs, cetaceans, or turtles, the microlite circled overhead until position, species, number of calves, group size, and behavior were documented. We then returned to the transect line.

To decrease the chances of perception bias, I did not consider a sighting confirmed unless both the pilot and I saw the animal. To minimize availability bias, I planned the flights for early morning, for less glare from the sun, and clouds that usually became more numerous later in the day. Since the time for field surveys was limited, and I had to fly at specific tidal levels, this was not always possible. The turbidity of the water was also unpredictably variable, though worse as the spring tides approached.

Latitude and longitude positions of all sightings and routes were recorded in a global positioning system (GPS) for later creation of digital maps. I also recorded the time, weather, tidal level, and Beaufort sea state (Appendix 9.3). In 2000, Kanjana Adulyanukosol from the MESU joined me for the Three Island transects, and in 2001 we worked together in Phuket and Trang.

I used the program DISTANCE (Thomas *et al.* 1998) for statistical calculations of population abundance and density. Distance is a statistical program created for wildlife population estimation, widely used among marine mammal scientists (Thomas *et al.* 1998, Buckland *et al.* 1993, Wade, pers. comm. 2001). To analyze strip transects in Distance, I used a uniform detection function model with 0 adjustments terms (Buckland *et al.* 1993, Strindberg, pers. comm. 2000). A detection function is $g(x)$, or the probability of detecting an object, given that it is at a distance x from the random point or line (Distance 3.5 Program Reference, Thomas *et al.* 1998). Under these model definitions, the program assumes a probability of detection of 1 between 0 distance from the observer and the truncation distance. I set the truncation distance here as 200 meters, or half the estimated width of the strip.

3.5.2 Habitat Assessment

An objective of this case study is to determine the distribution and species of seagrass beds considered to be suitable habitat for dugongs. Aerial photos are regarded as the standard source of data for the spatial monitoring of seagrass, and have been used for previous projects in this area (Ferguson & Korfmacher 1997, Chansang & Poovachiranon 1994). I purchased black and white aerial photos of seagrass areas with known populations of dugongs at a scale of 1:15,000 from the Thai Department of Defense.

In 2000, I placed transects perpendicular to shore in sites in Kuraburi and Trang to determine seagrass species composition and percentage cover in the areas where dugongs have been reported. At sites in the Yao Islands and the Three Islands area, I surveyed the seagrass beds by boat, gathered samples of seagrass, and determined the species in each area (Figure 16). Transects and methods of visual and sampling assessment were performed according to baseline and monitoring methods established by English *et al.*

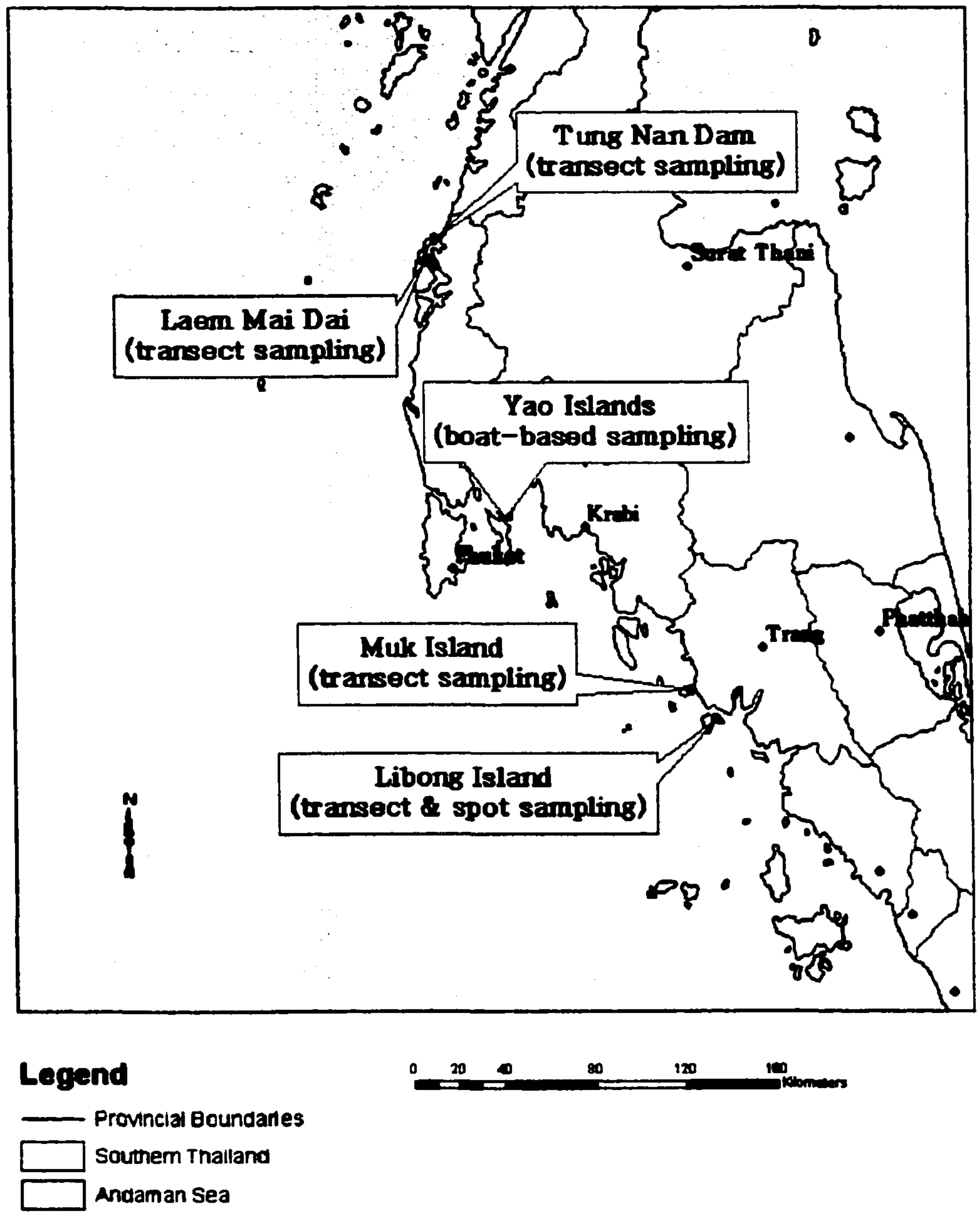


Figure 16. Seagrass field sites and sampling methodology for the 2000 and 2001 field seasons.

(1997), Coles *et al.* (1995), and Saito & Atobe (1970). At low tide, I placed 100 meter linear transects randomly across the seagrass beds perpendicular to the shore. The transects began anywhere from the high-water mark to 10 meters offshore. The lines were positioned at least 100 meters apart. Observations were made of species composition and cover percentage every 20 meters from the beginning of the line. Two 50 x 50 centimeter quadrats were placed side by side at each 20 meter observation point. I made the quadrats out of aluminum channeling, drilling holes and stringing surveying line to create twenty-five 10 x 10 centimeter areas in each one (Figure 17). I averaged the species composition and cover percentages in each quadrat section, and extrapolated those results to the area as a whole. Other variables that I recorded include substrate description, depth at mean low water, water temperature, and salinity.

I then videoed and/or photographed the transects and quadrats for a permanent record of the site. Latitude and longitude positions for the transects and quadrats were recorded in a GPS. Using these coordinates will enable future replication of these transects to monitor the seagrass beds. Specimens of seagrass from each area were collected and dried in a plant press using methodology recommended by Menĕz *et al.* (1983). Species classifications were confirmed with scientists at PMBC (Adulyanukosol, Poovachiranon, pers. comm. 2000).

In the 2001 field season, between February and April, a group of students and scientists led by Sombat Poochaviranon from the Phuket Marine Biological Center conducted seagrass sampling in association with this project. Random spot sampling was completed at 80 locations around Libong Island and in the estuary around the village of Ban Chao Mai (Figures 15 and 16). The general areas of sampling were chosen based on earlier research; previous transects in 1992, aerial surveys in 1997, and aerial photographs. During the high tide, scuba diving was used, and at low tide, researchers could walk to the sites. The sites were 10 square meters in area. Three researchers agreed on the species and percentage of cover in each location. Latitude and longitude positions were recorded in a Global Positioning System (GPS) for each spot as well as average species composition and percentage (Poochaviranon, pers. comm. 2001).

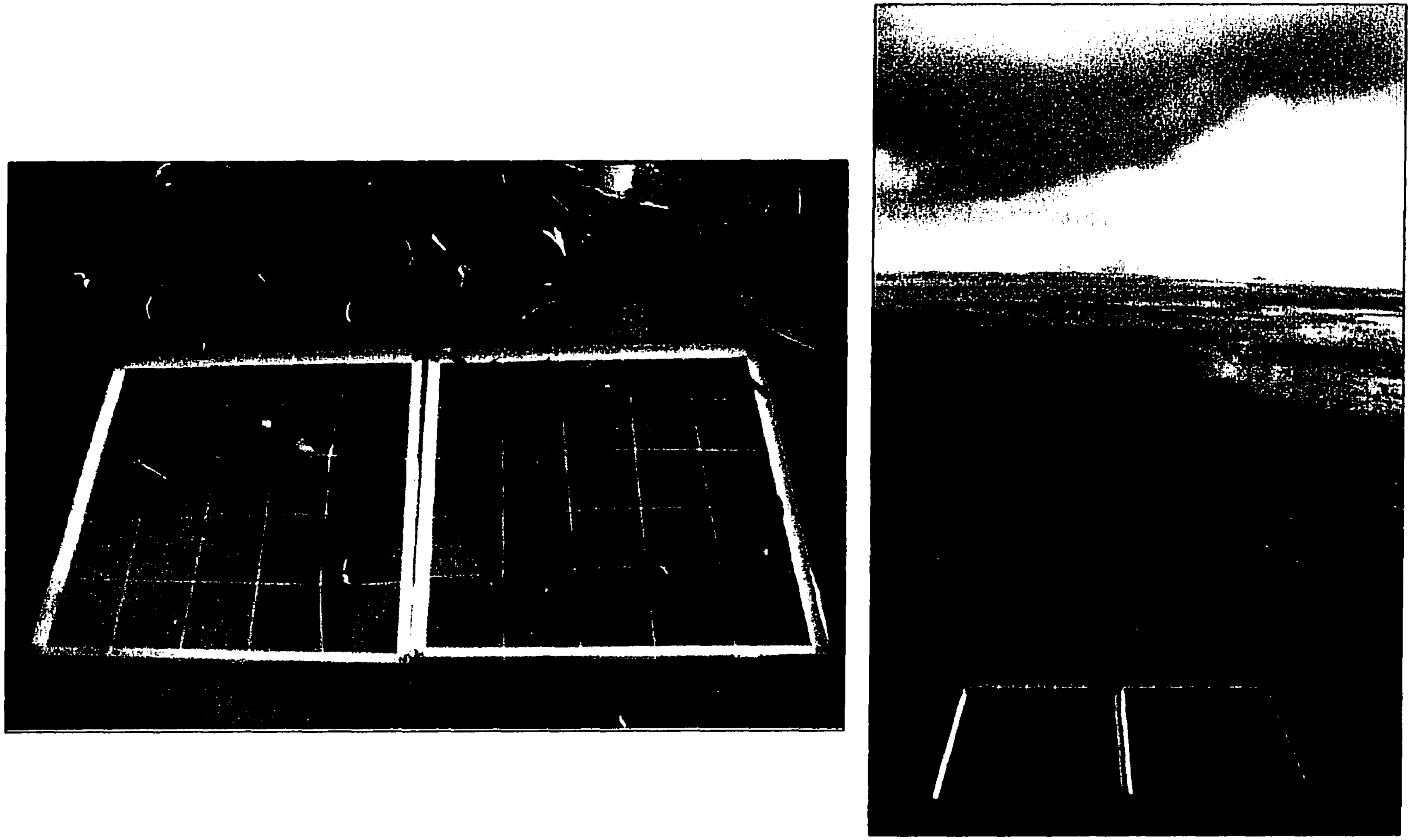


Figure 17. Examples of seagrass quadrat sampling: *Left*, the quadrats on a patch of *Enhalus acoroides*. *Right*, looking down a transect path at Muk Island (*Halophila ovalis*).

3.5.3 Interviews

The third objective is to determine the cultural and economic importance of the dugong both currently and historically in the fishing villages that border dugong populations. In terms of the first objective, especially in more remote areas, interviews are also a way to identify areas that presently or in the past have supported dugongs, and to assess dugong populations. Another advantage of interviews is that further research can be based on new information gained from interviews (Silva & Araújo 2001, Perrin *et al* 1996, Marsh & Lefebvre 1994, Chambers *et al.* 1989). The interview was also used here as an opportunity to disseminate information on the importance of conserving the dugong and seagrass beds in an area (Marsh & Lefebvre 1994, Hudson 1981).

During the two field seasons, I conducted interviews in five of the provinces that have seagrass beds capable of supporting dugongs or within which dugongs have been sighted (Adulyanukosol, Chantrapornsyl, Pitaksintorn, Poochaviranon, pers. comm.) (Figure 18). Interview respondents were chosen using several methods. In some areas I had contact names supplied by local Non-Governmental Organizations (NGOs), or other connections. I also sought to interview the heads of villages as key informants, or a person whose role in the community exposes them to the type of information being sought (Tremblay 1982). Sometimes the heads of villages or contacts within the area also recommended people to talk with. I went to stores and restaurants where people gather, and also walked through villages and stopped at houses with nets outside. I purposely tried to mix ages and genders in choosing interview respondents whenever possible. While a more random sample of interview respondents would have been optimal, I was dependent on both the limited availability of the fishers and the guidance of my contacts and translators. Also in Thai

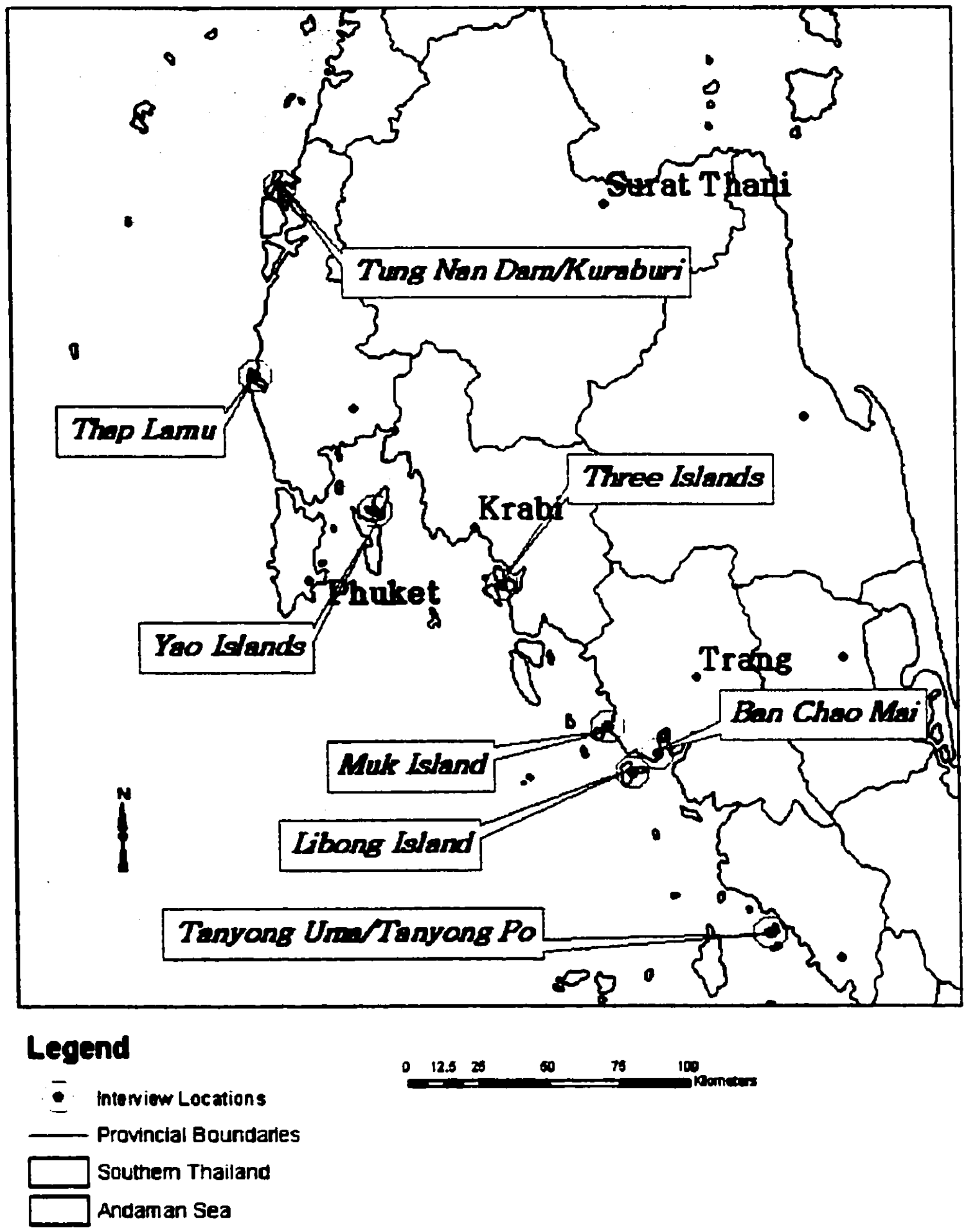


Figure 18. Interview locations along the Andaman coast for the 2000 and 2001 field seasons.

culture, it is rare to interview a single person. Respondents are more comfortable being interviewed in groups. Sometimes, if people see an interview happening, they will join in. Occasionally the original respondent or respondents will even leave or stop answering questions and let the newcomer finish the interview, depending on everyone's position within the community.

Kahn & Cannell (1958) define an interview as a "...conversation with a purpose." (as cited by Fowler & Mangione 1990). Two components are essential to any type of interview (Fowler & Mangione 1990, p. 11):

1. The substantive part of the interview consists of questions and answers.
2. The participants have defined, non-overlapping roles: one person asks the questions (the interviewer) and the other answers the questions (the respondent).

To create an environment as described above, I wrote a standardized form. The basic structure of the interview was unstructured and exploratory in nature, specifically used as an instrument to open up dialogue, rather than an empirical attitudinal survey based on a specific hypothesis and designed for quantitative analysis (Pole 2000, Verhoeven 2000, Holstein & Gubrium 1995). I used a mixture of open and closed-ended questions to get information (Fowler & Mangione 1990, Whyte 1982). Some of the questions were structured, and demanded either a fixed-response answer or a short answer (e.g. "How many dugongs have you seen in the past year?"). Several of the fixed answer questions were followed by a probe question (e.g. "Why do you think this is important or not?"). Other questions were unstructured, and encouraged free-response answers, where I wanted respondents to speak without restraint and at length (Backstrom & Hursh-César 1981). An unstructured question is particularly useful when the interviewer has limited information about the types of answers to expect, or expects a large range of answers. A free-response question can also be employed when it is important that the respondent answer freely without the influence of prompting (Backstrom & Hursh-César 1981).

Verhoeven (2000, pg. 6) writes that an unstructured cross-cultural interview has to be based on an atmosphere of mutual respect, where the interviewer is interested in all kinds of information. The interviewer in this case must guard both tone of voice and body language to ensure that the interviewee will not "loose [*sic*] face" if they misinterpret or do not know the answers to interview questions. Broadfoot (2000) agrees, emphasizing the importance of minimizing the cultural differences between interviewer and respondent during an interview session. Based on these recommendations, I chose to appear knowledge-less, receptive and grateful for any information, and to remain in the background during the interviews. The advantage of this type of approach is in gaining unanticipated and valuable information; the disadvantage is an increased difficulty in judging the reliability of responses (Broadfoot 2000).

The content of the interview questions was initially based on a questionnaire survey done by Chambers *et al.* (1989). Questions in the interviews addressed the history of interactions with dugongs, also knowledge of legends or stories or beliefs. I also asked about temporal and seasonal patterns of dugong sightings (also including sightings of whales, dolphins, and marine turtles). In other questions I inquired about past or present hunting, and sources and levels of dugong mortality. I questioned the villagers about their opinions regarding threats to dugongs, the importance of conserving dugongs and seagrass, and designating areas off-limits to fishing to conserve dugongs, seagrass, and mangroves (see Appendix 8.1 for English and Thai interview forms) (Marsh & Lefebvre 1994). I developed the questionnaire with the assistance of Dr. Noppawan Tanakanjana of the Department of Conservation at Kasetsart University in Bangkok. Her expertise is in the interviewing of villagers living in or near national parks and conservation areas in Thailand. She advised me on the cultural context of the construction of the questions and translated the interview into Thai.

The actual interviewing was done in Thai. The quantitative measurement of responses for these interviews was affected by the different language skills of the interviewers, and their varying reliance on the questionnaire. For most of the 2000 field season, the administration of the interviews was standardized. The translator for these interviews was a Canadian woman whose knowledge of the Thai language was limited. She also had no skills in translating the southern Thai dialect. Because of these difficulties, respondent understanding of the questions was sometimes compromised by incorrect translations of question wording. Subsequent translators in Thailand and Canada corrected most of these discrepancies. Native Thai speakers experienced in southern Thai dialects conducted the interviews in 2001. The first interviewer in the 2001 field season was a Thai woman who had prior experience interviewing villagers in southern Thailand. Kanjana Adulyanukosol and a research assistant from the MESU, both of whom had prior experience in interviewing procedures, conducted a second series of interviews in 2001. The research assistant was fluent in the southern Thai dialect. While the questionnaire was used as the basis for the interviews in 2001, I also encouraged the interviewers to elicit more discussion on related topics of interest to villagers (White 1986). I believe that the ensuing re-translations of these interviews are accurate enough to enable me to have confidence in the resulting measurements of responses.

4.0 RESULTS AND DISCUSSION

In the following sections I present the results of the case study for the 2000 and 2001 field seasons. In the first section, I report on the results of the aerial surveys first from the helicopters, then followed by estimates of population parameters from the microlite surveys. I will report the details of the microlite surveys in Trang province for each year, and then summarize the statistical population abundance and density estimations for both years. Then I present results of the microlite surveys in Krabi, Phuket, and the Yao Islands. The next section contains the findings of the seagrass surveys for both years, and afterwards I describe the results of the interviews in various areas around southern Thailand. The last section consists of a discussion of the results and suggestions for further research.

4.1 Aerial Surveys

4.1.1 Helicopter Surveys

Helicopter Surveys in 2000

In each of the two years of fieldwork, I employed the helicopter to survey for 3 days along the entire Andaman coast (Figures 11 and 12). In planning the flight path, I chose to spend extra effort circling areas where I and other researchers had found or heard from villagers about dugongs being present, or where we thought seagrass beds might be sufficient for dugongs to feed at.

On the 2000 helicopter survey along the coast I counted a maximum of 22 adult dugongs and 4 calves (Figure 19). The effort and sightings logs for the 2000 helicopter survey are in Appendices 8.2.1 and 8.3.1. As requested by the Thai Department of Fisheries, I also recorded between 24 and 30 sightings of dolphins, plus 2 young, and

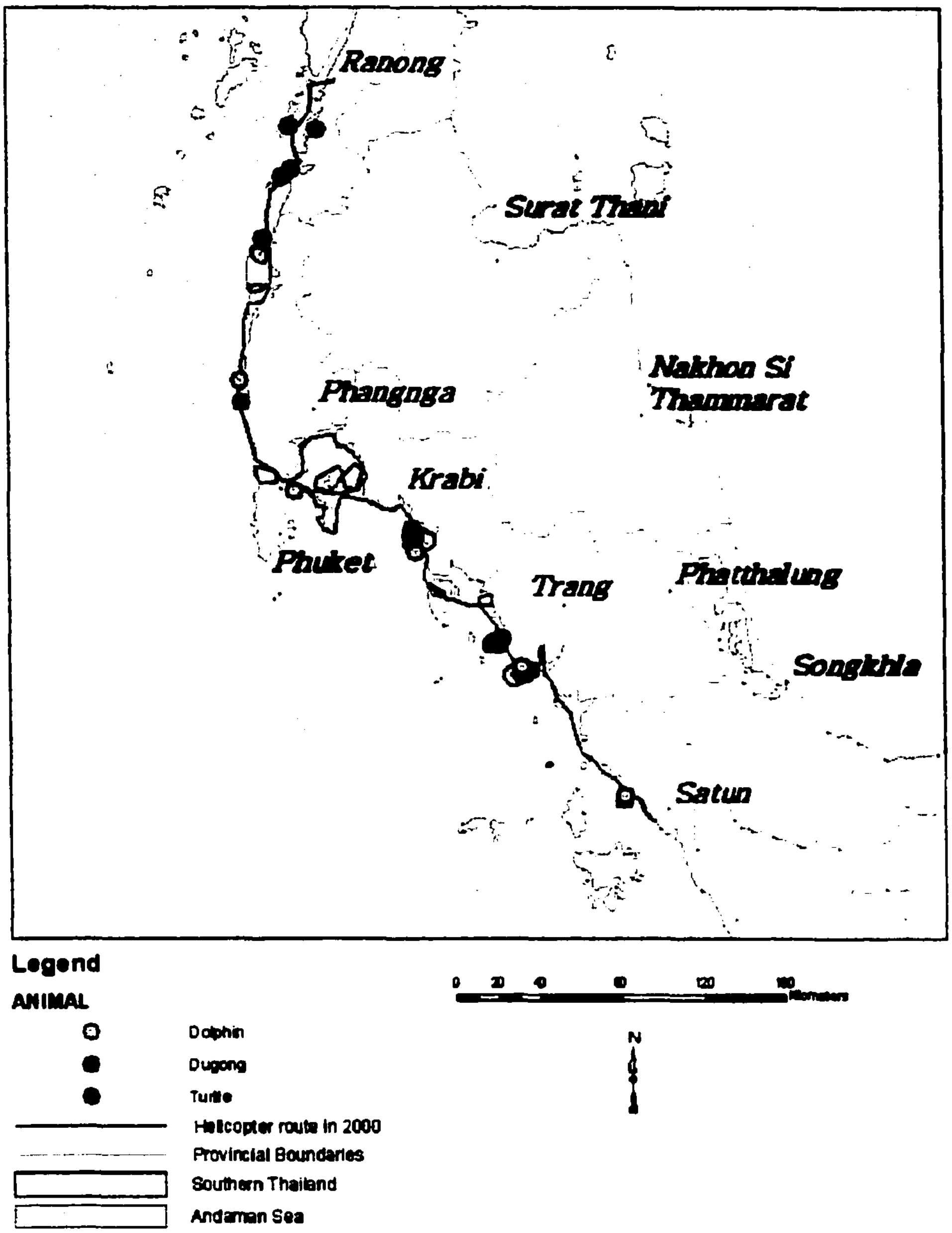


Figure 19. Sightings of dolphins, dugongs, and turtles from the helicopter survey in 2000. Please refer to the Sightings Log in the Appendix for an itemization of species and counts.

made 11 sightings of marine turtles. The dolphin species included *Tursiops aduncus*, *Orcaella brevirostris*, and *Sousa chinensis*. I noted the locations of seagrass beds along the survey path.

Helicopter Surveys in 2001

In 2001, I selected essentially the same flight path along the Andaman coast, and additionally surveyed along the northeast coast of Phuket Island, the east coast of Phang-nga Bay, and flew over seagrass beds at Bulon Le Island in Satun province (Figures 12 and 20). During the 3-day survey I saw a group of approximately 4 or 5 dugongs including one calf at Libong Island in Trang province. In Ranong province I found 2 adult dolphins and one calf (*Tursiops aduncus*) (Figure 20). The effort and sightings logs for this survey are presented in Appendices 8.2.2 and 8.3.2. During the 3 days of the survey, the water was generally turbid, and on two of the days, the weather was stormy. I did see dugong feeding trails between Yao Noi and Yao Yai Islands in the middle of Phang-nga Bay, and in Ban Thalane on the eastern coast of Phang-nga Bay,

4.1.2 Microlite Surveys

4.1.2.1.Trang Province

Microlite Surveys in 2000

In 2000, I conducted aerial surveys in Trang province on 10 days between 6 and 20 March (Figure 15). The average daily count of dugongs and calves was 38, the

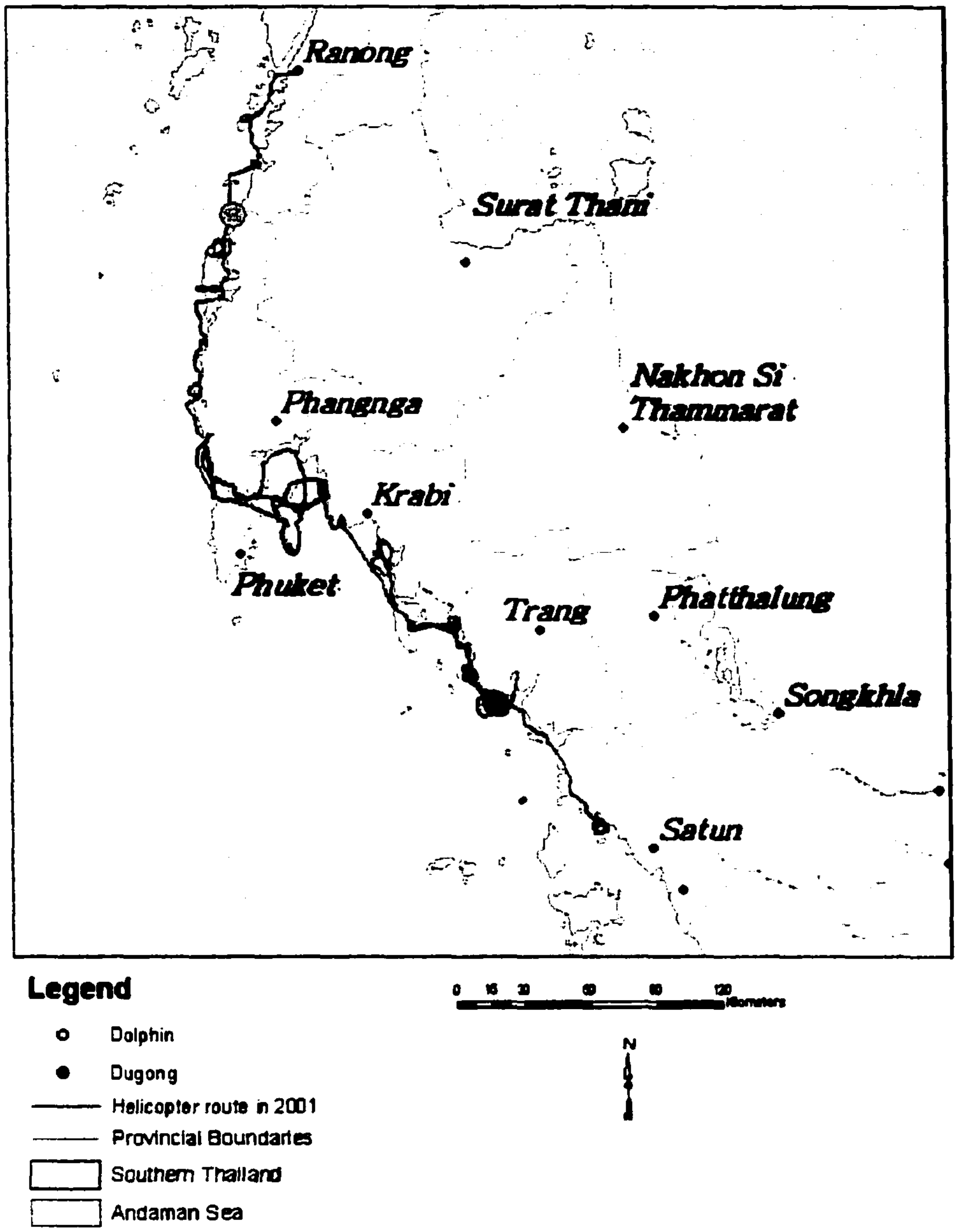


Figure 20. Sightings of dolphins and dugongs from the helicopter survey in 2001. Please refer to the Sightings Logs in the Appendix for an itemization of species and counts.

minimum 15, and the maximum 66, with a standard deviation of 16.61. The transect line extended for 162.50 linear kilometers, and the area of the sampling blocks totaled 93.21 square kilometers. The aerial surveys were conducted in clear weather conditions, with a Beaufort sea state of 1.

Figures 21 through 25 show the sightings for each day. The effort log and sightings logs are in Appendices 8.2.3 and 8.3.3. All dugongs sighted were in 5-meter depth or less at lowest low water (Thailand Hydrographic Department Maps). I recorded a total of 52 calves, an average of 5.2 daily. A minimum of 2 and a maximum of 13 calves were located in one day with a standard deviation of 3.6 (Figure 26). Out of the total number of dugongs, adults were 86% of the total, and calves, 14%. For the microlite surveys in Trang in 2000, I recorded 20.81 dugongs per hour.

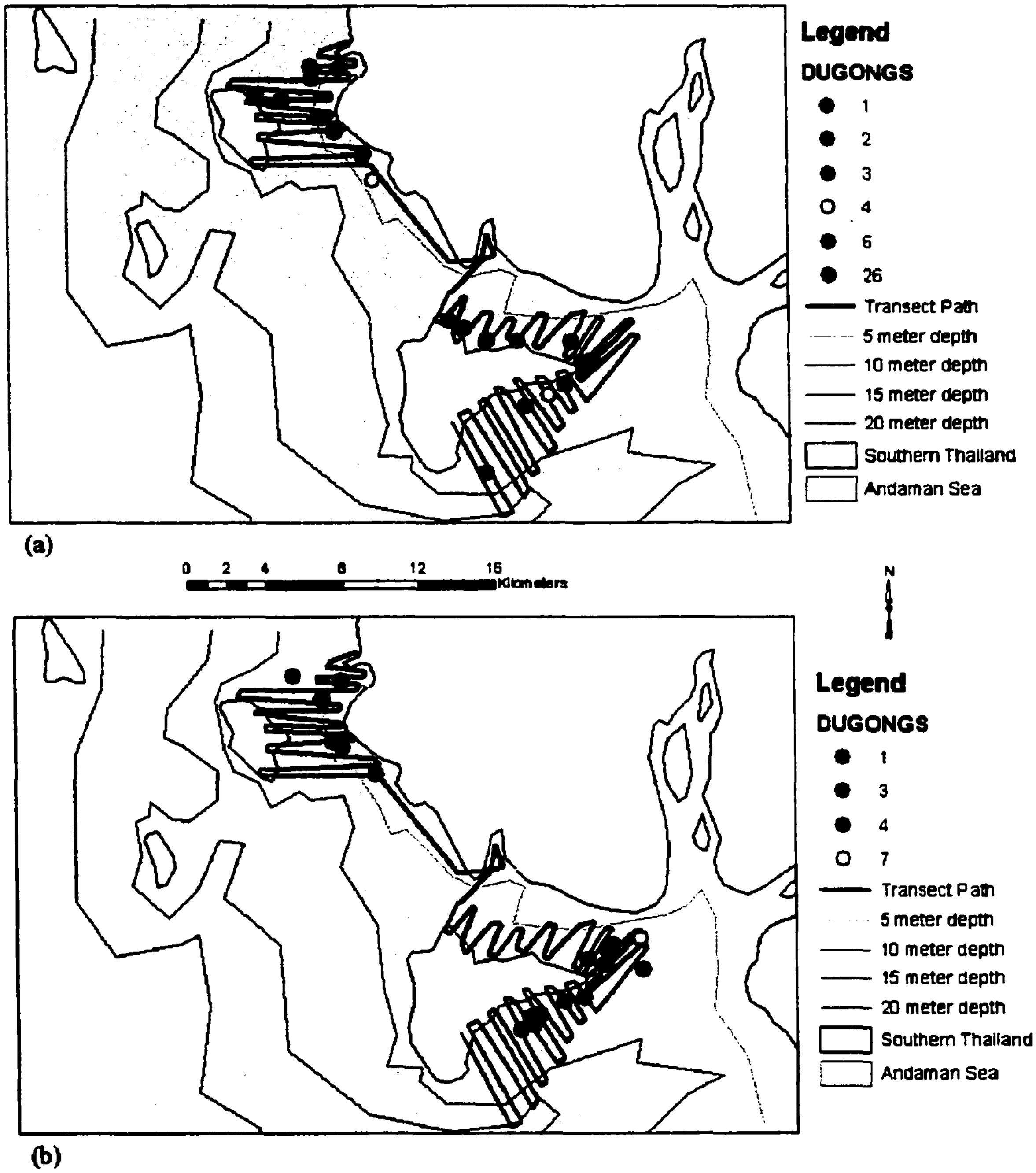


Figure 21. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 6 (a) and 7 (b), 2000.

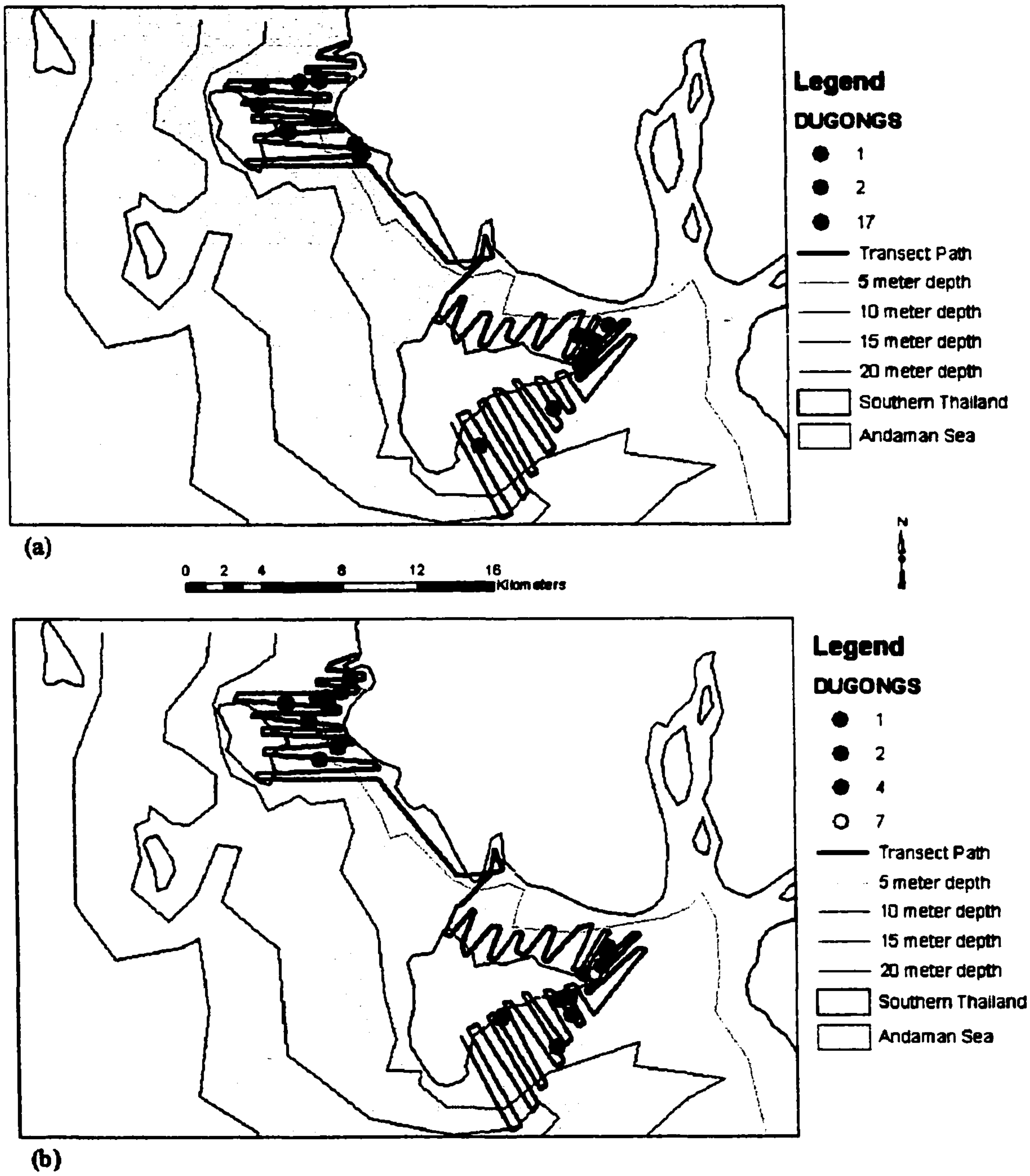


Figure 22. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 8 (a) and 9 (b), 2000.

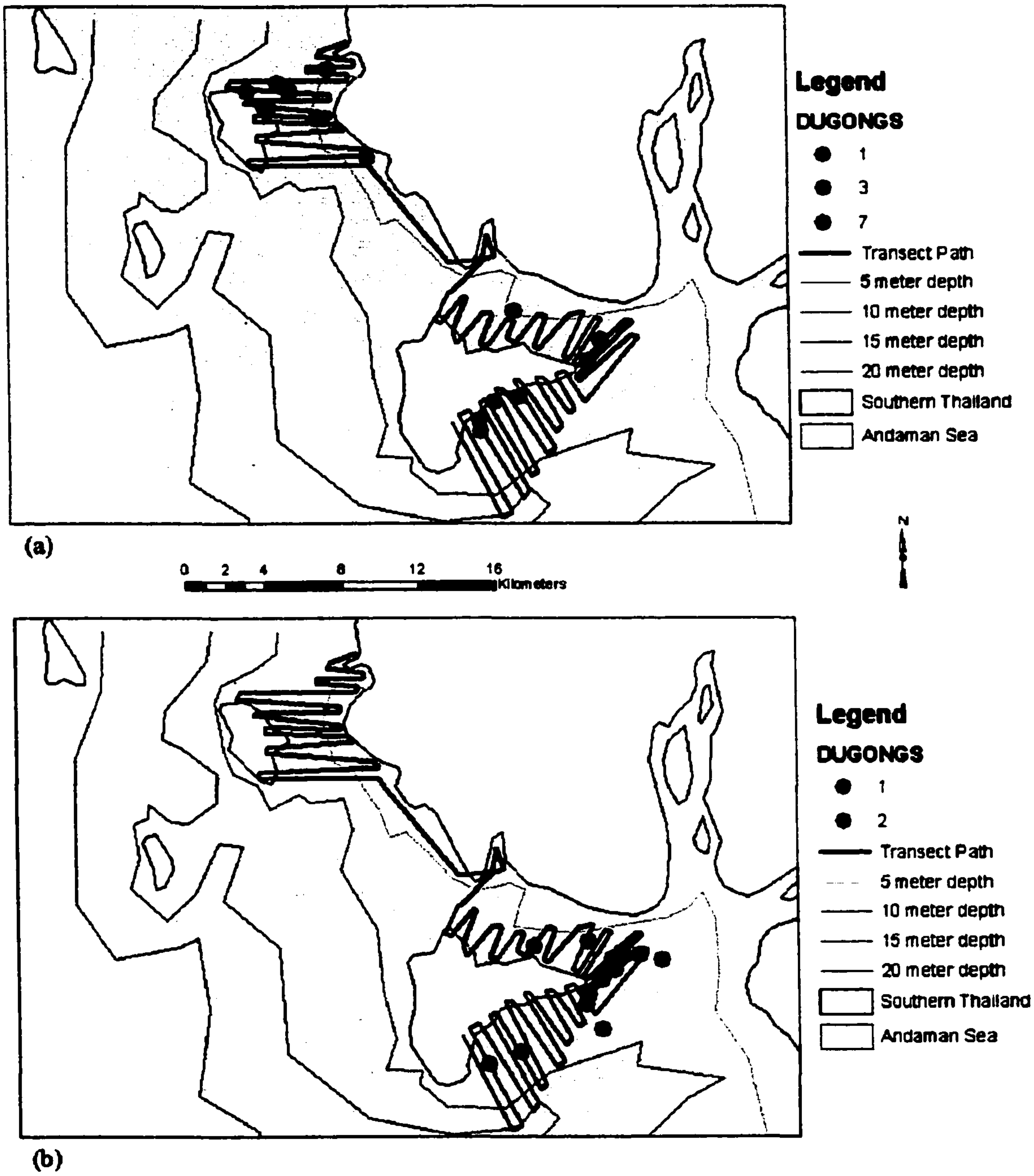


Figure 23. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 10 (a) and 13 (b), 2000.

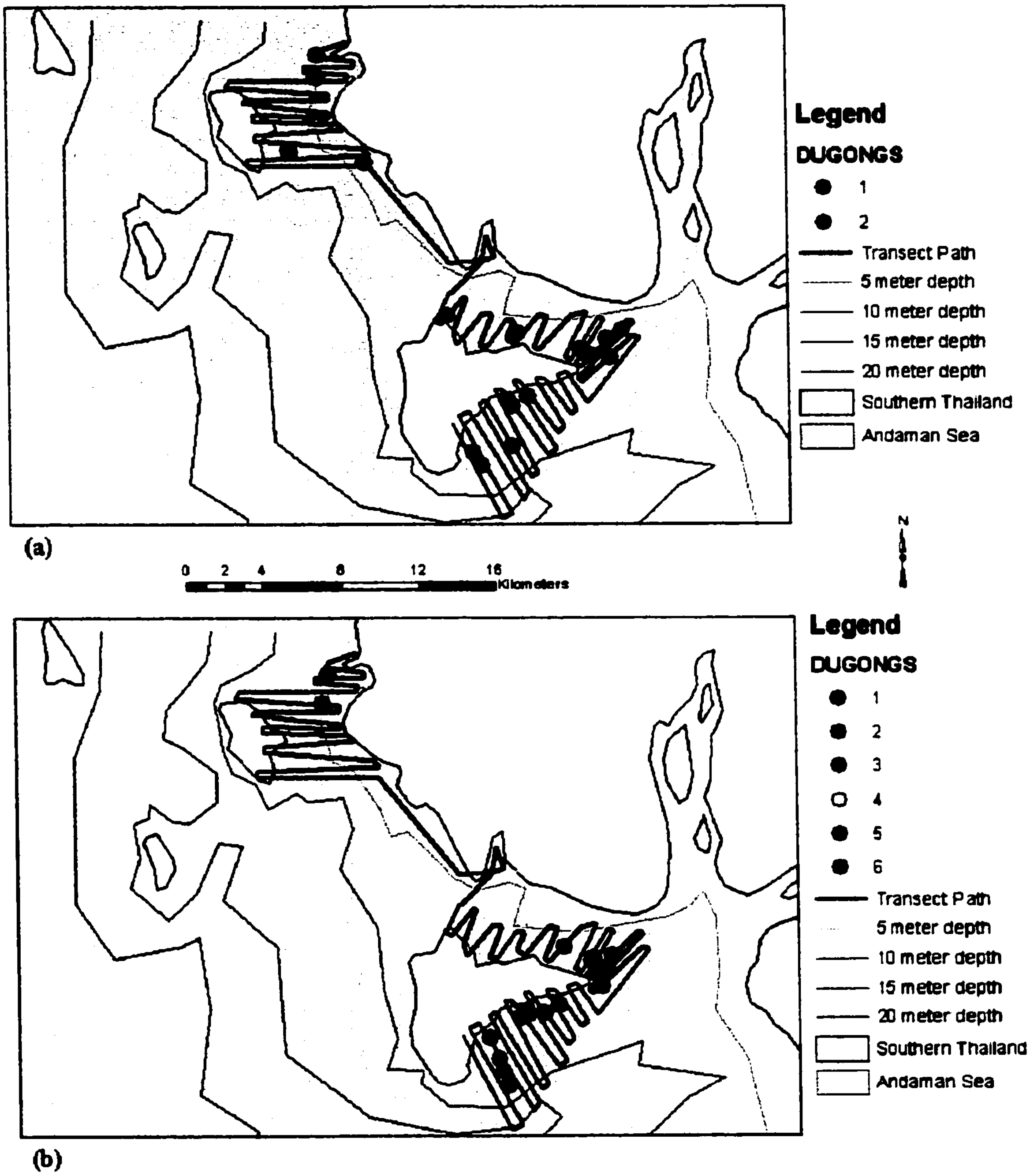
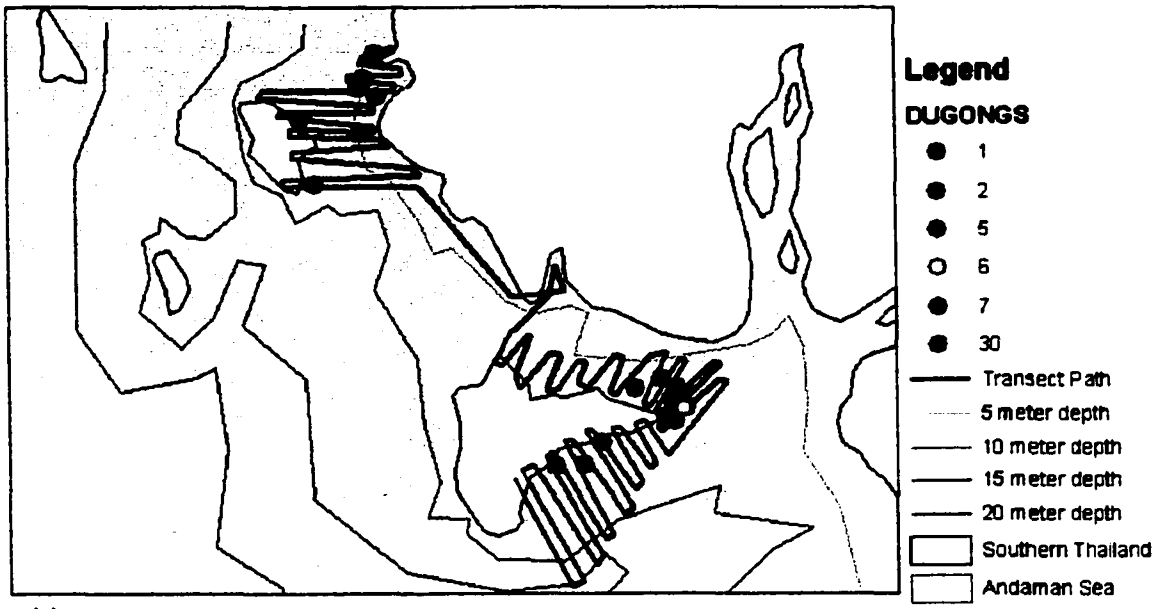
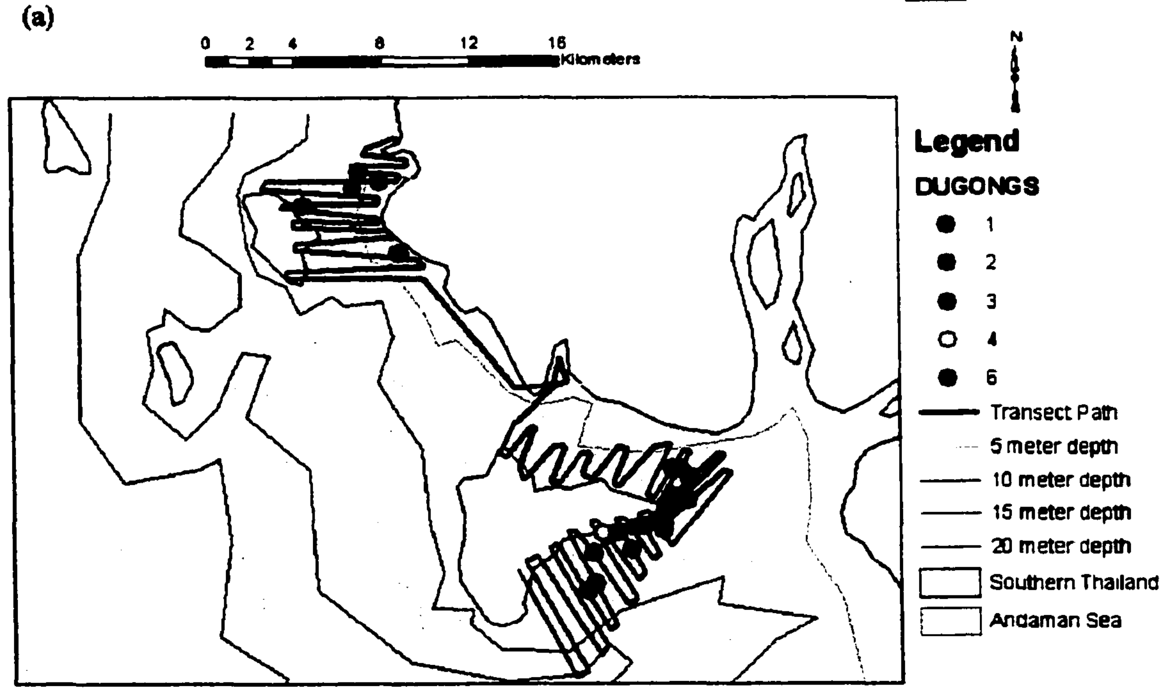


Figure 24. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 17 (a) and 18 (b), 2000.



(a)



(b)

Figure 25. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 19 (a) and 20 (b), 2000.

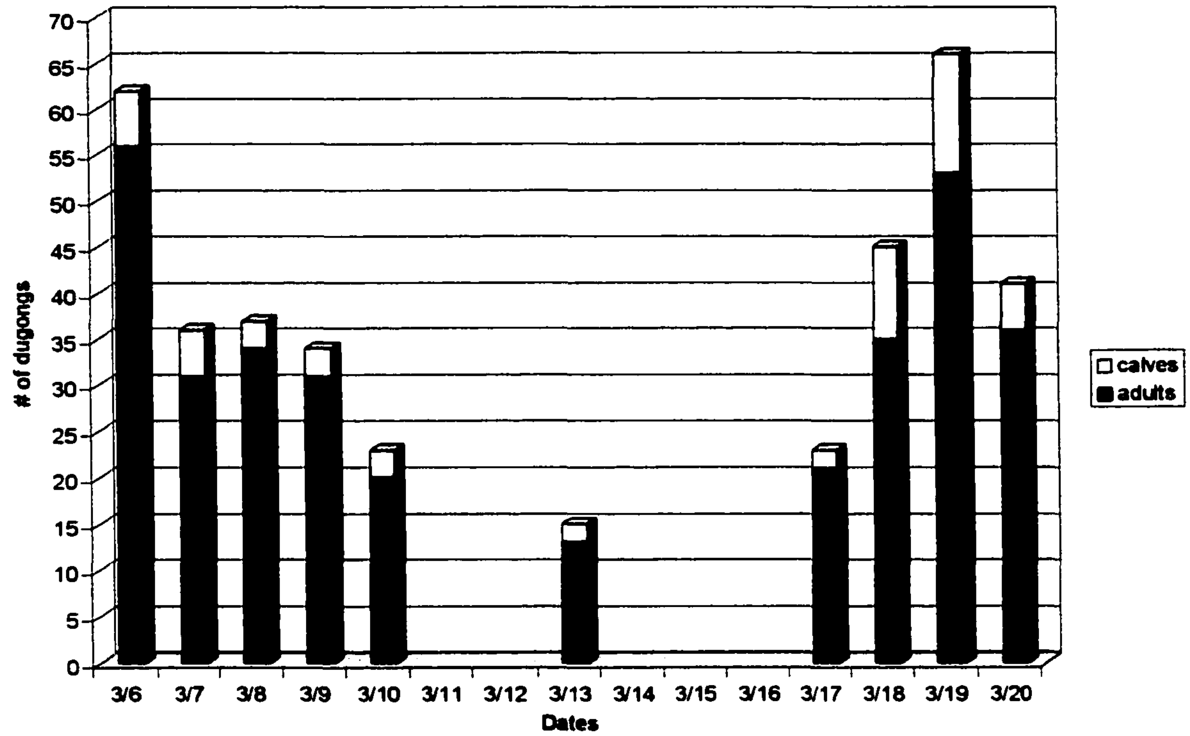


Figure 26. A histogram showing the number of calves as compared to the number of adult dugongs seen per day in Trang province during the microlite surveys in March of 2000.

A group of dugongs can be defined as "a subjectively distinct clump" (Marsh and Sinclair 1989a). The group, or cluster size is defined as the size of the aggregation of the object of interest (Distance 3.5 Software Glossary). In a strip transect survey a cluster is defined by the location of the center of the group. If the center of the group is inside the strip, the count of the size of the group has to include all animals within that cluster, even if some of the animals are outside the width of the strip (Buckland *et al.* 1993).

From a total of 186 sightings, 75% consisted of a single animal, and 93% of groups seen of more than one animal numbered three or less (Figure 27). Only 3

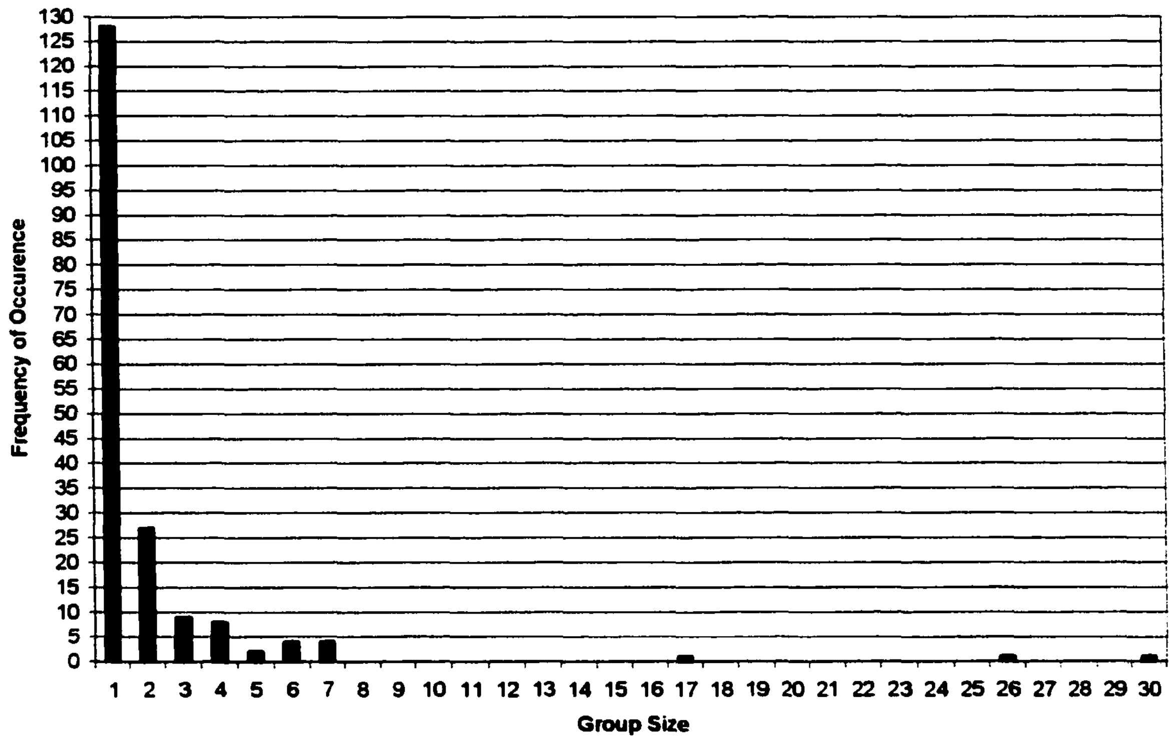


Figure 27. A frequency histogram showing the distribution of group sizes in dugongs seen in Trang province in microlite surveys during March of 2000.

sightings (2%) were of groups over 6 (17, 26, 30). The average group size including outliers was 1.76, with a standard deviation of 2.68. Group size is not considered to be a significant factor in dugong visibility (Marsh and Sinclair 1989*a*,*b*). However, in this instance single dugongs were markedly more difficult to see than a pair or larger group.

On March 7, the second day of the survey, the pilot and I noticed a dead dugong tied to a mooring buoy and broke off the transect effort to report this to local authorities. I will discuss this incident further in the next chapter.

Microlite Surveys in 2001

During the 2001 field season in Trang province, I completed 12 aerial surveys between March 31 and April 12. I worked in association with Kanjana Adulyanukosol of the MESU. We saw an average of 33.08 dugongs and calves per day, with minimum sightings of 5, and a maximum of 88 dugongs, and a standard deviation of 29.03. For 2001, the daily surveys extended for 169.53 linear kilometers. The sampling blocks, with the addition of the estuary block, totaled 94.89 square kilometers. During the aerial surveying the weather was clear, except for one day of intermittent rainfall. Beaufort sea state was between 1 and 3.

The effort log and the sightings logs are shown in Appendices 8.2.4 and 8.3.4. Figures 28 through 33 show the distribution of daily sightings and group sizes. As in the previous field season, all dugong sightings were within 5-meter bathymetry depth as measured at lowest low water. We saw 46 calves in total, averaging sightings of 3.8 daily. For three days in a row, we saw no calves, with a maximum of 9 seen in one day, for a standard deviation of 3.5 (Figure 34). For this year, 12% of the dugongs seen were calves, and 88% adults. We saw on average 18.90 dugongs per hour.

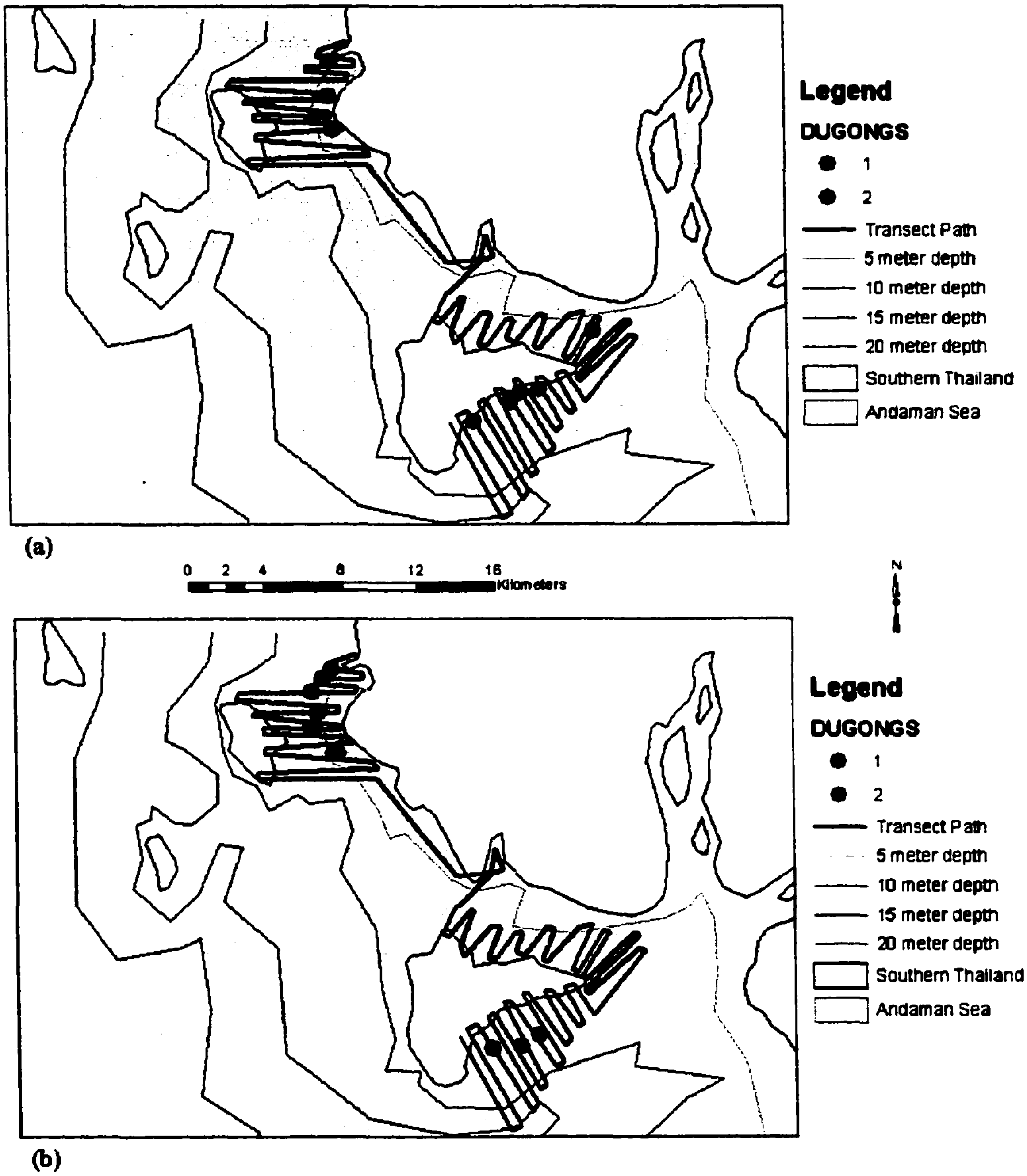


Figure 28. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of March 31 (a) and April 1 (b), 2001.

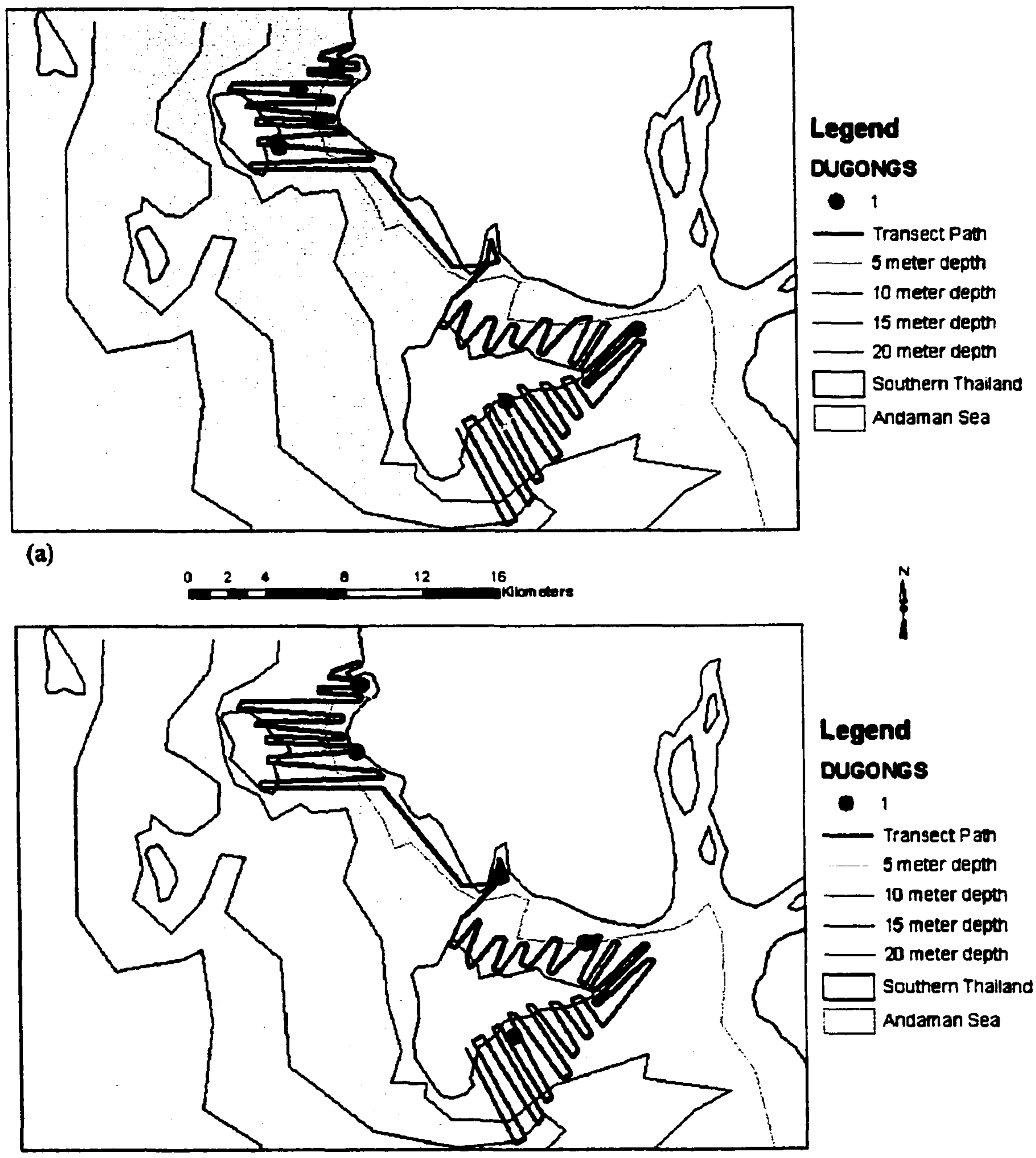


Figure 29. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of April 2 (a) and 3 (b), 2001.

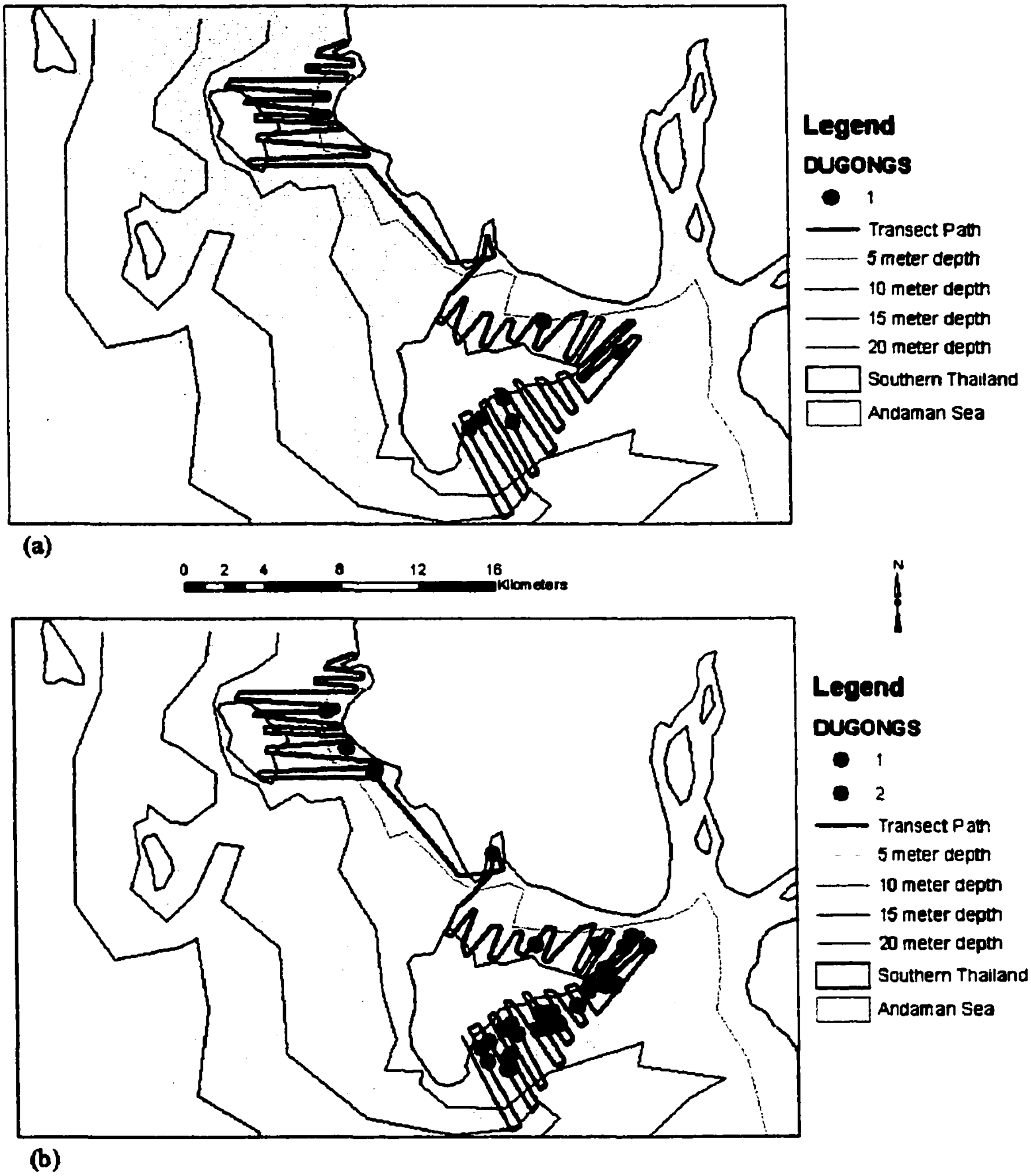


Figure 30. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of April 4 (a) and 5 (b), 2001.

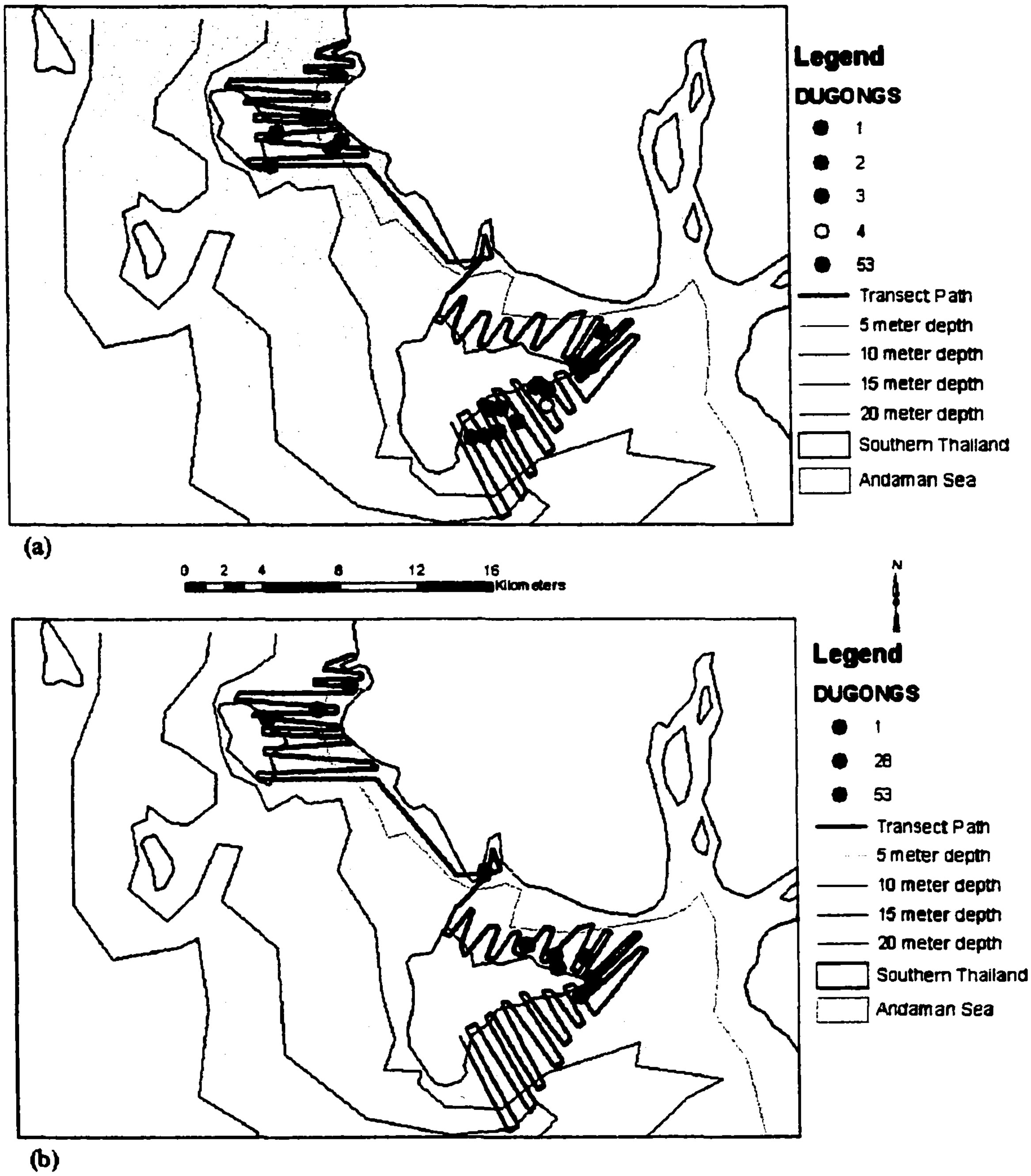


Figure 31. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of April 6 (a) and 7 (b), 2001.

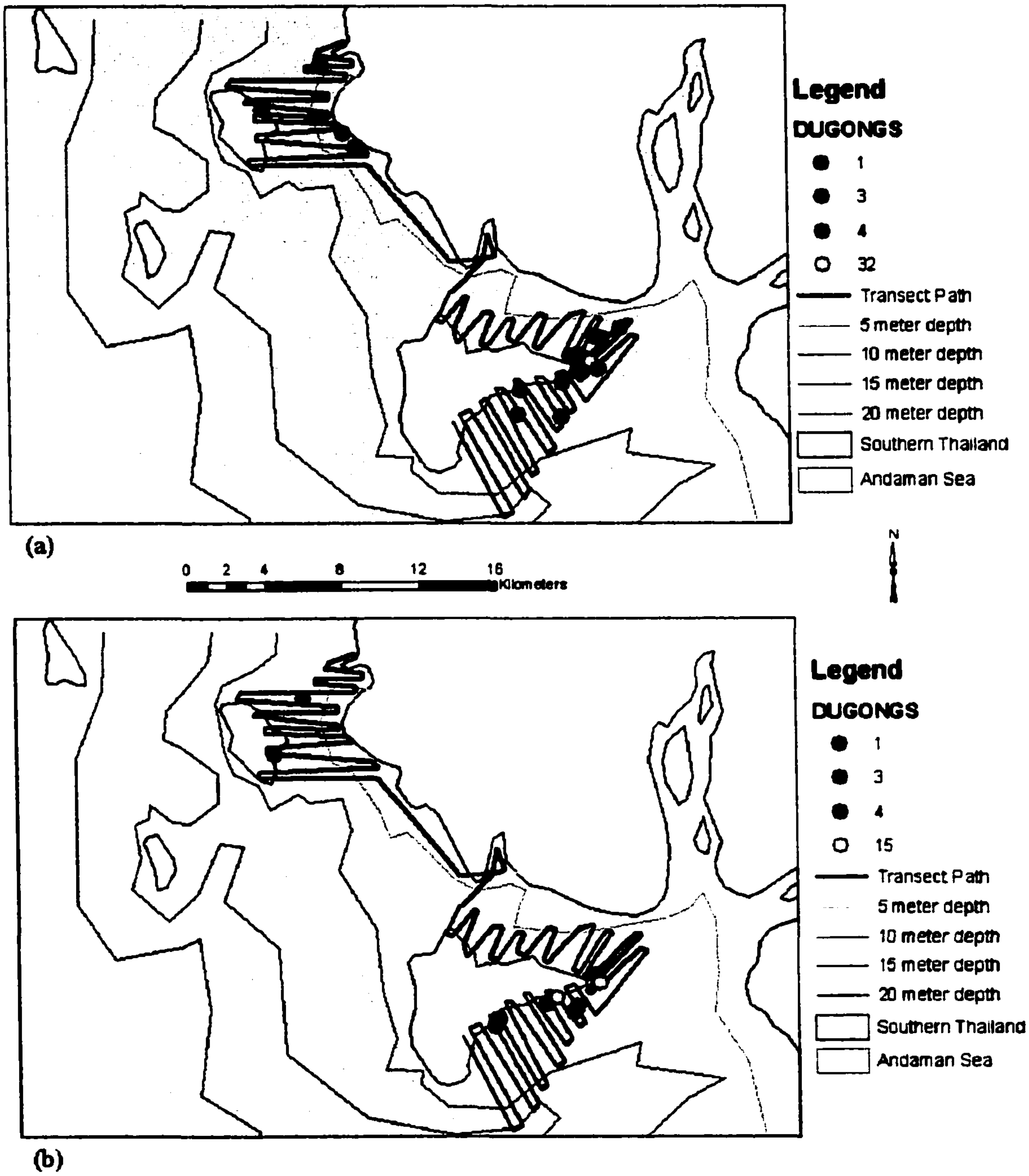


Figure 32. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of April 8 (a) and 10 (b), 2001.

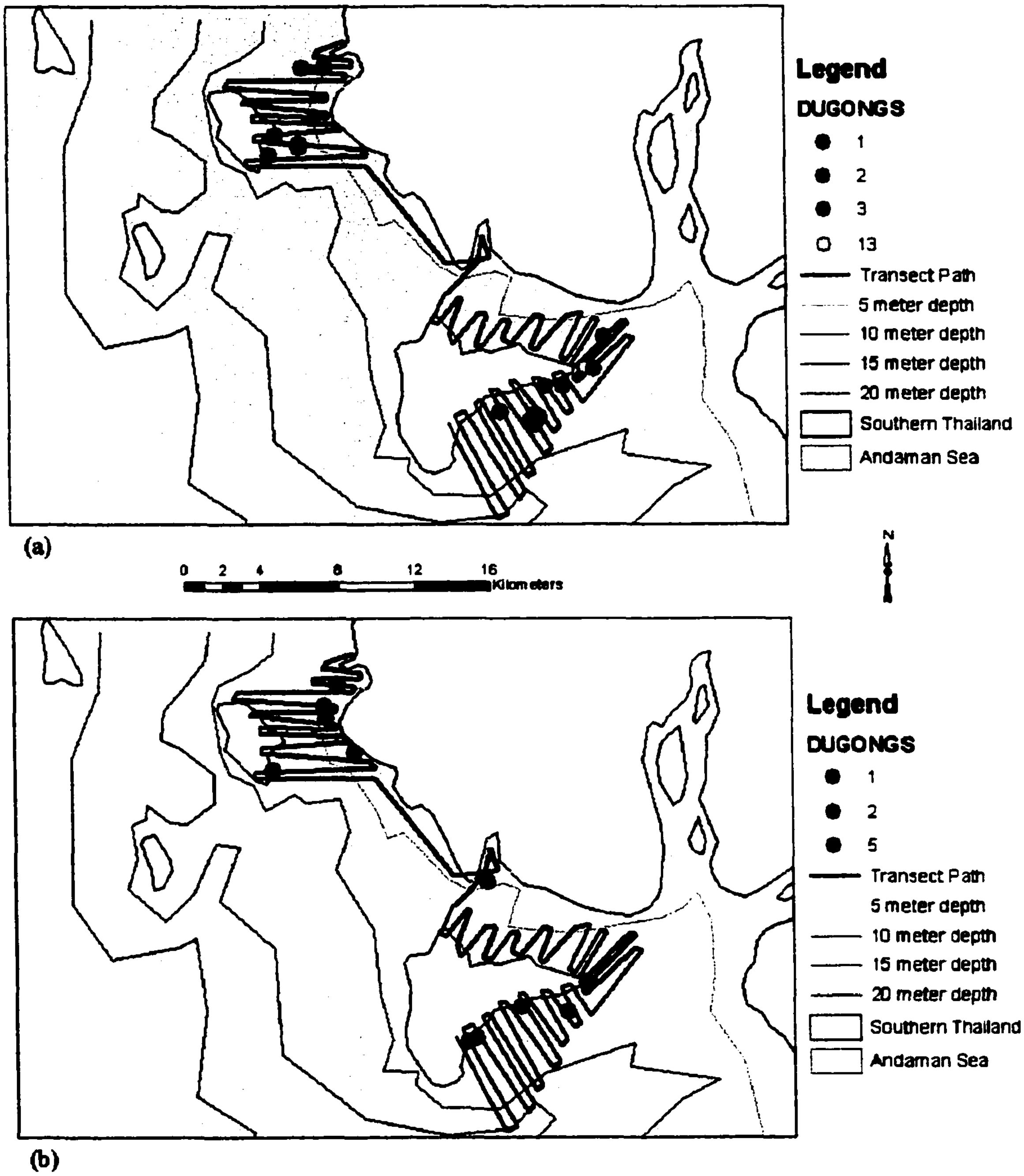


Figure 33. Sightings of locations and group number of dugongs in Trang province from the microlite surveys of April 11 (a) and 12 (b), 2001.

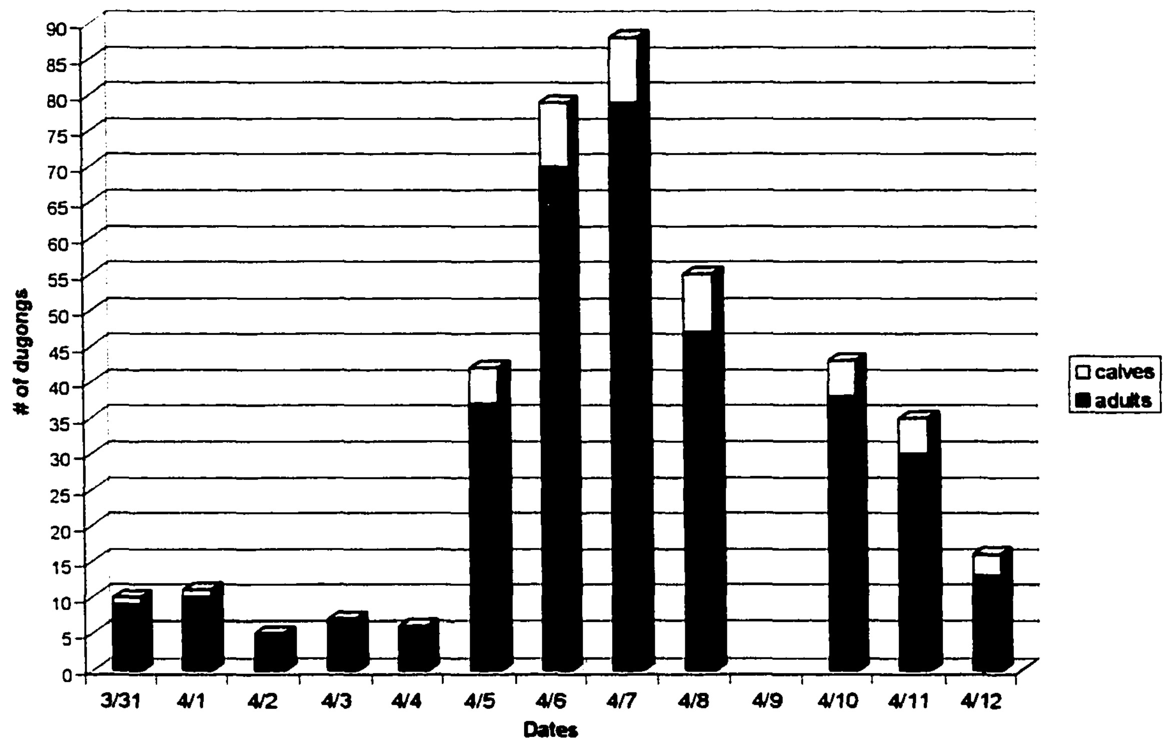


Figure 34. A histogram showing the number of calves as compared to the number of adult dugongs seen per day in Trang province during the microlite surveys in March and April of 2001

We had a total of 124 separate sightings, out of which 31.5% were of single animals. Groups of 3 or less were 42.6% of all sightings, and there were 6 sightings, or 45.6%, of groups of 6 animals or larger (Figure 35). A group of 13 animals was seen once, groups of 15 were seen twice. Thirty-two dugongs were seen in a group one time, and the largest group seen, 53, was seen two days in a row. Group and specific sighting areas are missing for one of the sampling blocks. On April 7, the GPS display did not work along the south coast of Libong Island, so we do not know how animals were grouped, or specifically where they were seen in that area. We did record how many adult dugongs and calves were seen.

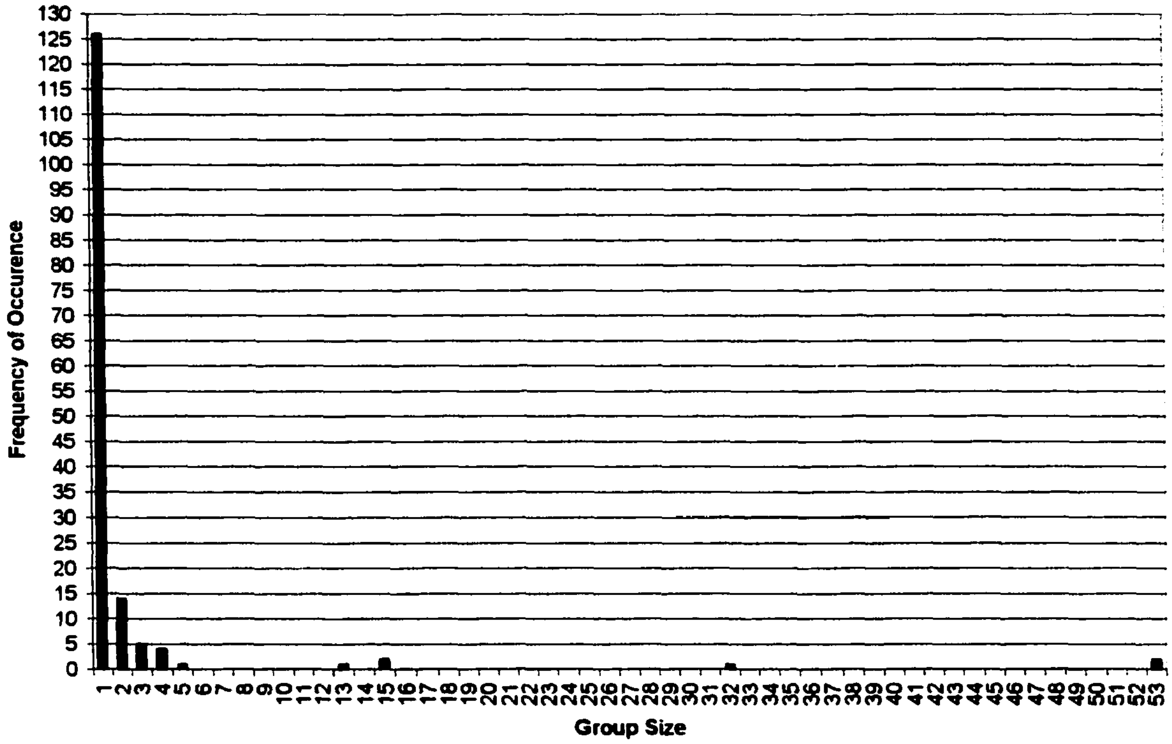


Figure 35. A frequency histogram showing the distribution of group sizes in dugongs seen in Trang province in microlite surveys during March of 2001.

We also recorded behavior for 365 of the dugong sightings. Figure 36 shows the distribution of behaviors seen. We decided upon 5 classifications that could be clearly seen. The first was rolling, when a single dugong was seen to be rolling around in the water without submerging. This was seen twice. Thirty-three animals were seen to be traveling, and 16 moving through the water and stopping to dive and feed. Six animals were 'resting', or not moving on the water surface. Most, or 308, of the animals were seen to be feeding. Sometimes during the feeding activity we saw sediment clouds from disturbed sediment, but not always. The water was clear enough that we could see the dugong submerged in a bed or patch of seagrass. Anderson and Birtles (1978) also recorded feeding as the most frequently observed activity of dugongs.

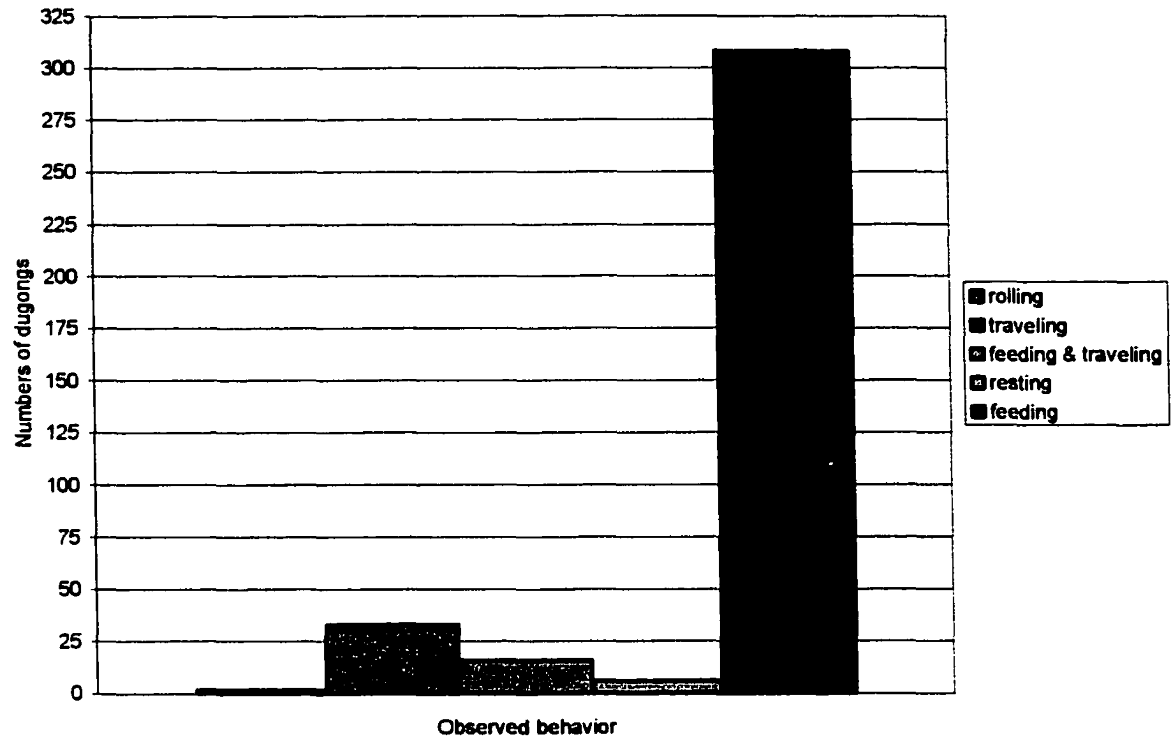


Figure 36. A histogram of the different behavior types seen in dugongs sighted in Trang province during microlite surveys in 2001.

Strip Transect Abundance and Density Data Analysis in Trang

I used Distance 3.5 (Thomas *et al.* 1998) to analyze the strip transect data for the microlite surveys in Trang province for both years. I begin by reporting the estimates of population abundance and density for both areas. Next I summarize abundance and density for each sampling block or strata (Figure 37). Afterwards, I show the different results according to the tide level at which the microlite survey was performed.

Table 4 presents the parameters calculated for the strip transect surveys in Trang. The maximum value of *N*, or individual abundance, can be considered a minimum estimate of population abundance (Jefferson 2000). The minimum estimate of the total population size in the area surveyed is 123 dugongs. On April 7, 2001, the day that this estimate is based on, the density of individual dugongs is calculated at 1.2980 (100 km^2), and the average cluster size is 8.80. These are both maximum values for both survey years. The encounter rate (*n/L*), the number of observed objects divided by the total length of the transect line, on this day (April 7, 2001) is 0.0590, below the average *n/L* for both years. This was the day that the display broke on the GPS, and therefore 88 dugongs were seen in only 9 sightings. This caused an abnormally large clustering statistic. One group was found to be composed of 53 animals, and another, after the GPS broke, was recorded as 26. While the number of animals seen is still valid for April 7, and therefore the number of on-effort sightings (n) and estimate of animals (N) valid as well; I did not include the average cluster size, the encounter rate (n/L), the density estimate (D), the standard deviation (S.E.), or the coefficient of variation (CV) for that day in total or average calculations (Table 4). In contrast, on April 6, the day with the second highest *N* estimate, of 111, the average cluster size was lower, at 4.94, though the encounter rate was larger, 0.944. On that day I saw 79 dugongs, in 16 sightings, even though one group did number 53 animals.

Out of the 5 sampling blocks, the average population abundance estimate of 34.77 is highest in the 4th strata (S.E. = 25.14, C.V. = 67.01%) (Table 5). The average cluster size and density of individual animals is also highest here. The highest *N* and the minimum population estimate in this area is 98 animals. Figure 38 shows the minimum population estimates in each sampling block.

During the aerial surveys in 2001, the numbers of dugongs seen were at first quite low compared to the previous year. When Kanjana and I looked at the results of the 2000

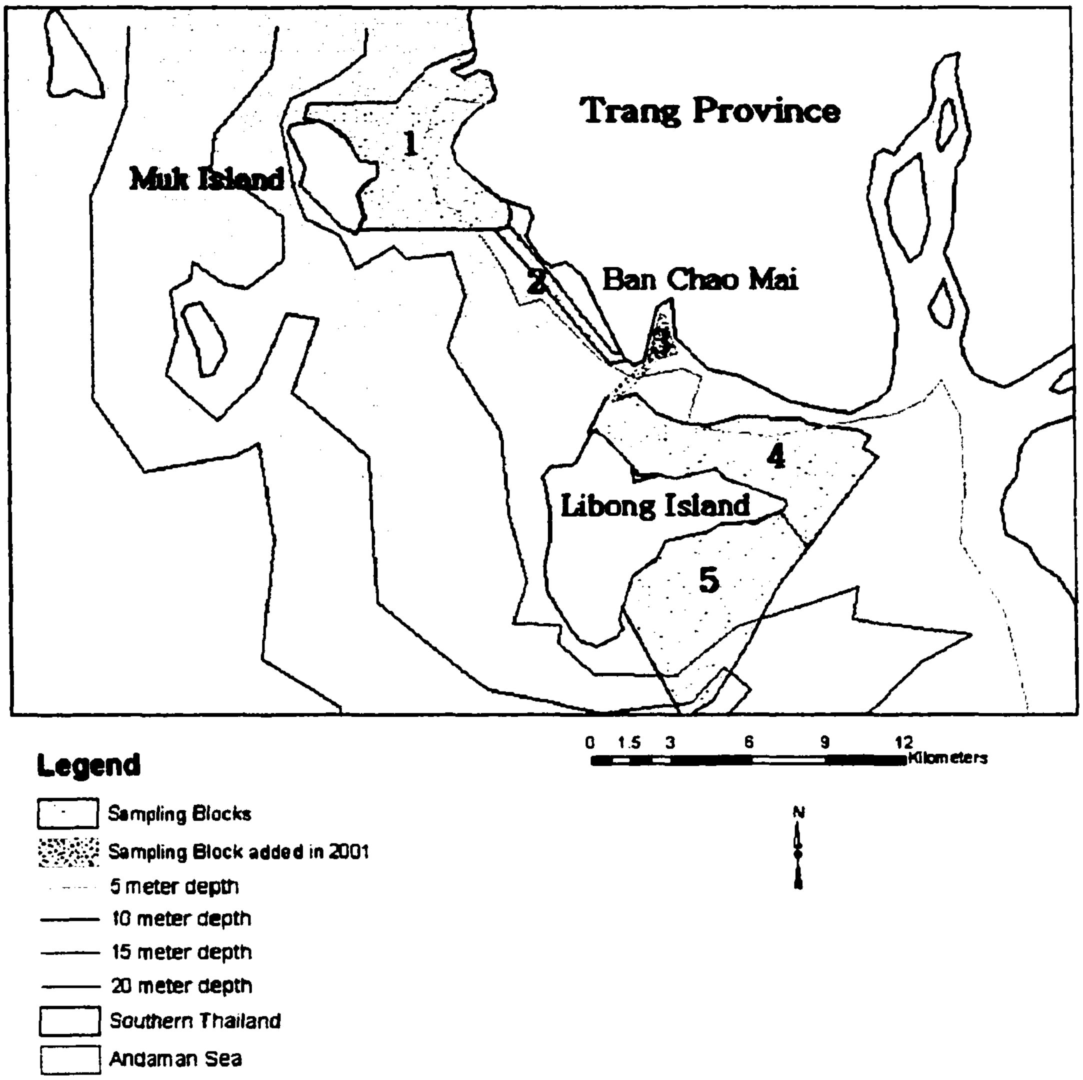


Figure 37. The sampling blocks used for the strip transects for microlite surveys in Trang province. Block 3 was added in 2001.

Table 4. Estimates of abundance, density, and other associated parameters for the microlite surveys in Trang province in 2000 and 2001. Symbols used: k, numbers of samples (the number of transect lines); L, total length of transects surveyed; # of animals seen, the actual count of dugongs, including calves; n, number of on-effort sightings; ESW, effective strip width on each side of the vehicle; n/L, encounter rate; D, estimate of density of animals; N, estimate of animals in specified area; S.E., standard error; C.V. coefficient of variation.

Area	Year	Day	Area (sq.km.)	k	L (km)	# of animals seen	n	ESW	AverageCluster Size	n/L	D	N	S.E.	CV (%)
Trang	2000	6-Mar	93.21	45	162.20	62	19	200	3.26	0.1171	0.9556	89	39.77	44.68
Trang	2000	7-Mar	93.21	45	162.20	36	16	200	2.25	0.0986	0.5549	52	17.52	33.70
Trang	2000	8-Mar	93.21	45	162.20	37	12	200	3.08	0.0740	0.5703	53	25.90	48.87
Trang	2000	9-Mar	93.21	45	162.20	34	13	200	2.62	0.0801	0.0524	49	16.11	32.89
Trang	2000	10-Mar	93.21	45	162.20	23	11	200	2.09	0.0678	0.3545	33	13.96	42.30
Trang	2000	13-Mar	93.21	45	162.20	15	10	200	1.50	0.0616	0.2312	22	7.89	35.85
Trang	2000	17-Mar	93.21	45	162.20	23	15	200	1.53	0.0925	0.3545	33	8.84	26.78
Trang	2000	18-Mar	93.21	45	162.20	45	13	200	3.46	0.0801	0.6936	65	22.46	34.55
Trang	2000	19-Mar	93.21	45	162.20	66	13	200	5.08	0.0801	1.0173	95	51.93	54.66
Trang	2000	20-Mar	93.21	45	162.20	41	18	200	2.28	0.1110	0.6319	59	16.22	27.50
				Total 2000		382	140					550		
				Average 2000		38.20	25.45		2.72	0.0863	0.5416	55.00	22.06	38.18
Trang	2001	31-Mar	94.89	49	169.53	10	8	200	1.25	0.0472	0.1475	14	4.87	34.76
Trang	2001	1-Apr	94.89	49	169.53	11	9	200	1.22	0.0531	0.1622	15	4.68	31.19
Trang	2001	2-Apr	94.89	49	169.53	5	5	200	1.00	0.0295	0.0737	7	2.79	39.85
Trang	2001	3-Apr	94.89	49	169.53	7	6	200	1.17	0.0354	0.1032	10	4.82	48.16
Trang	2001	4-Apr	94.89	49	169.53	6	6	200	1.00	0.0354	0.0885	8	2.98	37.28
Trang	2001	5-Apr	94.89	49	169.53	42	20	200	2.10	0.1180	0.6194	59	13.33	22.59
Trang	2001	6-Apr	94.89	49	169.53	79	16	200	4.94	0.0944	1.1650	111	78.16	70.41
Trang	2001	7-Apr	94.89	49	169.53	88	9	200	8.80	0.0590	1.2980	123	87.04	70.76
Trang	2001	8-Apr	94.89	49	169.53	55	12	200	4.58	0.0708	0.8111	77	49.59	64.40
Trang	2001	10-Apr	94.89	49	169.53	43	9	200	4.78	0.0531	0.6341	60	30.72	51.20
Trang	2001	11-Apr	94.89	49	169.53	35	13	200	2.69	0.0767	0.5161	49	20.35	41.53
Trang	2001	12-Apr	94.89	49	169.53	16	11	200	1.45	0.0649	0.2360	22	7.84	35.63
				Total 2001		397	124					555		
				Average 2001		33.08	10.33		2.92	0.0617	0.4142	46.25	20.01	43.36
				Average 2000 & 2001		35.64	17.89		2.82	0.0740	0.4779	50.63	21.03.	40.77
				Totals for both years		779	264							

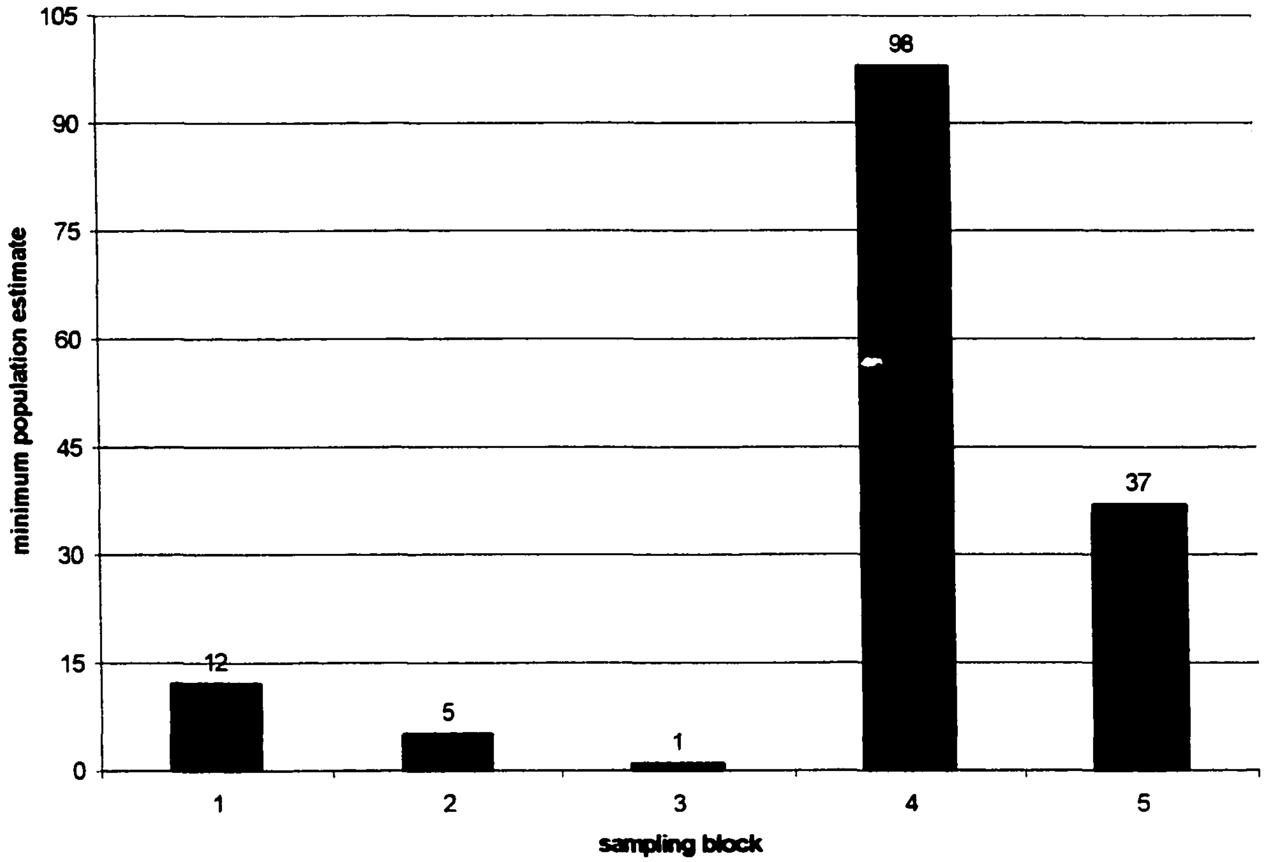


Figure 38. A histogram showing the highest *N* value from each sampling block in the microlite surveys in Trang province from 2000 and 2001. Sampling block 3 only contains values from 2001. The quantity shown is the minimum estimated population abundance in each sampling block.

aerial surveys, we noticed that the higher number of sightings seemed to correspond with the spring tides. The first 5 survey days in 2001 were around the first quarter neap tide. We had thought that the dugongs would move into the feeding areas as soon as the water level began to get higher, and so timed the survey to begin as soon as the tide started to rise, and therefore were not always surveying at the highest tide level. We adjusted the start time of the surveys so that we were flying over Libong Island at the highest tide level. At this point, the highest tide level was also rising as the full moon spring tide

Table 5. Estimates of abundance, density, and other associated parameters for the different sampling blocks on the microlite surveys in Trang province in 2000 and 2001. Symbols used: k, numbers of samples (in this case, the number of transect lines); L, total length of transect surveyed; n, number of on-effort sightings; n/L, encounter rate; D, estimate of density of animals; N, estimate of animals in specified area; S.E., Standard error; C.V., coefficient of variation.

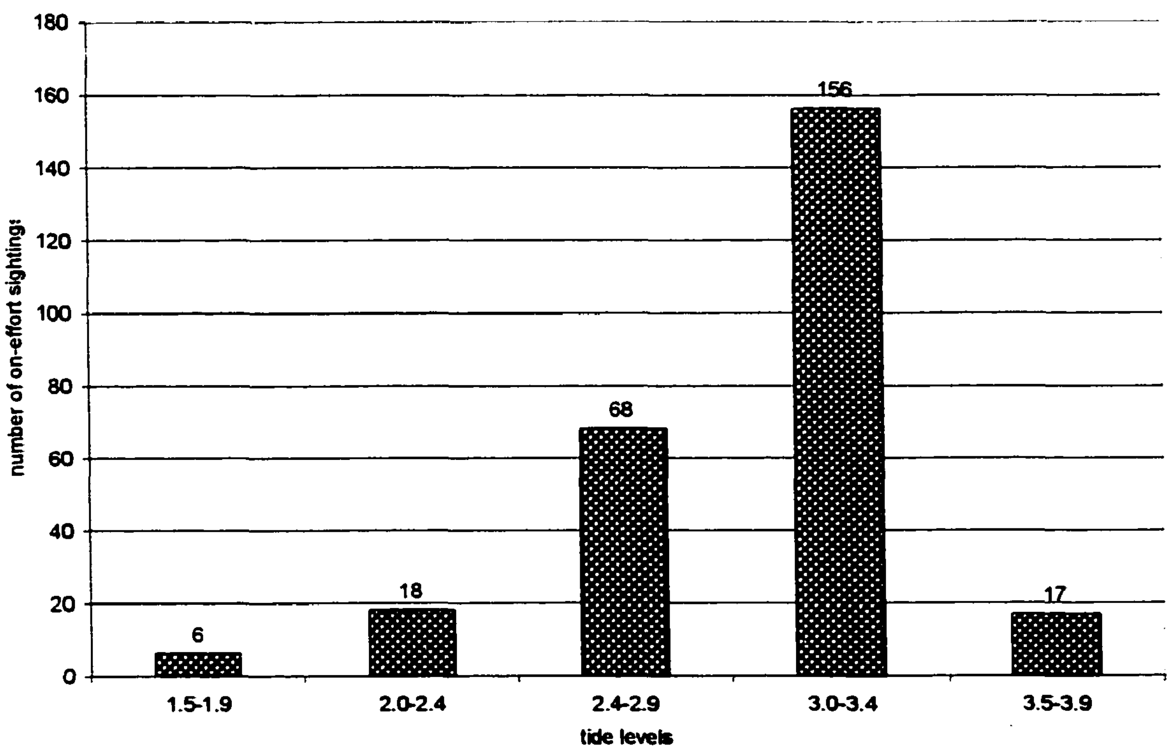
Parameter (block #)	Estimate		
Area (sq.km.)			
1	29.24		
2	3.25		
3	1.68		
4	29.29		
5	31.43		
k			
1	14		
2	1		
3	4		
4	17		
5	13		
L(km)			
1	59.12		
2	6.73		
3	7.33		
4	42.77		
5	53.58		
average n			
1	4.00		
2	0.05		
3	0.33		
4	3.55		
5	4.43		
Average cluster size			
1	1.07		
2	0.18		
3	0.42		
4	5.12		
5	1.85		
average n/L			
1	4.77		
2	0.18		
3	0.50		
4	20.36		
5	9.82		
average D			
1	0.20		
2	0.07		
3	0.17		
4	1.19		
5	0.42		
average N		SE	CV (%)
1	5.68	2.58	44.75
2	0.23	0.23	4.55
3	0.33	0.33	33.43
4	34.77	25.14	67.01
5	13.19	6.71	55.86

Table 6. Tidal ranges and numbers of dugong sightings for microlite surveys in Trang province in 2000 and 2001.

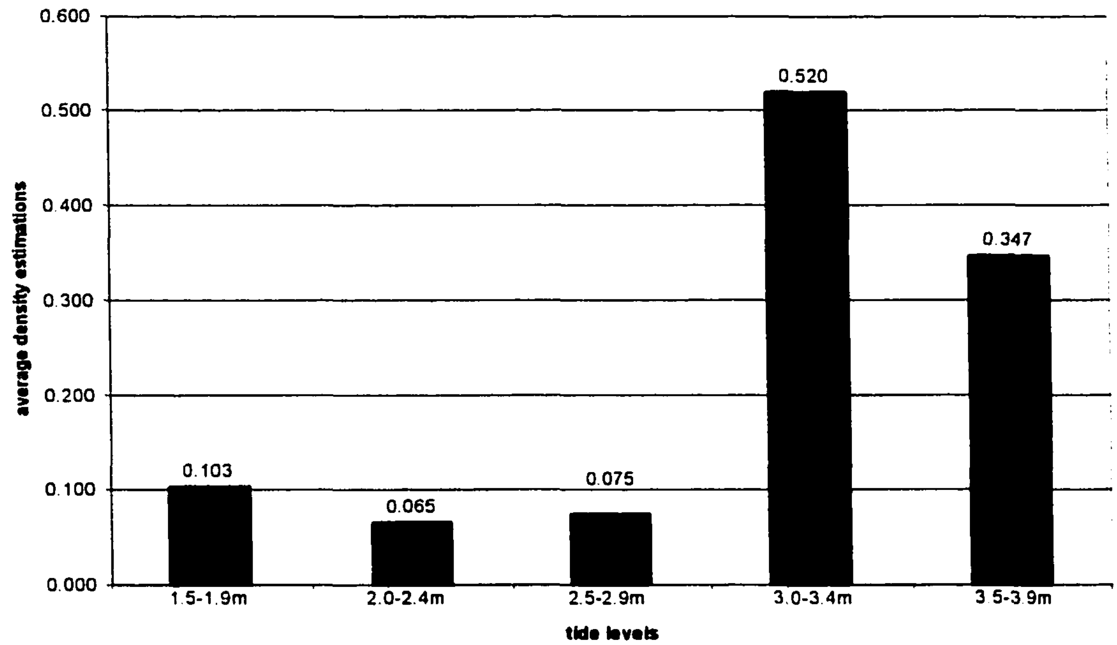
date	effort time/minutes	start	end	tidal range	# of sightings		
3/6/00	107	1009	1156	2.7-3.2	62		new moon spring
3/7/00	35	1124	1159	3.0-3.3	7		
3/7/00	84	1331	1455	3.3-2.6	29		
3/8/00	131	1151	1402	3.3-3.4	37		
3/9/00	124	1215	1419	3.1-3.5	34		
3/10/00	129	1246	1455	3.2-3.4	23		
3/13/00	125	1500	1635	2.8-2.8	15		first quarter neap
3/17/00	130	854	1104	2.8-2.9-2.8	23		
3/18/00	150	905	1135	2.8-3.2	45		
3/19/00	141	918	1139	2.6-3.2	66		
3/20/00	150	1014	1244	2.9-3.4	41		full moon spring
3/31/01	104	1204	1348	2.3-3.0	10	went to 3.1	
4/1/01	118	1044	1242	1.7-2.7	11	went to 2.8	first quarter neap
4/2/01	125	1340	1545	2.2-2.6	5		
4/3/01	119	644	843	2.3-2.4	7		
4/4/01	123	713	916	2.2-3.0	6		
4/5/01	130	815	1025	2.7-3.1	42		
4/6/01	144	855	1119	3.0-3.3	79		
4/7/01	115	939	1134	3.0-3.5	88		
4/8/01	128	954	1204	3.0-3.6	55		full moon spring
4/10/01	135	1030	1245	2.6-3.7	43		
4/11/01	130	1055	1305	2.7-3.6	35	went to 3.7	
4/12/01	130	1109	1319	2.4-3.4	16	went to 3.6	

approached. Table 6 shows the tidal range flown for both years, and the corresponding number of animals seen. On the days that we surveyed at the higher tides, with the approaching spring tide, the numbers of dugongs sighted were appreciably larger. On the full moon itself, however, the water was so turbid that dugongs could not be seen unless surfacing. Even so, 57 animals were sighted. On April 10, with a highest high tide level of 3.7 meters, the water was even more turbid. Also, with the tide levels so high, the microlite had no room to take off or land. We then decided to time the flights one hour earlier, both because of the microlite and to try to escape the turbidity. The numbers of animals seen still decreased (Table 6).

I separated the sightings into truncated tide level categories. All tide levels are taken from the annual Tide Tables for Thai waters published by the Hydrographic Department of the Royal Thai Navy. In Distance I ran abundance and density estimation analyses on each category. The next three figures show similar patterns in the number of on-effort sightings, density per 100 square kilometers, and abundance estimates for each tide level grouping (Figure 39 *a*, *b*, & *c*). The values of all the parameters rise to a peak level in the 3.0 to 3.4 class, and fall at the highest tide level. There is a slight positive skew to the distribution of values as shown in the abundance and density estimates, as observations during the 1.5-1.9 tide level grouping occurred only one time, with a relatively high number of observations (6).



a. The number of on-effort observations (*n*) at each tide-level grouping.



b. **The average abundance estimate (*N*) at each tide-level grouping.**

c. **The average density estimate (*D*) at each tide level grouping.**

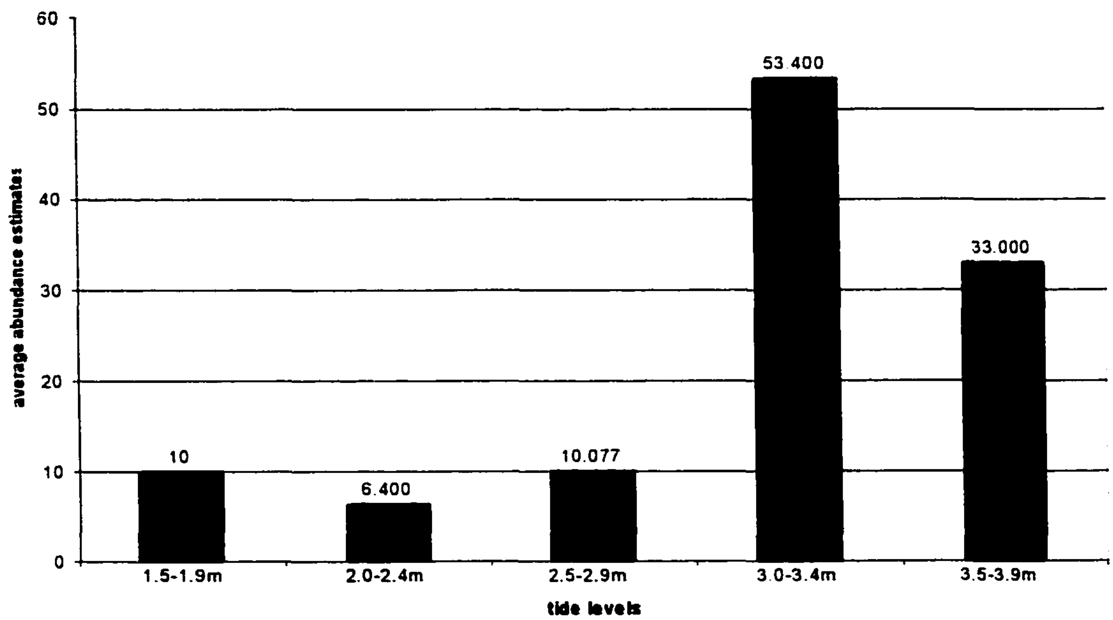


Figure 39. Histograms of on-effort sightings (a), average abundance estimates (b), and average density estimates (c) of dugongs categorized according to truncated tide levels for the microlite surveys in Trang province in 2000 and 2001.

4.1.2.2 Krabi Province

In Krabi province, within the Three Islands area (Figure 13), after 5 days of transects, the maximum sighting was 4 adult dugongs, plus one calf. The total number of sightings over all five days was 12. Adults were 75% of the total, and calves, 25%. The average number of sightings was 2.4, the minimum 0, and the maximum 5, with a standard deviation of 2.5. The number of dugongs per hour in this area was 2.15. All dugongs were seen in 5-meter depths or less. The sampling block area here is 60.28 square kilometers, and the transect length is 105.19 linear kilometers. The weather was clear for the first 2 days, with a Beaufort sea state of 1. The third day was rainy with low visibility and a Beaufort value of 3. The last two days were cloudy with Beaufort values of between 1 and 2.

Dugong sighting locations are shown in Figure 40. Effort and sightings logs are in Appendices 8.2.5 and 8.3.5. The sample size in this area was not sufficient for a reliable statistical estimate of population abundance and density. In Krabi province, I also flew 3 transects over the seagrass beds on the southwest tip of Lanta Noi Island (Figure 10). The seagrass was patchy and sparse, and no dugongs were sighted.

4.1.2.3 Phuket and Phang-nga Provinces

We flew microlite surveys on the northeast coast of Phuket Island and around the Yao Islands in Phang-nga Bay between March 23 and 25 in 2001 (Figure 14). In Phuket, we established one sampling block of 58.26 square kilometers, containing 55.13 linear kilometers of transect path. Three different sampling blocks in the Yao Islands totaled 31.78 square kilometers. The total linear kilometers of the three transect paths equaled 88.52. The weather was generally rainy and the visibility low, especially on the first day,

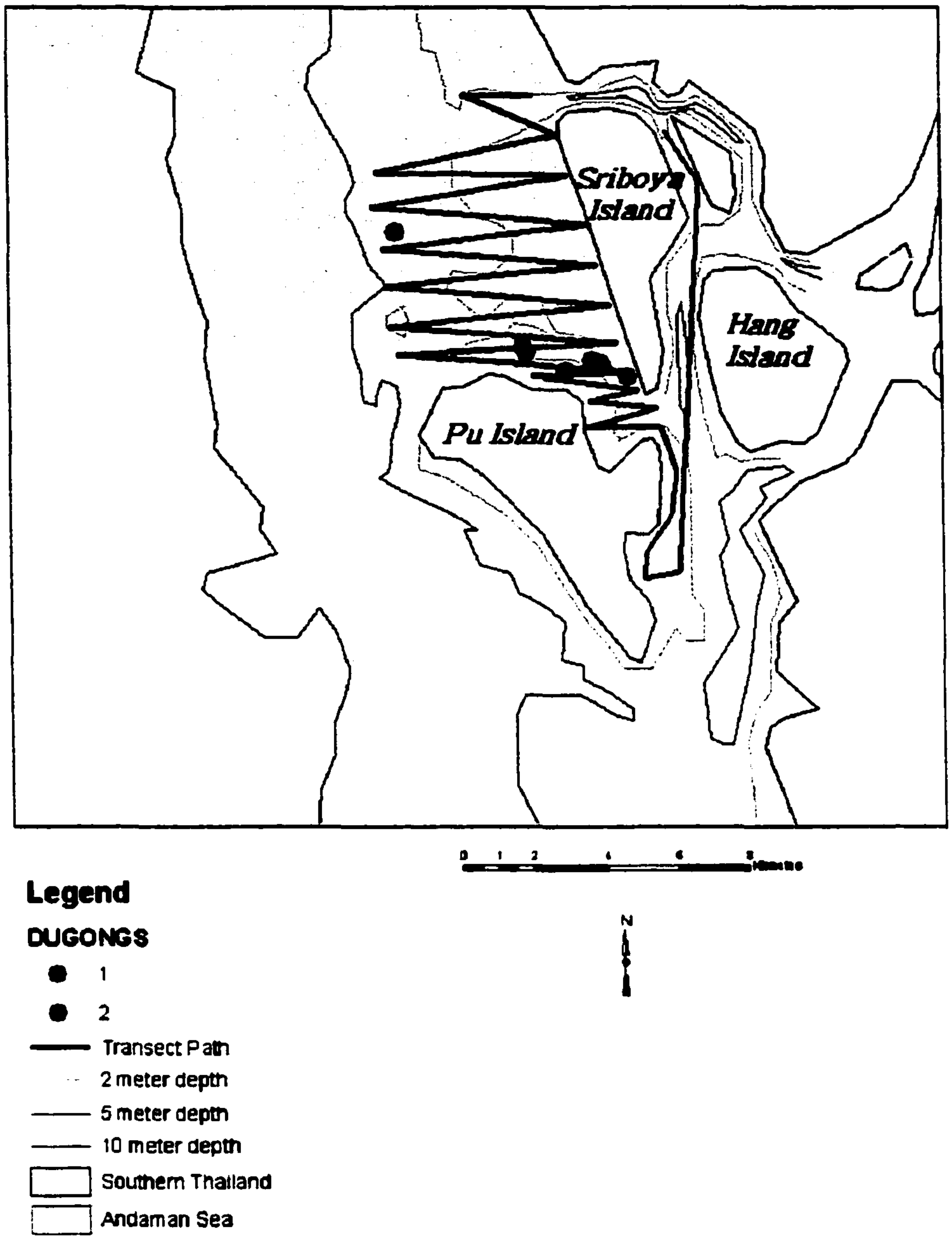


Figure 40. Sightings locations and group numbers of dugongs from the microlite surveys in the Three Islands area of Krabi Province between March 22 and 26, 2000.

when the survey was cut short by a storm. The Beaufort sea state values were between 2 and 3.

We sighted 3 dugongs during this time, one near Ban Pak Lok on Phuket, and 2 in the Yao Islands (Figure 41). No calves were seen during these surveys. I did see numerous feeding trails in seagrass beds between Yao Noi and Yao Yai Islands, as well as in the seagrass in the sampling block at the south end of Yao Yai Island (Figure 14). The effort and sightings logs for Phuket and the Yao Islands are shown in Appendices 8.2.6 and 8.3.6. As in the surveys in other areas, no dugongs were seen in waters greater than 5-meter depth. As in Krabi, the sample size was too low to perform statistical analysis. In sample sizes of 1, a probability density function for the width of the transect [*(f0)*] cannot be calculated, and density and abundance cannot be estimated reliably (Jefferson 2000, Buckland *et al.* 1993).

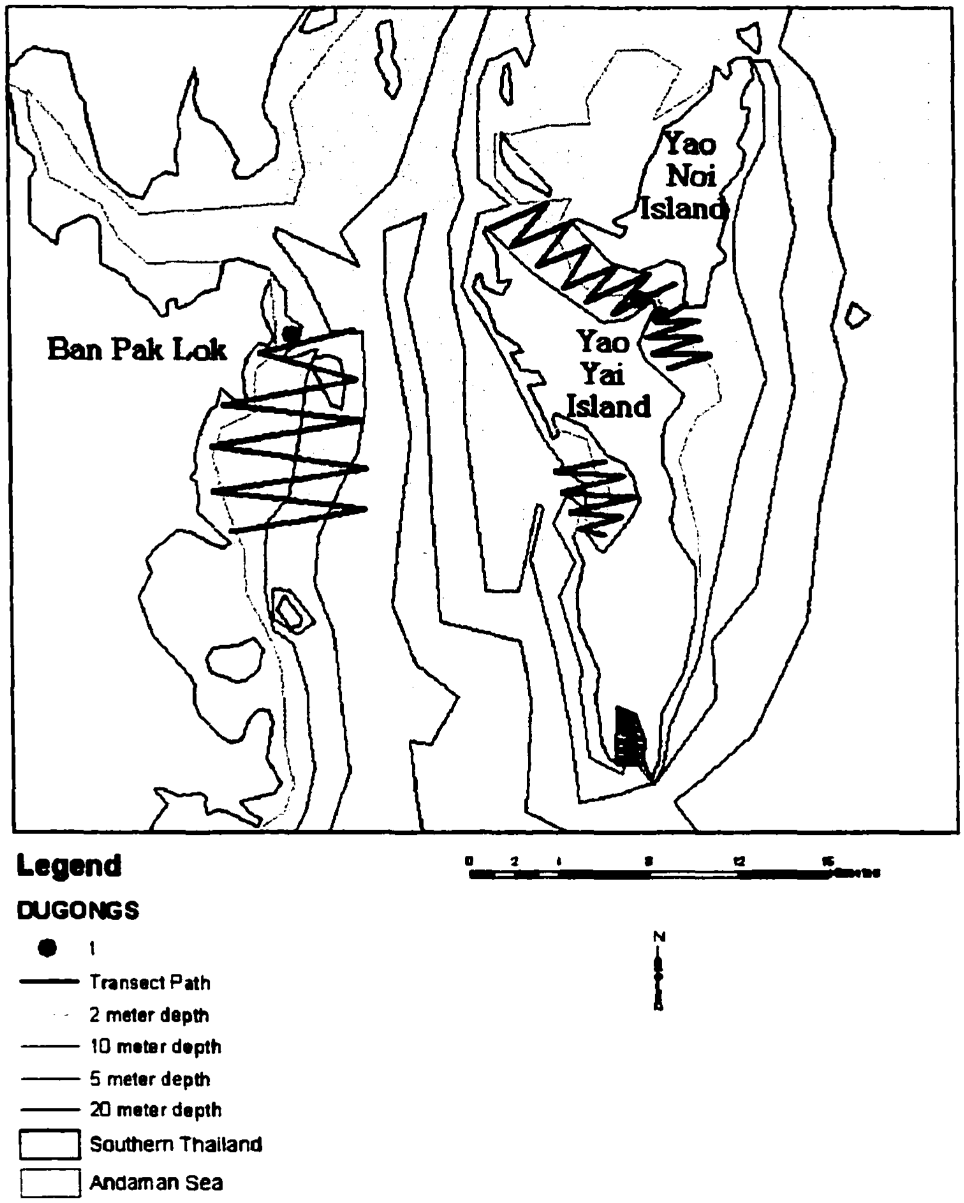


Figure 41. Sightings locations from the microlite surveys in Ban Pak Lok (Phuket Province) and the Yao Islands (Phang-nga Province) between March 23 and 26, 2001.

4.2 Seagrass Surveys

As the dugong is a species with specialized foraging requirements, heavily dependant on seagrass, my first objective for the case study included research on the distribution and species of seagrass beds along the Andaman coast. Thai researchers have delineated the general locations and species composition of most seagrass beds in southern Thailand (Chansang & Poochaviranon 1994, Poochaviranon & Chansang 1994). However, recent research has not been done in most of the habitat areas with larger populations of dugongs, such as Trang. Current knowledge of seagrass bed boundaries and species is important due to damage of seagrass areas from monsoon storms and possibly from destructive fishing methods and coastal development. In 2000, I looked at ten seagrass beds spread throughout the coast between Kuraburi and Trang, and in 2001, working with scientists from PMBC, concentrated on seagrass sampling in Trang.

4.2.1 Seagrass Research in 2000.

In 2000, throughout the study area, I conducted line transects or boat-based sampling at seagrass beds as described in the previous section (Figures 8 through 10). I collected and pressed representative species samples gathered in a standard plant press using procedures for collecting and preserving seagrass by Meñez *et al.* 1983. Table 7 shows the species of seagrass found in the surveys, the type of seagrass bed association, the estimated cover percentage, and the area of the seagrass bed (according to Chansang and Poochaviranon 1994). *Halophilia ovalis* has the most widespread distribution of all the seagrasses, occurring at 94% of all the seagrass beds sampled. *Enhalus acoroides* and *Cymodocea serrulata* were next in frequency, occurring at 89% and 72% respectively.

The species most restricted in distribution is *Halophilia decipiens*, found at only one of the seagrass beds. This species is rarely found at the shallow depths of this survey, usually being found in a minimum depth of 2.02 meters (Poochaviranon 2000).

As mentioned earlier, the seagrass at Khao Bai Na was badly damaged by siltation during the rainy season of 1999 (Poochaviranon, Mukai, pers. comm. 2000). The cover percentage and patchiness of seagrass beds at Khao Bai Na during my survey was considerably less than as seen by Koike *et al.* in 1999. I was unable to use the air photos that I acquired from the Department of Defense. Only a few of the photos were taken at a low enough tide that the extent of the seagrass beds was visible.

4.2.2. Seagrass surveys in 2001

In April and May of 2001, spot samples were taken at 80 locations in Trang province in the seagrass in Ban Chao Mai estuary, and the seagrass beds surrounding Libong Island (Figure 42). The resulting data show the various species of seagrass found at each point, and the cover percentage of each (Table 8). As in the 2000 surveys, the most widely occurring species are from the family Hydrocharitaceae. *Halophilia ovalis* is the most prevalent species, found in 61% of the sites. *H. ovalis* also has the highest cover percentage of the various seagrasses here, up to 90% in various sites. *Enhalus acoroides* is widespread also, in 60% of the sites, with a maximum cover percentage of 80%. *Cymodocea rotundata* is found in 16% percent of the sampling sites, with up to 60% cover density, and *C. serrulata*, of the same family, Potamogetonaceae, occurs in 15% of the samples, with a cover percentage reaching 20%. The most sparsely distributed seagrass is *Syringodium isoetifolium*, also from the Potamogetonaceae, only found in 1 sample. In comparison with a previous line transect survey at Libong Island in

1992, *Syringodium isoetifolium* has disappeared from most areas. The depth of water in the transect areas is also more shallow, possibly from sedimentation due to increased development on the mainland (Poochaviranon, pers. comm. 2001).

Table 7. Seagrass survey locations, species and cover percentages from transects and boat-based surveys in 2000.
HO = *Halophilia ovalis*, HM = *Halophilia minor*, HD = *Halophilia decipiens*, EA = *Enhalus acoroides*,
CR = *Cymodocea rotundata*, CS = *Cymodocea serrulata*, HU = *Halodule uninervis*, SI = *Syringodium isoetifolium*,
TH = *Thalassia hemprichii.*

Site	date	latitude	longitude	Ho	Hm	Hd	Ea	Cr	Cs	Hu	Hp	Si	Th	# of species	approximate cover (%)	remarks
Tung Nan Dam	2/5	9.2494	98.3392	35	0	0	15	0	5	0	0	0	0	3	55	
Tung Nan Dam	2/5	9.2488	98.3401	35	0	0	15	0	5	0	0	0	0	3	55	
Tung Nan Dam	2/5	9.2501	98.3397	35	0	0	15	0	5	0	0	0	0	3	55	
Tung Nan Dam	2/6	9.2491	98.3366	40	0	0	15	0	0	0	10	0	0	3	65	saw dugong feeding trail
Tung Nan Dam	2/6	9.2485	98.3370	35	0	0	20	0	0	0	5	0	0	3	60	
Tung Nan Dam	2/7	9.2497	98.3362	40	0	0	15	0	2	5	5	0	0	5	67	
Laem Mai Dai	2/9	9.2274	98.3314	40	0	0	15	5	5	0	0	0	0	4	65	
Laem Mai Dai	2/9	9.2263	98.2268	35	0	0	0	0	5	0	0	0	0	2	40	
Thuei Island	2/9	9.1882	98.2922	40	0	0	2	0	2	2	0	0	0	4	46	
Khao Bae Na	3/9	7.4107	99.3421	0	0	0	0	0	10	0	0	0	0	1	10	
Khao Bae Na	3/9	7.4101	99.3298	3	1	0	3	1	1	0	0	0	1	6	10	
Laem Yong Lam	3/21	7.3779	99.3390	40	2	2	15	3	3	0	0	0	1	7	66	
Libong Island	4/2	7.2638	99.4042	70	5	0	0	3	0	0	1	0	0	3	79	
Libong Island	4/3	7.2522	99.4504	60	3	0	10	3	3	0	0	0	1	6	80	
Muk Island	4/4	7.3812	99.3053	50	3	0	10	2	0	0	0	0	1	4	66	
Muk Island	4/5	7.3815	99.3033	50	1	0	10	0	0	0	0	0	0	3	61	
Sriboya Island	4/9	7.8927	98.9743	40	0	0	15	5	5	5	0	0	0	5	70	
Yao Yai Island	4/12	8.0942	98.5988	35	0	0	10	5	5	5	0	0	0	5	60	
				94	33	0.6	89	44	72	22	22	0	22			

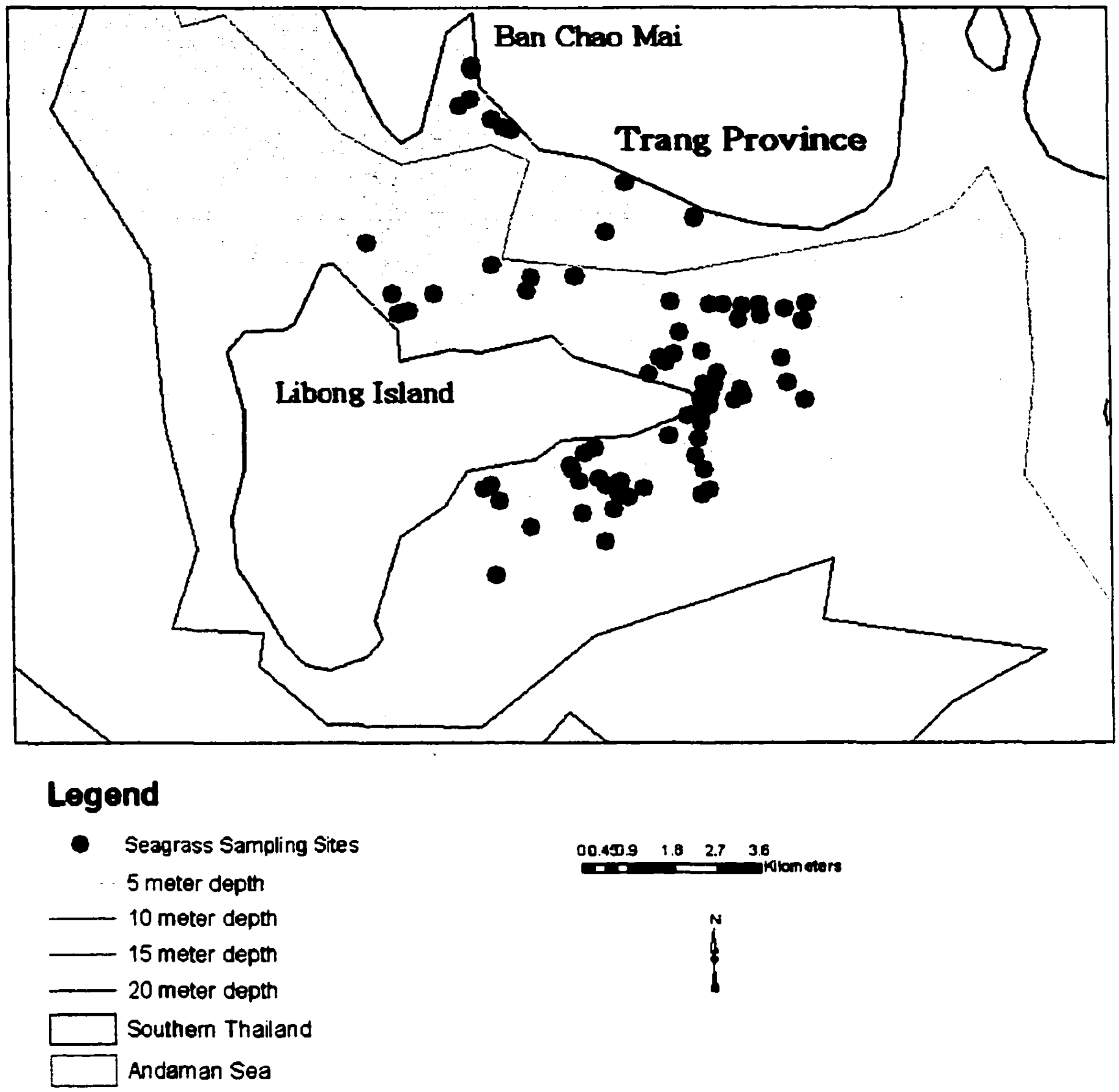


Figure 42. Seagrass spot sampling sites between Libong Island and Ban Chao Mai in Trang province in April and May of 2001.

Table 8. Seagrass survey locations, species and cover percentages from transects and boat-based surveys in 2001. HO = *Halophilia ovalis*, HM = *Halophilia minor*, HD = *Halophilia decipiens*, EA = *Enhalus acoroides*, CR = *Cymodocea rotundata*, CS = *Cymodocea serrulata*, HU = *Halodule uninervis*, SI = *Syringodium isoetifolium*, TH = *Thalassia hemprichii*.

station	latitude	longitude	Ho	Hm	Hb	Ea	Cr	Cs	Hu	Hp	Si	Th	remark	date
TLB01	7.26042	99.45244	0	0	0	40	0	0	0	0	0	0	-	4/4/2001
TLB02	7.26453	99.45344	0	0	0	0	0	0	0	0	0	0	Fine sand	4/4/2001
TLB03	7.26078	99.45761	0	0	0	0	0	0	0	0	0	0	Water way	4/4/2001
TLB04	7.25100	99.45825	0	0	0	30	0	0	0	0	0	0	-	4/4/2001
TLB05	7.25881	99.45089	10	0	0	20	0	0	0	0	0	0	-	4/4/2001
TLB06	7.25078	99.45886	80	0	0	5	0	0	0	0	0	5	-	4/4/2001
TLB07	7.25686	99.46050	70	0	0	5	0	0	0	0	0	0	-	4/4/2001
TLB08	7.25475	99.45975	90	0	0	5	0	0	0	0	0	0	-	4/4/2001
TLB09	7.25272	99.45900	0	0	0	0	0	0	0	0	0	0	-	4/4/2001
TLB10	7.25175	99.46356	90	0	0	3	0	0	0	0	0	2	-	4/4/2001
TLB11	7.25233	99.46525	35	0	0	0	0	0	0	0	0	0	-	4/4/2001
TLB12	7.25369	99.46475	85	0	0	5	0	0	0	0	0	0	-	4/4/2001
TLB13	7.25469	99.45794	85	0	0	0	5	0	0	0	0	0	-	4/4/2001
TLB14	7.25189	99.45731	5	5	15	0	5	0	0	0	0	0	-	4/4/2001
TLB15	7.24914	99.45625	0	0	0	0	0	0	0	0	0	0	Land mark	4/4/2001
TLB16	7.25958	99.45006	0	0	0	0	0	0	0	0	0	0	Beach	4/4/2001
TLB17	7.31522	99.41656	0	0	0	0	0	0	0	0	0	0	Land mark	4/4/2001
TLB18	7.28150	99.39753	0	0	0	0	0	0	0	0	0	0	Sandy bottom	4/5/2001
TLB19	7.26811	99.40297	15	0	0	0	0	0	0	0	0	0	-	05/04/2001
TLB20	7.27169	99.40203	70	0	20	0	0	0	0	0	0	0	-	05/04/2001
TLB21	7.26850	99.40478	0	0	0	0	0	0	0	0	0	0	Sandy bottom	05/04/2001
TLB22	7.27181	99.40939	60	0	0	0	0	0	0	0	0	0	-	05/04/2001
TLB23	7.27725	99.41997	0	0	0	0	0	0	0	0	0	0	Fine sand	05/04/2001
TLB24	7.27236	99.42633	85	0	0	0	0	0	0	5	0	0	-	05/04/2001

Table 8. continued

station	latitude	longitude	Ho	Hm	Hb	Ea	Cr	Cs	Hu	Hp	Si	Th	remark	date
TLB25	7.27483	99.42689	10	0	0	0	0	0	0	0	0	0	-	05/04/2001
TLB26	7.27503	99.43492	5	0	0	75	0	0	0	0	0	0	-	05/04/2001
TLB27	7.27506	99.43511	0	0	0	50	5	0	0	0	0	0	-	05/04/2001
TLB28	7.25961	99.47211	0	0	0	0	0	0	0	0	0	0	-	05/04/2001
TLB29	7.25164	99.47617	20	0	0	5	0	5	0	0	0	0	-	05/04/2001
TLB30	7.25494	99.47311	0	0	0	0	0	0	0	0	0	0	-	05/04/2001
TLB31	7.24486	99.45136	30	0	0	0	0	0	2	0	0	0	-	05/04/2001
TLB32	7.23469	99.45892	0	0	0	0	0	0	0	0	0	0	Mangrove fringe	05/04/2001
TLB33	7.23367	99.45742	0	0	0	20	0	0	2	0	0	0	-	05/04/2001
TLB34	7.24739	99.45739	20	0	0	40	0	0	0	0	0	20	-	05/04/2001
TLB35	7.31436	99.41650	0	0	0	0	0	0	0	0	0	0	Sandy beach	4/6/2001
TLB36	7.30739	99.41436	10	0	0	70	0	0	0	0	0	0	-	4/6/2001
TLB37	7.30878	99.41631	0	0	0	0	0	0	0	0	0	0	-	4/6/2001
TLB38	7.30328	99.42217	0	0	0	40	0	0	0	0	0	0	-	4/6/2001
TLB39	7.30492	99.42011	65	0	0	0	0	0	0	0	0	0	-	4/6/2001
TLB40	7.30294	99.42358	30	0	0	0	0	0	0	0	0	0	-	4/6/2001
TLB41	7.28350	99.44058	0	0	0	0	0	0	0	0	0	0	Muddy sand	4/6/2001
TLB42	7.29300	99.44403	0	0	0	0	0	0	0	0	0	0	Fine sand	4/6/2001
TLB43	7.23914	99.43400	0	0	0	30	0	0	0	0	0	0	-	4/6/2001
TLB44	7.23617	99.43531	5	0	0	30	0	5	0	0	0	0	-	4/6/2001
TLB45	7.24142	99.43647	5	0	0	60	0	0	0	0	0	10	-	4/6/2001
TLB46	7.23669	99.43903	50	0	0	30	0	0	5	0	0	5	-	4/6/2001
TLB47	7.23547	99.44025	50	0	0	15	0	0	2	0	0	15	-	4/6/2001
TLB48	7.23411	99.44219	50	0	0	20	5	0	2	2	5	5	-	4/6/2001
TLB49	7.23086	99.44164	60	0	0	2	2	0	0	1	0	15	Sand dune	4/6/2001
TLB50	7.23303	99.44414	80	0	0	5	5	0	0	0	0	5	-	4/6/2001
TLB51	7.23494	99.44689	60	0	0	10	0	0	0	0	0	0	-	4/6/2001
TLB52	7.23603	99.44269	50	0	0	15	0	0	0	0	0	15	-	4/6/2001

Table 8. continued

station	latitude	longitude	Ho	Hm	Hb	Ea	Cr	Cs	Hu	Hp	Si	Th	remark	date
TLB53	7.28669	99.45647	30	0	5	0	0	0	0	0	0	0	-	5/5/2001
TLB54	7.28597	99.45636	80	2	5	5	0	0	0	0	0	0	-	5/5/2001
TLB55	7.26689	99.46442	50	2	5	5	0	0	0	0	0	0	-	5/5/2001
TLB56	7.27011	99.47681	0	0	0	70	0	0	0	0	0	0	-	5/5/2001
TLB57	7.26786	99.46858	50	0	0	10	0	0	0	0	0	0	-	5/5/2001
TLB58	7.26683	99.47597	45	0	0	50	0	0	0	0	0	0	Tide pool	5/5/2001
TLB59	7.26892	99.47297	35	0	0	60	0	3	2	0	0	0	Tide pool	5/5/2001
TLB60	7.26967	99.46831	55	0	0	40	0	0	0	0	0	0	Tide pool	5/5/2001
TLB61	7.26958	99.46517	30	0	0	60	0	0	0	0	0	0	Tide pool	5/5/2001
TLB62	7.26978	99.46169	40	0	0	40	0	0	0	0	0	0	Tide pool	5/5/2001
TLB63	7.26967	99.45906	5	0	0	80	0	0	0	0	0	0	Sand dune	5/5/2001
TLB64	7.27036	99.45192	0	0	0	35	0	0	0	0	0	0	-	5/5/2001
TLB65	7.24903	99.45728	0	0	0	0	0	0	0	0	0	0	Mangrove fringe	5/6/2001
TLB66	7.23453	99.41800	5	0	0	0	60	0	0	0	0	0	-	5/6/2001
TLB67	7.23847	99.43411	10	0	0	0	0	0	0	0	0	0	-	5/6/2001
TLB68	7.24247	99.43825	5	0	0	5	0	20	0	0	0	0	-	5/6/2001
TLB69	7.23531	99.44261	10	0	0	30	5	5	0	0	0	0	-	5/6/2001
TLB70	7.23003	99.43594	3	0	0	5	0	2	0	1	0	0	sand dune	5/6/2001
TLB71	7.22467	99.44008	20	0	0	5	0	5	10	0	0	0	-	5/6/2001
TLB72	7.22761	99.42653	50	0	0	3	0	7	0	0	0	0	-	5/6/2001
TLB73	7.23228	99.42092	0	0	0	5	20	5	10	0	0	0	-	5/6/2001
TLB74	7.21831	99.42022	2	0	0	3	20	5	0	0	0	0	-	5/6/2001
TLB75	7.23539	99.41933	50	0	0	3	20	5	0	0	0	2	Water way	5/6/2001
TLB76	7.23856	99.45775	20	0	0	5	50	5	0	0	0	1	-	5/6/2001
TLB77	7.24097	99.45633	0	0	0	50	0	0	0	0	0	1	Tide pool	5/6/2001
TLB78	7.24425	99.45683	0	0	0	5	35	0	0	0	0	0	Mangrove fringe	5/6/2001
TLB79	7.24872	99.45478	70	5	1	0	0	0	0	0	0	0		5/6/2001
TLB80	7.25656	99.44792	0	0	0	5	0	0	0	0	0	0	Mangrove fringe	5/6/2001

4.3 Interviews

Within the two years of field research, I conducted 86 interviews with 145 individuals of ages between 7 and 100 years. The wide spread of ages of interview respondents has a bimodal distribution, with a slight positive skew towards the younger ages (Figure 43). The maximum numbers of respondents occurred at ages 29 and 42. The average age of interview respondents is 40.92 years, the median age is 40, and the standard deviation 14.56. I interviewed 110 men and 35 women. Interviews were done in the villages of Ban Kuraburi, Ban Tung Nan Dam, Thap Lamu, and various villages on Ra and Phratong Islands in the northern sites of Kuraburi and Thap Lamu in Phang-nga province. In more southern sites, interviews were conducted in the coastal villages of Ban Chao Mai, Ban Laem Makham, and Ban Ta Se, and on Libong and Muk Islands in Trang province. I also interviewed villagers on Sriboya and Pu Islands in Krabi (Three Islands), villages on Yao Noi and Yao Yai Islands in Phang-nga Bay, and the villages of Ban Hua Hin, Ban Tanyong Uma, Ban Yaratot Yai, Ban Sakorn, Ban Tanyong Po, and Ban Kan Kurre in Satun province (Figure 18).

In Thap Lamu, I was only able to do two interviews. The fishers all work on large trawlers that leave every afternoon at 2pm, and return at about 5am. After sleeping, the men spend the rest of their time preparing to leave again. The women spend their days processing the fish. I was told that everyone was too tired to be interviewed. One of the men I did talk to was the assistant to the Gamnan (a village official), and did not fish, the other was a fisherman I interviewed at the docks just before his boat left.

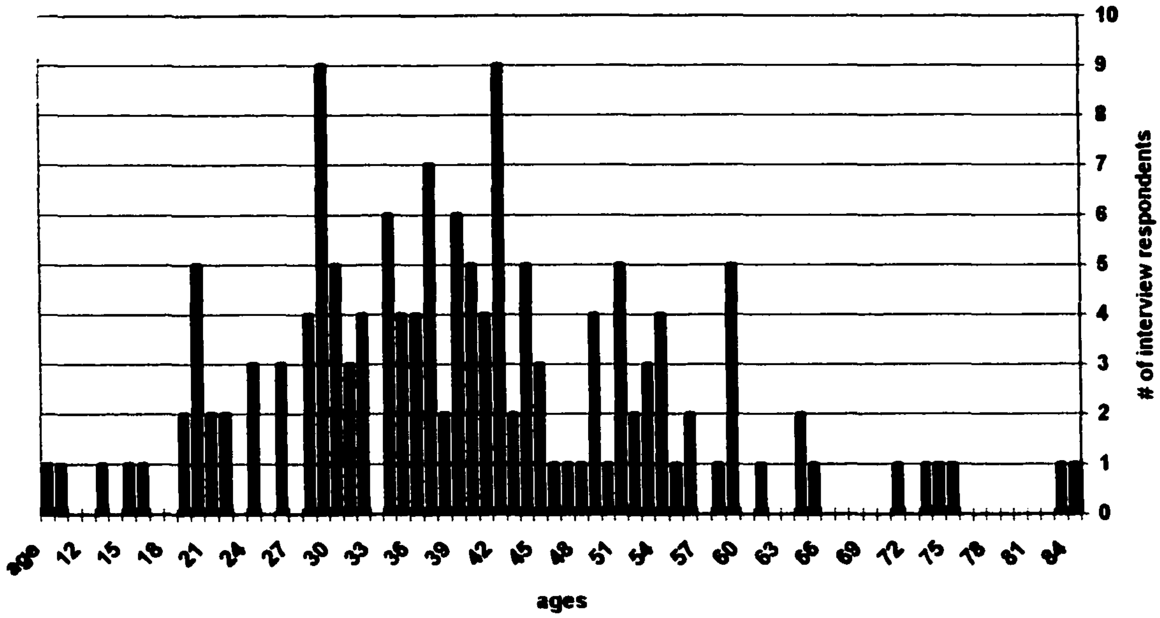


Figure 43. The distribution of ages of interview respondents for 2000 and 2001.

Most of the men were fishers (87%). Other professions mentioned were boat driver, shrimp farmer, rubber plantation worker, and store-worker (each 2.4%), teacher, fish-packer, and retiree (each 1.2%). Fishers represented 45% of the total professions for women; store-worker and shell collecting were each 14%. Ten percent of the women were students, and 7% of the women interviewed stayed at home with their families, collected crabs, or taught. One woman owned her own crab export business, one sold fish, and another sorted fish.

Due to my determination to stay in the background during the interviews, and my dependency on the different translators, interviewees were sometimes not asked all the questions in the questionnaire. In 2001 especially, when Kanjana Adulyanukosol and a research assistant from the MESU conducted interviews, the interview format was not followed, and in particular, questions on conservation were generally not asked. I was given a choice as to whether I wanted them to use my questionnaire, or the interview format they had created. As they seemed more accustomed to their own system, I decided to use their survey questions. The resulting numbers of interview respondents varies as a result.

Therefore, as the different number of respondents biased the results, I summarized the results descriptively using percentage distribution tables (Ember & Ember 2001, Alreck & Settle 1995). Each table shows the frequency of each answer as well as the adjusted percentage for that answer out of the number of respondents. In this way, the sample percentage can be interpreted as an estimate of the percentage of the respondents that answered each question (Alreck & Settle 1995).

4.3.1 History

Interview respondents have seen dugongs in the surrounding areas for between 3 and 100 years (Table 9). Dugongs were never hunted locally according to 78% of 55

Table 9. The length of time dugongs have been seen in this local area.

Percent of respondents	**Length of time**
12	within the last 10 years
9	30 years
16	100 years
18	Since respondents' vouth
25	A long time

Total of 57 responses

responses. Eleven percent said that dugongs were hunted in their area, and 2% did not know. Respondents who gave positive answers about hunting in their area were in Trang, in the Three Islands area, and in Satun. In Trang, hunting stopped reportedly between 10 and 40 years ago. One man, who claimed to be 100 years old, said he used to hunt dugongs when there were a lot more dugongs, but he stopped 30 years ago. He then drew an example of a special dugong spear in the sand. In the Three Islands, one respondent mentioned that hunting stopped 20 years ago, another that dugong hunting only stopped in 1994 when Yadfon (a local Non-Government Organization [NGO]) came into the area and started a conservation education program. When I arrived in the Three Islands area, 3 villagers came to show me bones from hunted or stranded dugongs. One of our interviewees, the Puyi (village official) of Pu Island, showed me an entire skeleton he had collected from a stranded animal. In Satun province, dugongs used to be hunted over 20 years ago for their tears.

Half of the respondents had not heard any legends or stories about dugongs or about their interactions with humans. Out of the half who had, 50% of those came from Trang province. I heard eight different stories, some only slightly different, from 30 respondents. Forty-five people in all told me stories. Thirty-eight percent of the legends told of tears, tusks, or body parts being used as aphrodisiacs. An 11-year old girl on Yao Noi Island showed me a solution of dugong tears mixed with oil that belonged to her family. Most respondents mentioned that the dugong aphrodisiac only works for men to attract women, and not vice versa. In Satun however, I heard the story of an island woman who used dugong tears to charm a man from the city who came to see dances in her village. He was so bewitched that he swam to the islands to be with her.

The next most frequent story about dugongs and people (30%) was a series of variations on the pregnant woman who wanted to eat seagrass, and as the tide rose, different parts of her body turned into that of a dugong. In one variation, her boyfriend came out to rescue her in a boat, and he also became a dugong. Gahat Tomat, the 100-year old man on Muk Island, recounted the following:

> "Two people had sex and the woman became pregnant. She was not a real woman because she could only eat seagrass. On *seep ha cam* (the full moon) she went out to eat seagrass alone. The third time she went out alone to eat her friends and family called her back to the shore while the water quickly rose to her neck. Her boyfriend took a boat to go and rescue her, but she had become a dugong by the time he reached her."

Thirteen percent of the stories told about how dugongs cry and make sniffling noises when trapped in a net. One respondent said that people in his area say that if someone steps on the tail of the animal while it is trapped or stranded, then it will cry, and they soak up the tears with cotton balls. Ten percent of legends told of other variations on how dugongs used to be humans. I also heard how dugongs used to be fish, or beautiful mermaids, or women picking shells. The Puyi of Ban Chao Mai, in Trang province, told the following story:

> "This story takes place in the past when there was a plentiful amount of dugongs. When young couples married (approximately at age 15) they would round up nearly 100 dugongs in a group. From the group they chose a dugong to be killed. Then when the couple was separated and lonely they would call to the dugongs in the water to remind themselves of their love."

4.3.2 Patterns

The amount of time that small-scale fishers along the coast spend on the water is unconstrained by the limited field season and airtime of these surveys. News of sightings is spread throughout the villages. Respondents pointed out dugong sighting points on bathymetric maps of the surrounding area. This information, while not always reliable, is valuable as a relative indicator of animal presence. Figures 44 through 48 show areas where dugongs were stated to occur in each of the five regions. Dugongs were reported by half of the respondents to be seen primarily in the rainy season (the southwest monsoon between May and October). In the opinion of 35% of the respondents, they are seen all year, whenever the seagrass is healthy. Ten percent felt that dugongs were more commonly seen in the dry season (the northeastern monsoon between November and April), and 6% did not know. Most of the dugongs (91%) were reported to occur in small groups of less than 10 animals (Table 10). Out of 60 respondents, 63% reported they have never seen dugong calves. Thirty-three percent have, and 4% did not know.

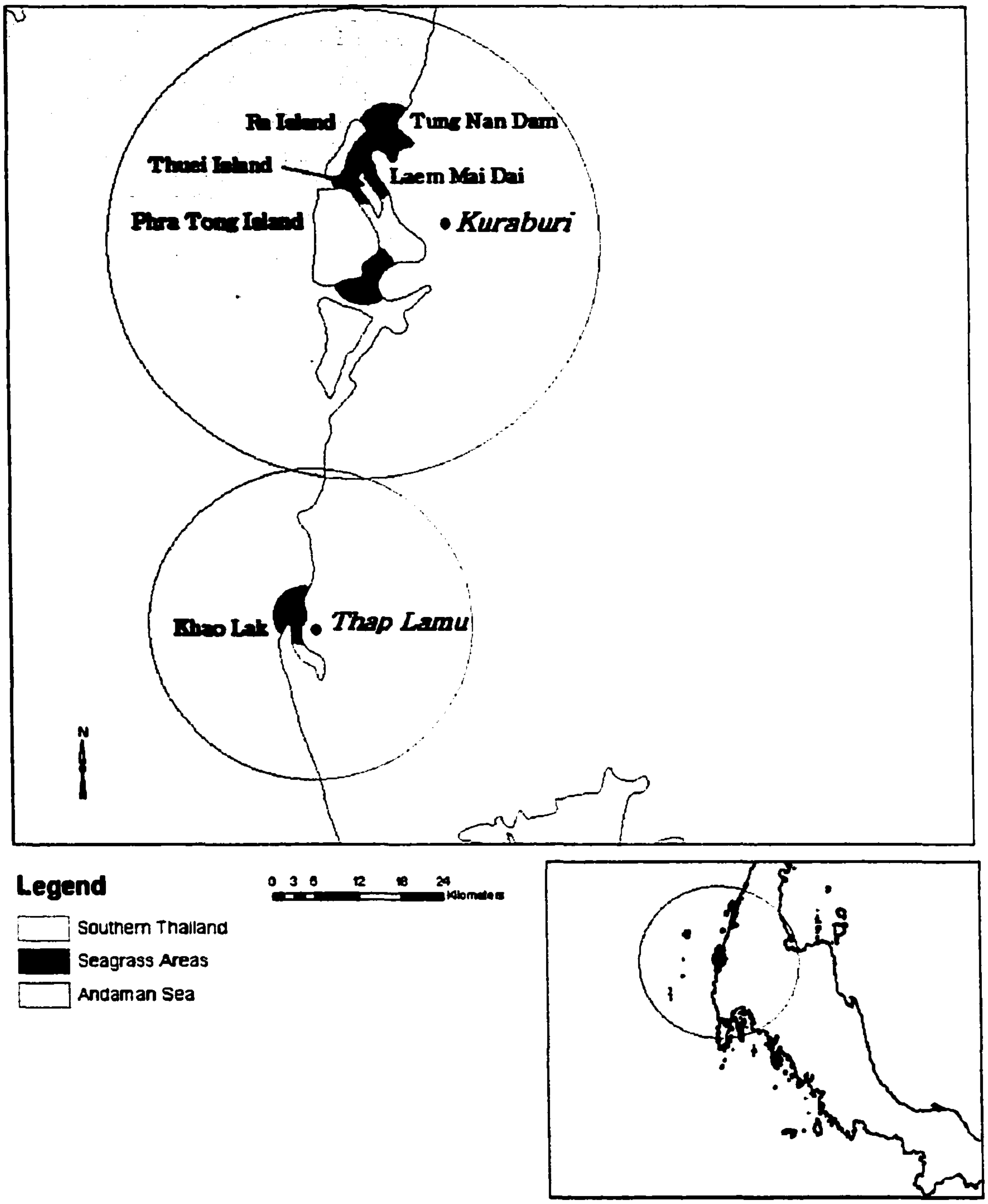


Figure 44. Areas where interview respondents have seen dugongs around Kuraburi and Thap Lamu in Phang-nga Province.

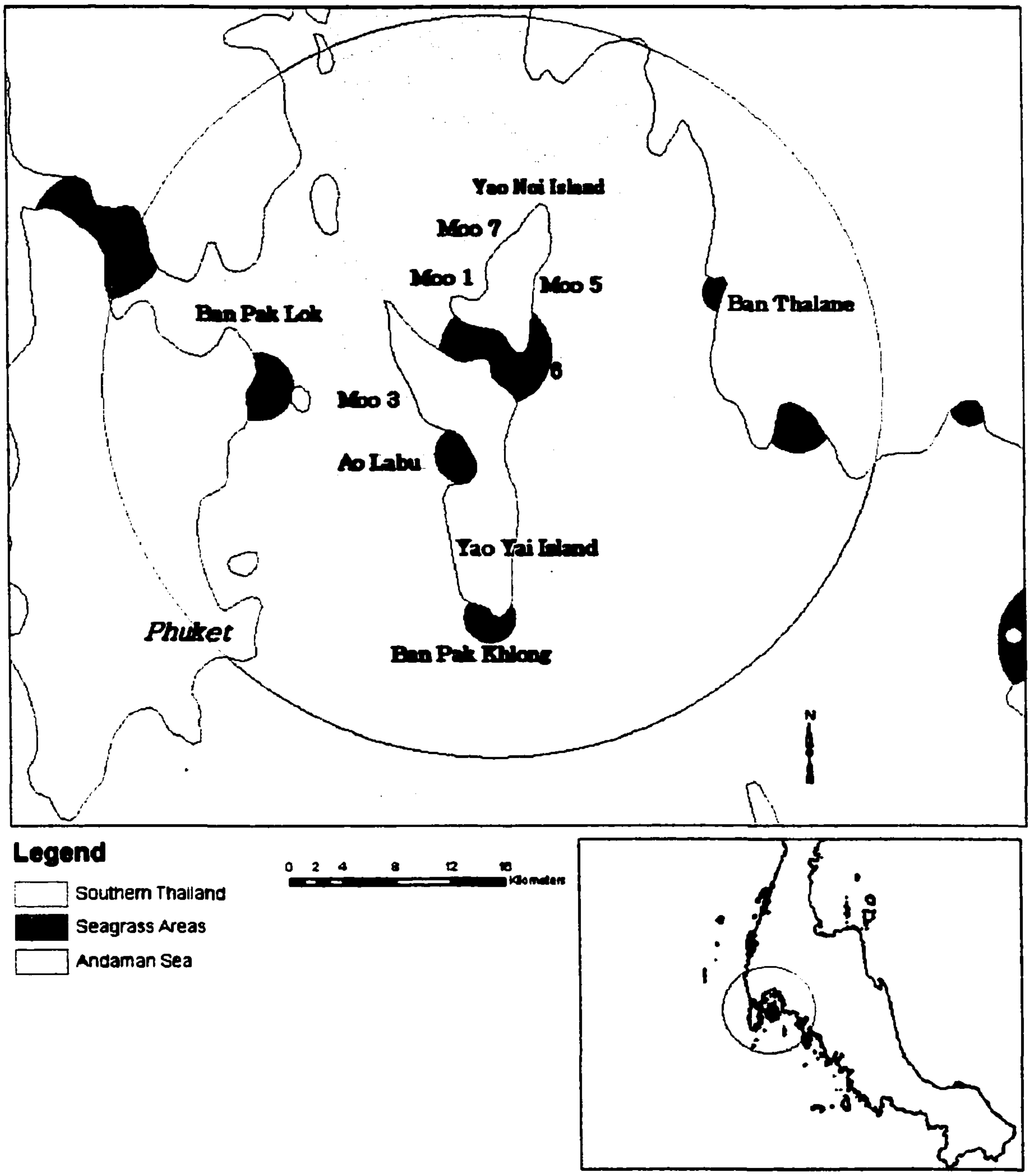


Figure 45. Areas where interview respondents have seen dugongs around Phuket and the Yao Islands in Phang-nga Bay.

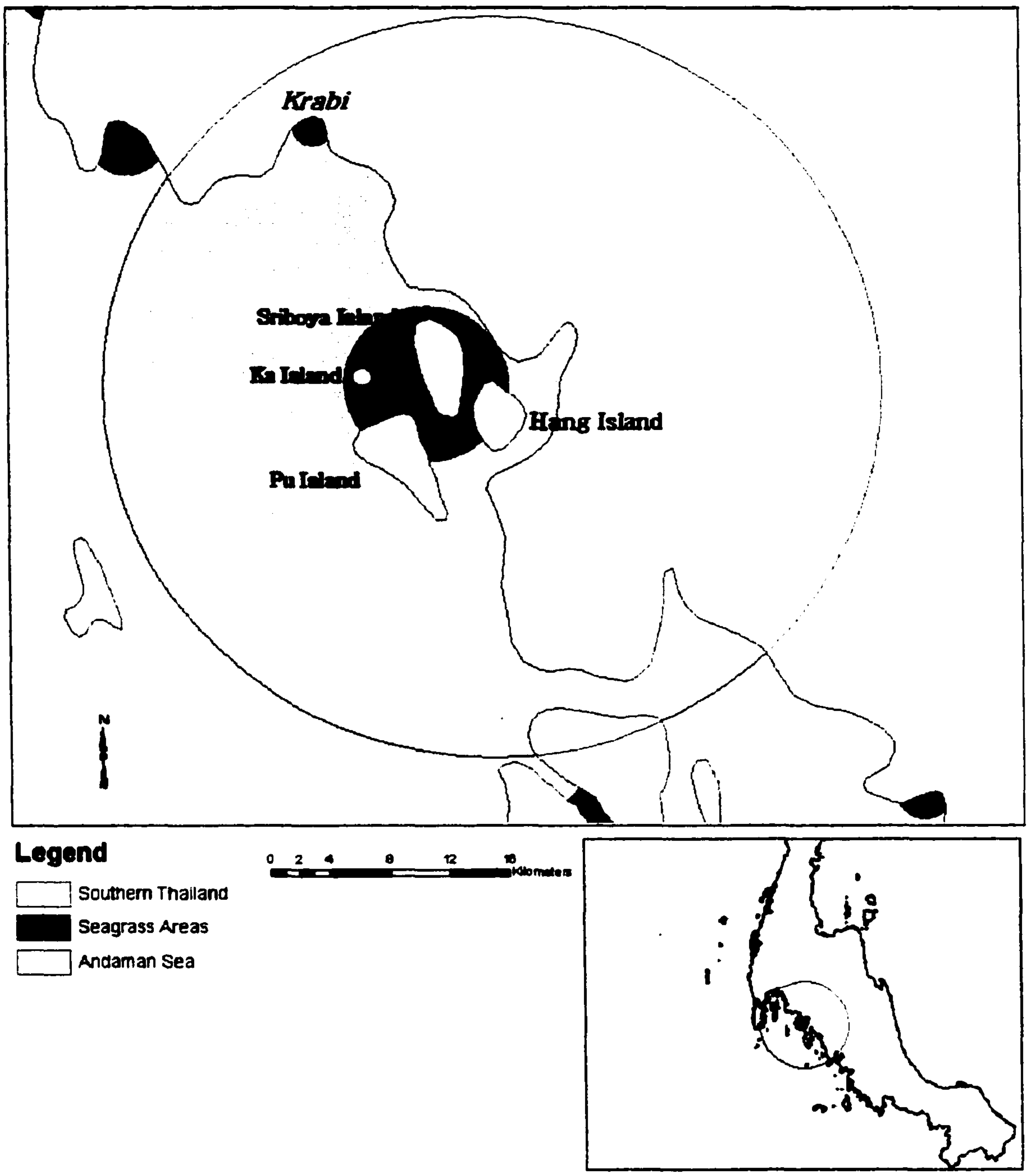


Figure 46. Areas where interview respondents have seen dugongs around the Three Islands in Krabi province.

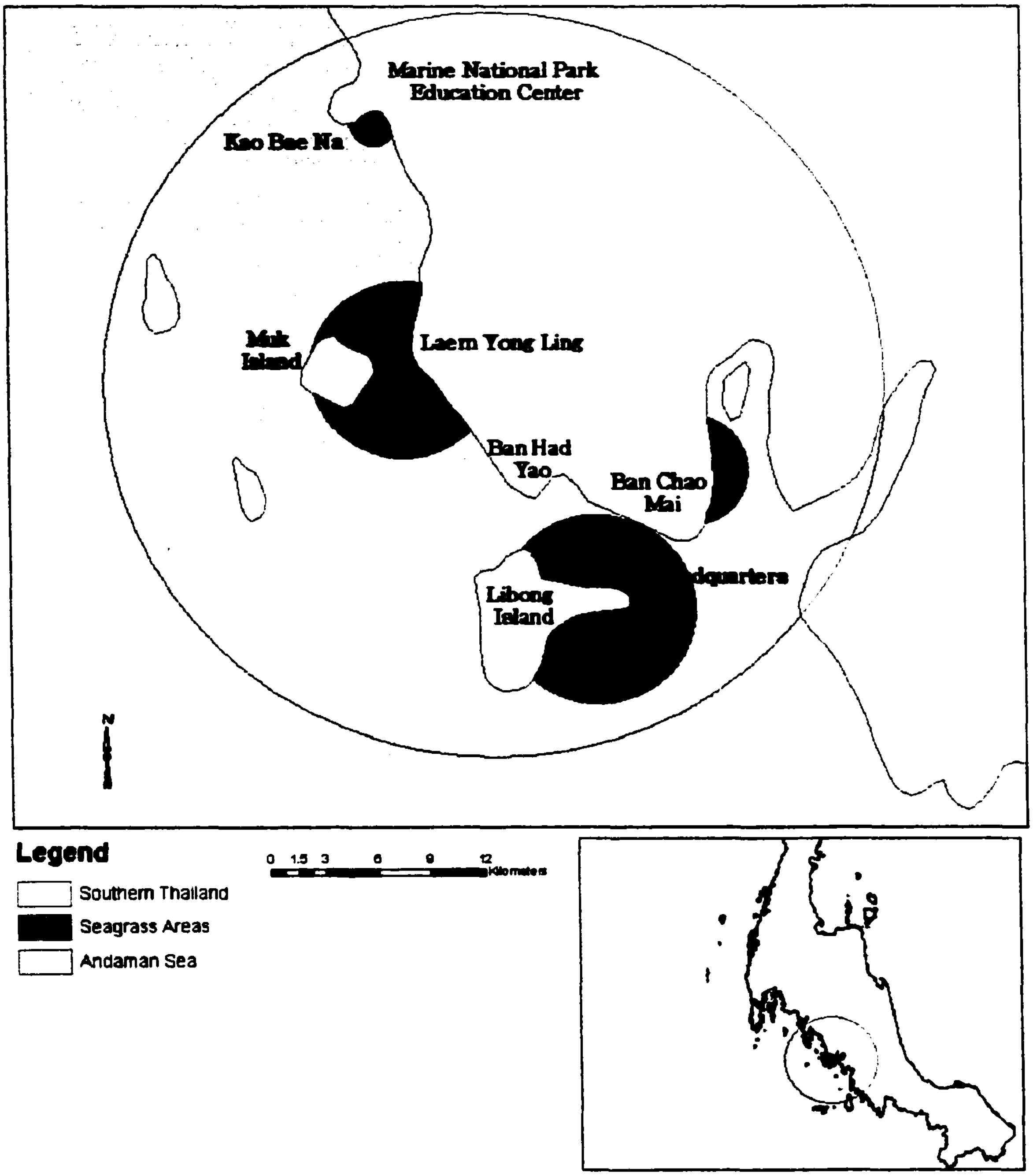


Figure 47. Areas where interview respondents have seen dugongs in Trang province.

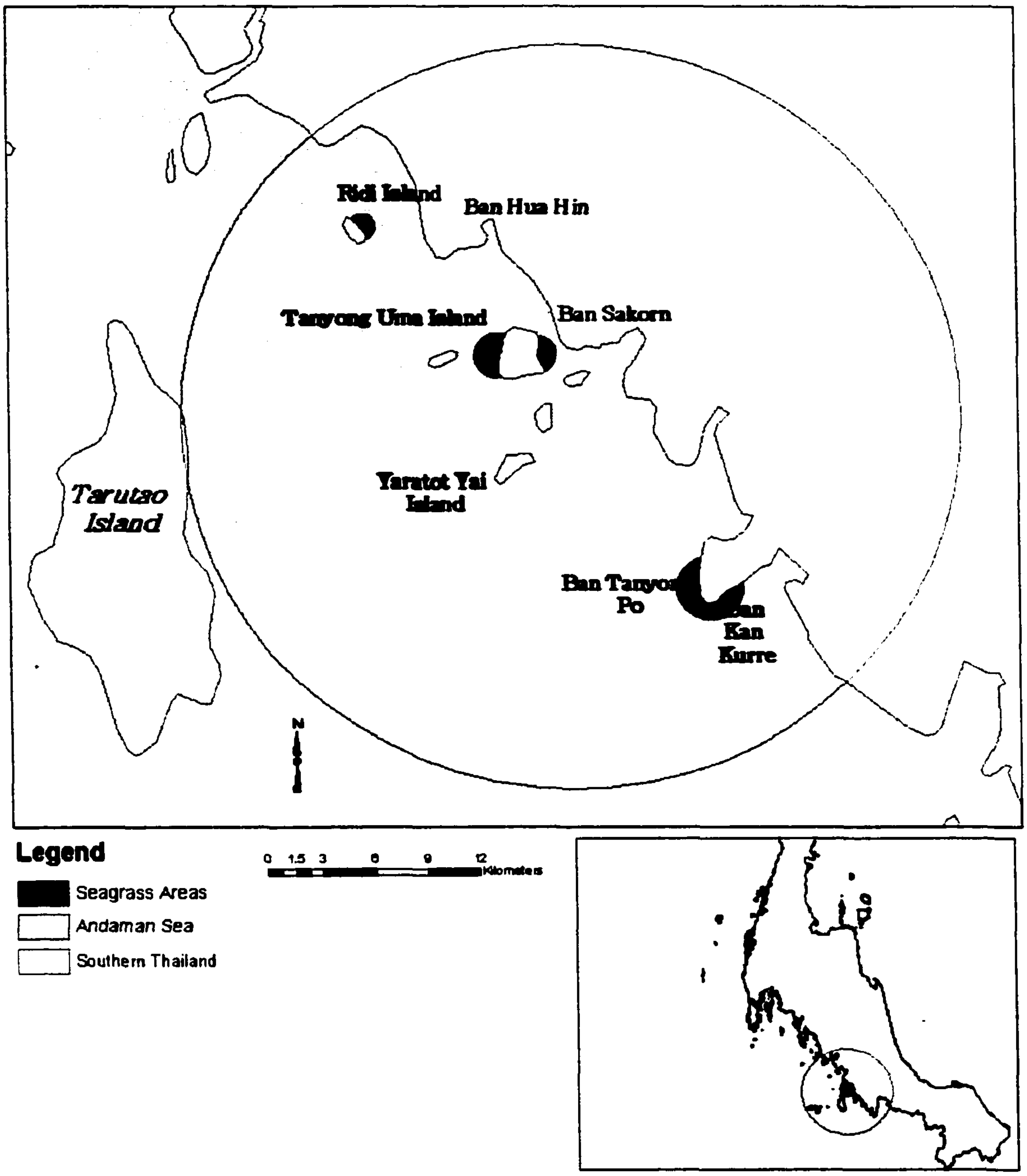


Figure 48. Areas where interview respondents have seen dugongs in Satun province.

Table 10. Dugong group sizes according to interview information.

SIZE OF GROUP	NUMBERS OF REPORTS	% OF TOTAL REPORTS
1	30	45
2 to 3	14	22
4 to 5	5	7
7 to 8	9	13
Greater or equal to 10	3	4
"big"	5	7
Hardly sees dugongs	1	2
Total # of responses	67	100

Table 11 contains a summary of how many dugongs were seen by interviewees within the past year. Sixty-four percent of respondents have seen 10 or fewer dugongs. The 7 people who saw more than 10 dugongs are all fishers from Trang province. Two of the people who reported seeing "many" dugongs are from Trang, one of the other respondents who reported similarly is from the Three Islands area, and the other three are from the Yao Islands. A group of five women fishers in Yao Noi Island said that they see dugongs all the time, too many to remember. A group of five male fishers, also from the Yao Islands area, mentioned that dugongs are seen all the time in groups of two or three at a time. Another group of four fishers here (three male, one female) stated that every fisher sees at least one dugong a day. In Satun province, dugongs had never been seen or only seen as a child by respondents in the 4 southernmost villages I visited, though the respondents had heard stories of dugongs being seen by past generations. In Tanyong Uma Island (Figure 48), villagers talked about seeing long lines of feeding trails and groups of up to 10 dugongs while fishing.

Table 11. The number of dugongs seen between 1999 and 2000.

NUMBER OF DUGONGS SEEN	NUMBER OF PEOPLE (%)
1	23 (35)
2	13 (19)
4 or 5	8 (11)
10	3 (5)
50 to 60	3 (5)
70 to 80	1 (2)
100	3 (5)
many	6 (9)
unknown	6 (9)
Total # of responses	66 (100)

4.3.3 Threats

Seventy-three respondents gave their opinions as to whether dugong numbers were declining, increasing, or not changing (Table 12). Eighty-four percent of the respondents thought that dugong numbers in their area had either decreased or stayed the same.

Table 12. How dugong numbers are declining, increasing, or staying the same.

Declining (%)	56 (77)
Increasing (%)	11 (15)
Staying the same (%)	5 (7)
Don't know (%)	1 (1)
Total # of responses	73 (100)

Ninety-three percent of the interviewees did not feel that dugongs interfered with the fishing or boating activities of local fishers. However, 59% of respondents reported that dugongs had been caught in either their nets or the nets of other fishers in their villages. In Trang, a village official said that 9 dugongs had been found dead from being caught in nets in 2000.

4.3.4 Conservation

The following questions center around the importance of conservation, as represented by dugongs, other endangered species, as well as coastal mangroves and seagrass beds. Tables 13 through 17 summarize responses and comments to these questions. Other endangered species were explained as being whales, dolphins, and marine turtles. The next question asks for a choice on a continuum of positive and negative feelings about an area being designated off-limits to fishing in order to conserve an endangered animal or system. The tables below chart those opinions and comments (Tables 18 and 19).

Table 13. Opinions of interview respondents on the importance of conserving dugongs, other endangered species, seagrass, and mangroves, as reported in the interviews. Comments are summarized below in Table 14 for dugongs, Table 15 for other endangered species, Table 16 for seagrass, and Table 17 for mangroves.

	DUGONGS (%)	ENDANGERED SPECIES (%)	SEAGRASS (%)	MANGROVES (%)
Very important	41 (61)	36 (57)	34 (56)	27 (44.5)
Important	24 (36)	25 (40)	21 (34)	27 (44.5)
Neutral	2 (3)	1 (1.5)	5 (8)	5 (8)
Moderately negative	0	1 (1.5)	1 (2)	2 (3)
Very negative	0	0	0	0
Total # of responses	67	63	61	61

Table 14. Comments on the importance of conserving dugongs.

DUGONG CONSERVATION COMMENTS	NUMBER OF TIMES MENTIONED (%)
Would like to see in future	21 (34)
Because they are declining	11 (17)
They are killed by push-netters, people with money and influence who break the law	6 (9)
Because they are now hard to see they realize the importance of conservation	5 (8)
People need to see how important dugongs are	4 (6)
Dugongs do not harm people	4 (6)
They are a symbol of the sea	3 (5)
Because they create a healthy environment	2 (3)
Dugongs are like humans	1 (2)
We should love dugongs more than humans	1 (2)
Because all forms of life are connected	1 (2)
Because it would help to preserve the past	1 (2)
Use for medical purposes	1 (2)
Not many places left for dugongs	1 (2)
Total # of responses	62 (100)

Table 15. Comments on the importance of conserving endangered species.

ENDANGERED SPECIES CONSERVATION COMMENTS	NUMBER OF TIMES MENTIONED (%)
They are declining	14 (29)
Would like to see in future	13 (27)
They fear these species will become extinct	5 (10)
Because all forms of life are connected	4 (8)
They are a symbol of the sea	3 (6)
They want people to come and see the endangered species	2 (4)
The animals don't harm us, we shouldn't harm them	2 (4)
They can't protect themselves from harmful fishing	2 (4)
Don't know why the animals are important	1 (2)
Dolphins keep people safe in the water and show them where fish are	1 (2)
Wants to live in a natural environment	1 (2)
Dolphins are smart	1 (2)
Total # of responses	49 (100)

Table 16. Comments on conserving seagrass.

SEAGRASS CONSERVATION COMMENTS	NUMBER OF TIMES MENTIONED (%)
Food for dugongs	28 (34)
Food for fish/turtles	22 (29)
Many animals live in seagrass	23 (27)
Relationship with coral	3 (3)
Increasing	2 (3)
Wants to see in the future	1 (1)
Always catch in net, but need to fish	1 (1)
Declining	2 (1)
Will have more fish to live on	2
Total # of responses	84 (100)

Table 17. Comments on conserving coastal mangroves.

MANGROVE CONSERVATION COMMENTS	NUMBER OF TIMES MENTIONED (%)
Home and breeding ground for many animals (fish, crabs, shells, shrimp, birds)	42 (55)
Use wood for building homes/fuel	10 (13)
Filters the ocean to keep the water clean	6 (8)
Important interactions with coral and seagrass	3 (4)
Protects us from the wind	2 (3)
Does not know uses	2 (3)
People cut for firewood when the trees are small and the trees don't grow back	2 (3)
Mangroves have many uses	2 (3)
Mangroves are scarce	2 (3)
Beautiful	1 (1)
Nuisance, can only travel at high tide	1 (1)
Everything is connected	1 (1)
So the water will not wash the land away	1 (1)
Fishers need to live in the mangroves	1 (1)
Total # of responses	76 (100)

Table 18. Opinions on a local area being designated off-limits to fishing in order to conserve an endangered animal or system.

	OFF-LIMITS AREA (%)
Extremely positive	19 (29)
Moderately positive	24 (34)
Neutral	13 (21)
Moderately negative	6 (10)
Extremely negative	5 (6)
Total # of responses	62 (100)

Table 19. A summary of comments on a local area being designated off-limits to fishing in order to conserve an endangered animal or system.

OFF-LIMITS AREA COMMENTS	NUMBER OF TIMES MENTIONED (%)
Concerned about subsequent scarcity of resources	24 (41)
Off-limits area good for conservation	19 (32)
Concerned about enforcement of off-limits area	9 (15)
No need for off-limits area	6 (10)
No opinion	1 (2)
Total # of responses	59 (100)

4.3.5 Locations and History of Strandings

The first question in this section asked if respondents had ever found any dugongs or other large marine animals stranded. Seventy villagers answered with 74 positive responses as to having seen such events including one or more species. Table 19 summarizes these responses. Included in the dugong count is one subadult, and one cow/calf pair, otherwise, all the dugongs were said to be adults.

Table 20. Animals found stranded as related by interview respondents.

	NUMBER OF TIMES MENTIONED (%)
Dugongs	44 (50)
Dolphins	20 (23)
Whales	8 (9)
Porpoises	1 (1)
Whale sharks	1 (1)
None found	14 (16)
Total # of responses	88 (100)

For the remaining questions in this section, I summarize answers concerning dugongs only. Fifty percent of the strandings or incidental catches were found in Trang province, and 21% each in Kuraburi and the Yao Islands. Eight percent of the dugongs were found in the Three Islands, 5% in Satun province, and none were reported in Thap Lamu.

Eighty percent of the incidents reported were within the past five years. Two dugongs were found in stationary nets in the Yao Islands in March of 2000 and released. This apparently is common, and I was told that the dugongs are always found alive and released. A Yao Islands official told me that 3 dead dugongs have been found stranded there in the past 3 years, and all bodies were reported and taken to the Phuket Marine Biological Center. In the Three Islands, between 1994 and 2000, 7 or 8 dugongs were found dead. In this case, it is not clear what happened to the bodies. From other information gathered in this area, I would assume that the teeth, tusks, and bones were taken to be sold or used as medicine, and the meat distributed and/or sold within the community.

Sixty-seven percent of the dugongs involved in these incidents were dead. Officials were notified only in 12 (12%) of these cases. When asked about what they would do if they found a stranded dugong, 60% of respondents would help it back into the water if the dugong were still alive. Other answers are given in the table below (Table 21).

Table 21. According to the interviews, actions that a fisher said they would take upon finding a stranded dugong.

ANSWER	NUMBER (%)
Help it back into the water	57 (60)
If dead would tell officials	12 (12)
If dead will eat/sell/give away	7 (7)
If dead would take tusks/bones for medicine	6 (6)
If dead would not report, takes too much time	4 (4)
If dead would bury	4 (4)
Meat too similar to humans, would throw into the ocean and not eat	3 (3)
If dead would bring to shore to show children	2 (2)
If dead would talk to other fishers to decide	1 (1)
If dead would not know what to do	1 (1)
Total # of responses	97 (100)

In Table 22, I have summarized what was actually done with the dugongs found, either alive or dead. Only 32 people responded to this question. In the Three Islands, all except one of the respondents to this question would kill the dugong if found alive in order to sell the tusks.

A dugong was found caught in a small net on the 4th of April, 2000 at Bang Rong Bay, a port on the northwest corner of Phuket Island. I heard from people both in the Yao Islands and Phuket how the whole village came out and, along with officials from the local Fisheries Office, moved the 300 kg animal 10 meters to the water. On Yao Noi Island, I interviewed an 11-year-old girl who, with the help of her class at school and local villagers helped to release a dugong stranded by the tide. Both of these incidents were recounted to me as examples of how the awareness of villagers was increased by direct contact with these animals.

Table 22. What respondents did with the stranded or caught dugongs.

	NUMBER OF TIMES MENTIONED (%)
Eat/sell/take	9 (28)
Released alive	**8 (25)**
Do not know what happened	6 (19)
Officials took the body	**5 (16)**
Discarded body	4 (12)
Total # of responses	**32 (100)**

A major incident of this type occurred in Ban Chao Mai, a village in Trang Province, at the southern end of Had Chao Mai National Park (Figure 5). I put together this account from several interviews. In 1993, a 3-year-old female (approximately 40 kg) dugong came over to the Puyi's son (Cheo) as he was playing in the river near the village. He stayed around the village for almost 2 years. The villagers named the dugong 'Ja Tone', meaning 'lonely boy' in the local dialect, and according to the people I interviewed there, he became the baby of the village. One respondent mentioned that the dugong had some wounds that were tended by the villagers. When people wanted to see the dugong, they would slap the water and call "Tone" several times. Tone would come towards people in the water for affection, but only liked to be touched by Cheo, and then only when he was wearing the same color shirt as when he originally saw the dugong. The villagers began to charge 1500 baht (around $33.30 CDN) to take people to see

Tone, and even people from Bangkok came to see him. Eventually Tone was caught in a fishing net and drowned. He was found on a beach by a fisher from Ban Chao Mai, with markings on his skin that indicated he had been caught in a net. His bones remain in the village at the local school as a remembrance to the tragedy. The village went in mourning ("the heart of the village was broken"). Now people in Ban Chao Mai place greater value on dugongs and know that if the seagrass disappears, so will the dugongs.

Tone was originally found as an orphan off the coast of Ranong, and brought to the PMBC. Kanjana Adulyanukosol kept the animal in a tank, and eventually sought to release him in an area with good seagrass beds and an established dugong population. She released the animal in Upper Sikao Bay, north of the village of Ban Chao Mai. So Tone was used to being handled and hand fed by humans. After she heard about Tone, she came to Trang and recognized him from a burn mark made by a heater when he was in captivity.

4.3.6 Medicinal Use

Seventy-three percent of 60 respondents said that at least some part of the body of the dugong was currently used for some sort of medicinal use. As mentioned earlier, the tusks are considered to be especially valuable, and in the Three Islands, I was told that the Puyi of Pu Island would buy tusks for 10 000 baht ($400 CDN) and sell them to jewelry shops in Krabi for sale to Thais as amulets. In Trang province, a respondent at Libong Island mentioned that he had heard that tusks would sell for as much as 710 000 baht ($28 400 CDN). The specific comments are summarized in Table 23.

Table 23. As reported in interviews; what dugong body part was used, for what purpose, and how it was prepared.

	NUMBER OF TIMES MENTIONED (%)
Heard that tusks/bones/teeth are medicine but not sure how, have not used personally	12 (27)
People can wear tusks around their necks and waist to protect them from colds and evil and impotence	3 (7)
Bones make rings and earrings that protect people from evil	3 (7)
Bones are overall good medicine	3 (7)
Oil can be made into massage oil for sore muscles	3 (7)
Bones ground and mixed with juice can be used for throat and/or stomach problems	3 (7)
Bones boiled in water can give energy	2 (5)
Can use water from boiling tusks for skin problems	2 (5)
Every part of the body can be used as an aphrodisiac or for bone disease (arthritis)	2 (5)
Bones can be ground and mixed with herbs to cure colds	2 (5)
Bones will cool you down when you have a fever or other heat diseases	1 (2)
Can crush bones in mortar & pestle to make an ointment for skin problems	1 (2)
Can grind bones and mix the powder with lemon juice for skin problems	1 (2)
Can crush bones with a rock and mix them with juice for heat-sickness and shortness of breath; but tusks are better	1 (2)
Oil from bones and tusks are good for either cold or heat disease	1 (2)
Eating the meat helps the skin heal faster	1 (2)
Village doctors will use the tears for medicine and charge a lot of money	1 (2)
Hang the spine from your waist for waist pain	1 (2)
Will wear rings for protection but not use medicine because dugongs are decreasing	1 (2)
Total # of responses	44 (100)

4.4 Summary of results.

At the end of the two field seasons, the information gained from the surveys and interviews has enabled me to locate seagrass beds along the coast and on coastal islands that could support groups of dugongs. I have also located those areas currently supporting remnant populations of dugongs, and the estimated populations and densities of dugongs and calves. As set forth in the research goals, the methodology is repeatable, and can be readily documented in a geographic information systems database and mapping system. From the interviews, I gathered information about the history and movements of dugongs in various areas, as well as attitudes towards dugongs and the level of knowledge of local environmental issues. The threat of illegal push net and commercial trawling within the 3-kilometer coastal limit imperils not only dugongs and seagrass beds, but also village-based coastal fisheries. The extent of medicinal and amulet use of dugong body parts is another threat whose current pervasiveness has been made apparent by the interviews. The interview information is also useful as a tool to determine the foci needed for education about dugong conservation, as well as the possibility of a role for the dugong as a tool for education about coastal conservation.

4.5 Discussion.

4.5.1 Overview

In the next section, I focus on the interpretation of the results rising from the case study. Surrounding both the biological assessment of and conservation planning for the dugong are the larger issues of illegal and destructive fishing methods, the use of dugong body parts for medicine and amulets, and a lack of education on the importance of dugong and seagrass conservation. Some of the villagers I interviewed are becoming increasingly aware of the impact of destructive fishing, while others are taking advantage of illegal fishing methods to reap short-term economic benefits. While I have spoken to people who are exceptions, the majority of interview respondents have not associated overall coastal conservation issues with the consequent endangerment of the dugong and its habitat. Realization of the consequences of the widespread use of dugong tears as an aphrodisiac, the bones and oil as medicine, and the tusks as an amulet varies in the different villages.

In this section, I discuss the two-year case study, creating a context around these issues within which to place the results of the population and habitat assessments, and the information gained through the interviews. I then make recommendations for further research specific to the dugong along the Andaman coast.

4.5.2 Summary of Findings

Distribution, Movement, and Abundance

As in other countries in which dugongs are found, dugongs are distributed along the Andaman coast in population groups based on the locations of seagrass beds. Through past surveys, and the interviews and aerial surveys performed in this project, I have identified regular foraging areas for dugongs (Figure 49). From north to south, the major, or primary feeding areas are: 1) the islands and shoreline surrounding the Kuraburi estuary in Phang-nga province, 2) two seagrass beds in the Yao Islands in Phang-nga Bay, 3) in the seagrass beds surrounding Sriboya and Pu Islands in Krabi province, 4) in seagrass beds between Muk Island,and Laem Yong Lam beach, bounded at the north by

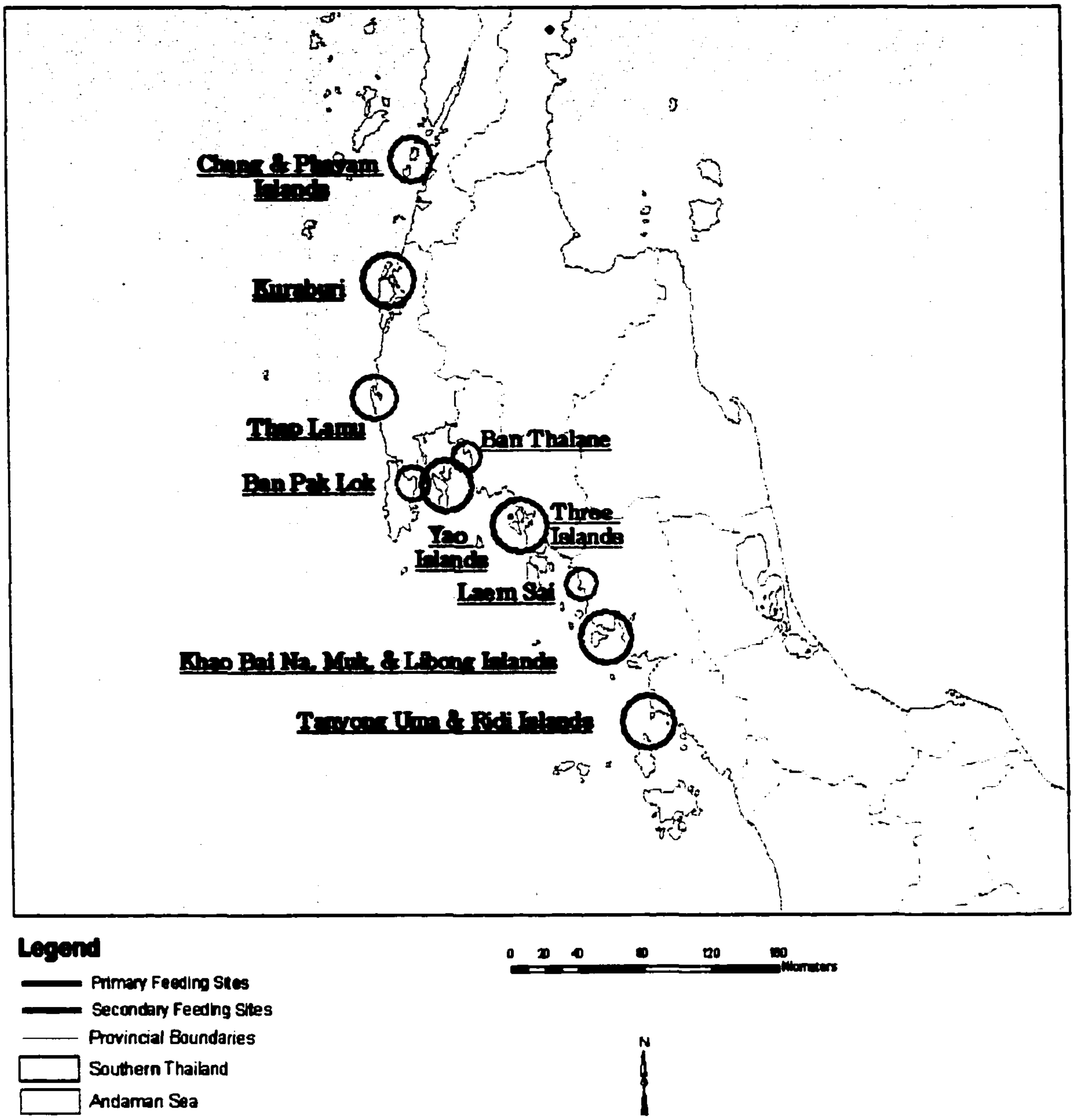


Figure 49. Primary and secondary dugong feeding areas along the Andaman coast of Thailand.

Kao Bai Na, and the seagrass surrounding Libong Island in Trang Province, and 5) seagrass beds bordering Tanyong Uma and Ridi Islands in Satun province.

The results of the helicopter surveys and interviews, as well as previous research and reported strandings show that intermittent, or secondary feeding sites possibly include seagrass beds near: Chang and Phayam Islands in Ranong province, Thap Lamu and Ban Thalane in Phang-nga province, Ban Pak Lok in Phuket province, and Laem Sai in Trang.

I define the primary feeding sites as areas where more than one dugong is currently seen regularly by villagers, and/or has been seen during the aerial surveys these past two field seasons. Secondary sites are areas where strandings have been reported in the past, villagers see single dugongs or cow/calf pairs occasionally, or single animals or cow/calf pairs were seen in the aerial surveys.

No research has been able to characterize feeding sites by specific seagrass density and bed area parameters. Preen (1992) found that 63% of the dugong groups he sighted in seagrass were in areas with sparse seagrass cover, and only 10% of his sightings were in areas of dense seagrass. de Iongh *et al.* (1995) observed that dugongs in Ambon Island in Indonesia seemed to favor foraging in seagrass beds with at least 20% cover, but mostly grazed out of beds with lower cover. Both authors, as well as Aragones (1996) agree that the most important factor in dugong foraging choice is the nutritional composition of the seagrass. Earlier in this document I discussed the likelihood that dugongs improve the seagrass bed as forage habitat by grazing on competitive species that are more digestible and contain higher nutrients (nitrogen and carbohydrates) (Aragones 1996). More research both in general, and along the Andaman coast, is needed to establish quantitative standards for the suitability of seagrass beds as dugong habitat.

From the interviews, there are mixed opinions as to the seasonal movements of dugongs. However, as the water is uniformly warm throughout the year, I agree with the respondents who stated that dugongs would be found in seagrass areas all year.
de Iongh (1996) found that dugongs in Indonesia will forage in the same areas in both calm and rough waters. In Shark Bay, Australia, however, dugongs have been seen to surface more horizontally and submerge more fully when waves are higher (Anderson and Birtles 1978). This could be more costly energetically. Seventy percent of the respondents who mentioned seeing dugongs more often during the rainy season live in or near sheltered bays and river mouths, where dugongs might spend more time during the southwest monsoon. In the Philippines, dugongs were seen to move to different sides of Calauit Island to escape monsoon storms (Aragones 1994). Satellite telemetry in another tropical habitat does not mention seasonal variation in distribution (de Iongh 1996). Though his sample size is small (n=4), two of the animals he followed were tracked during both the dry and rainy seasons, one of them for almost a year (285 days). He found that the animals simply alternated between grazing sites. In lieu of tagging, the only practical time for aerial surveys in Thailand is during the dry season.

Reviewing each feeding site specifically shows a highly variable range of dugong abundance. Adulyanukosol's 1997 survey found 3 dugongs at Tung Nan Dam in Phang-nga province. Interview respondents reported seeing 12 dugongs in the past 5 years, but some of those sightings are quite possibly repeats. Seagrass scientists have seen dugongs in this area on three separate occasions (Poochaviranon, Supanwanid, pers. comm. 2000). During the helicopter surveys, I circled the area quite a few times, but saw no dugongs.

In the Kuraburi area, I cannot at this time make a reasonable minimum population estimate. Based on trails that I saw, the animals seen by villagers and other researchers, and the extent and cover of the seagrass beds, the area can and most likely does support a small population of dugongs. In January of 2001, a stranded dugong was found at the Tung Nan Dam estuary. Due to the condition of the body, the cause of death was unable to be determined (Pitaksintorn, pers. comm. 2001).

In Thap Lamu, the seagrass beds have been damaged by monsoon storms. Each interview respondent mentioned having seen dugongs. One had seen a dugong last year in October. The other, however, said he saw the dugong in the Similan Islands, 50 kilometers offshore, which is questionable. Neither Adulyanukosol's survey nor mine located dugongs here. A regular dugong population in this area is not probable in my opinion, though it would be possible for a dugong in Kuraburi to travel the approximate 80 kilometers distance. I do recommend further aerial surveys in this area continue to look for dugongs and monitor the condition of the seagrass beds.

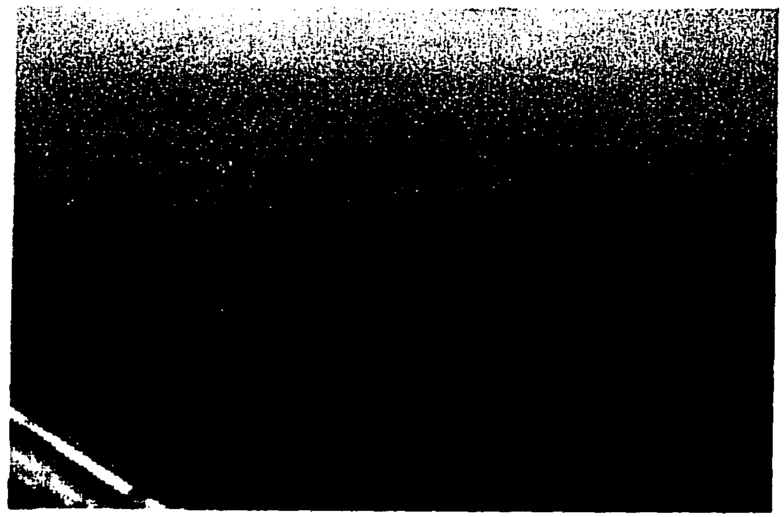
Adulyanukosol (1997) found 5 dugongs in the Three Islands area. In the 2000 microlite surveys, I saw up to 4 adults and 1 calf in one day. Villagers told of seeing 10 dugongs in the past 3 years. From the number of sightings, strandings, and the condition and extent of seagrass, the Three Islands area has seagrass beds that can support a small population of dugongs. The estimated minimum population here at this time is 5.

The Yao Islands has beds of dense, healthy seagrass in 2 areas, the first on the northeast coast of Yao Yai Island, and the second in a sheltered bay at the south end of

Yao Yai Island (Figure 9). I have seen feeding trails during boat-based seagrass sampling, and aerial surveys at both these sites (Figure 50). There is seagrass in the middle of the west coast of the same island, but the seagrass has been damaged by monsoon storms, and is quite sparse (Figure 9). During the 2001 microlite survey, 2 dugongs were seen in the seagrass beds on the northeast coast (Figure 41). In April of 1999, Kanjana Adulyanukosol saw a group of 8 dugongs between Yao Yai and Yao Noi Islands during a helicopter survey. Interview respondents in these areas have reported regularly seeing groups of between 1 and 10 dugongs. Fishers in this area feel that there are approximately 15 dugongs in the local seagrass beds. It is feasible that a group of dugongs feed here regularly.

In Trang province, for all sampling blocks combined, the best available estimate of minimum population abundance at this time is 123 dugongs. The maximum number of calves seen in a day is 13. However, the coefficients of variation (CVs) of the population estimates are relatively high (Table 4). In general, the highest levels of statistical precision are indicated by CVs of < 20%. At these percentages, the estimates are considered more reliable, and can be dependably utilized as the bases for trend analysis in the future (Jefferson 2000). In my observation of the survey statistics, and also as seen in the results of Florida manatee (*Trichechus manatus latirostris*) aerial surveys (Miller *et al.* 1998), the higher variance statistics were associated with larger numbers of animals, the number of sightings per stratum, and group size variability (Table 4). Transect sampling design and control of availability bias should be further refined to reduce the CVs.

(A)



(B)

Figure 50. Dugong feeding trails: (A) The southern coast of Libong Island, Trang province, (B) Between Yao Yai and Yao Noi Islands, Phang-nga province.

Another type of aerial-survey bias that has become apparent to me during the field surveys, that also been observed in Florida manatee surveys is absence bias, or the "...proportion of the target species that is not present in the survey area and for which the count is not corrected..." (Lefebvre *et al.* 1995, p. 67). There are several factors related to absence bias relevant to the aerial surveys in Trang. Survey related factors include the limited number of surveys made and survey dates available due to both the expense of the surveys, and the limits of the monsoon season. But more critical factors are the influence of the tides, and the unknown distribution of food resources (Lefebvre *et al.* 1995).

The differences of sighting numbers, as well as abundance and density estimates seen in various tide levels are shown in Table 6 and Figure 39. As the tide rises, more dugongs in larger groups are seen in the surveyed seagrass areas. At the highest spring tide levels, when the water depth is over 3.5 meters, the level of turbidity of the water is too high to see animals that are not completely at the surface. During the lower high tides, even though the water is clear, the number of animals seen in the same area is markedly lower. Where these animals go or feed is not known.

I predict that there are seagrass beds in this area that are not as yet identified by seagrass and dugong researchers. All of the animals that I saw were in depths of less than 5 meters. Seagrass species that are the preferred forage of dugongs are in beds deeper than the 5-meter intertidal beds that I surveyed (Poovachiranon 2000, Longstaff *et al.* 1999, Aragones 1996, de Iongh 1996, Marsh *et al.* 1994, Bay and Demoulin 1989). de Iongh (1996) noted that the majority of feeding tracks he found in a bay in Saparua Island were at depths of between 7 and 9 meters. Marsh *et al.* (1994) found that greater than 60% of the dugongs she sighted in Shark Bay in 1989 were in water 10 to 20 meters deep, probably feeding on seagrasses of the genus *Halophilia* and *Halodule*, species favored by dugongs for high nitrogen and low fibre (Aragones 1996, Preen 1992). *Halophilia ovalis* has been shown to be a very tolerant species, with low minimum light requirements, allowing it to survive in a wide range of depths, from intertidal waters to 50 meters in depth (Longstaff *et* al. 1999). In Papua New Guinea, *Halodule pinifoloia* is found at between 1 and 6 meters, and *H. uninervis* between 4 and 7 meters. *Halophilia decipiens* is found at depths of up to 40 meters (Bay and Demoulin 1989).

Along the Andaman coast, Poochaviranon (pers. comm. 2001) has found seagrass in the Three Islands area at depths of 6 meters. In scuba surveys he has found *H. ovalis* at depths to 6.56 meters, and *H. decipiens* at 6.96 meters. Future seagrass research needs to address the possibility of unknown feeding areas that are used at lower tide levels.

Feeding trails in Trang are plentiful (Figure 50). The sighting locations and sampling block statistics showed that the larger groups of dugongs gathered in the dense patches of mostly *Halophilia ovalis* along the eastern end of Libong Island, sampling block 4 (Figure 15). In this stratum, the average cluster size is 5.12, and the highest abundance estimate is 98 dugongs. Smaller groups of dugongs regularly fed on the more patchy seagrass along the south coast of the island. This area, sampling block 5, has an average cluster size of 1.82, and an abundance estimate of 37. Between Muk Island and Laem Yong Lam, sampling block 1, an estimated 12 dugongs fed in average groups of 1.07 (Figures 21 through 25 for 2000, 28 through 33 for 2001 show sightings locations, Table 5 shows sampling block statistics). The seagrass in this area, mostly *Halophilia ovalis*, grows in irregular patches between the island and the beach, becoming denser in cover towards the mainland shore.

I saw 4 dugongs in the Ban Chao Mai estuary, sampling block 3, in the 2001 field season. If the seagrass continues to grow here, this area could become a regular feeding site for dugongs. However, the seagrass beds are close to a village that is growing as the tourism industry expands in Trang province. A pier is going to be built by the Harbor Authority of Thailand as part of the tourism effort. While there is not enough information to know if the pier can cause harm on its own, the silt and discharge from the construction process will very likely harm the seagrass nearby. The effects of uncontrolled boat traffic in this area will also be polluting to the nearshore waters, damaging to shallow seagrass beds, and in all probability disturb the dugongs feeding in the estuary and around Libong Island. The arrival of tourism and extra traffic has been shown to be harmful to the nearshore environment in areas without the infrastructure to support a sudden influx of tourists (Fagence 1997, Knight *et al.* 1997, Agardy, 1993). In Ban Chao Mai, there are no sewage facilities, no centralized garbage disposal, and no running water.

All areas described have only been surveyed in times of high tide; therefore the complete diurnal movements of the dugongs on the Andaman coast have not been recorded. No research has been done to document possible mixing between these population groups, and consequently to question the possible source-sink nature of each group of animals. A source habitat is a good quality habitat where birth is greater than death, and a sink a lower quality habitat where mortality is greater than the rate of births. A sink habitat cannot persist without immigration from other sources (Dias 1996).

The dugongs in Trang could possibly be a source population for other groups of dugongs on the Andaman coast. As I mentioned earlier, the movements of the dugongs along the coast are unknown. For example, from Libong Island, it is approximately 85 kilometers north to the seagrass bed at Lanta Island. There are approximately 75 kilometers between Libong Island and Tanyong Uma Island in Satun province. Muk Island is about 70 kilometers from Lanta. From the Lanta Islands, it is approximately 30 kilometers north to the Three Islands. From there, there are approximately 50 kilometers to the Yao Islands or Ban Thalane in the north, and 20 more kilometers from the Yao Islands to seagrass beds on the northwest coast of Phuket. In de Iongh's (1996) study, the furthest distance tracked from a capture site was 65 kilometers for an immature male. Marsh and Rathbun (1990) tracked another pubertal male 183 kilometers. Preen and Morissette (1997) points out that dugongs can utilize large home ranges, averaging between 79 and 85 kilometers^2 in northeast Queensland and Moreton Bay in Australia. In Australia, dugongs make regular trips of between 40-to-50 kilometers, and sometimes travel between 200 and 500 kilometers (Preen and Morissette 1997). Groups of dugongs along the Andaman coast could possibly be mixed, with any number of animals migrating from one area to another.

In Satun province, a single dugong has been seen during an aerial survey (Adulyanukosol *et al.* 1997). During both of the helicopter surveys, the water was quite turbid, and visibility low. However, villagers have reported that dugong sightings have increased in the past 2 or 3 years, and have seen groups of up to 10 animals. More research on both dugongs and seagrass is needed here to better estimate the possibility of a regular feeding group.

Seagrass Research

Seagrass beds along the Andaman coast can be characterized according to their associations with surrounding vegetation and substrate (Chansang and Poochaviranon 1994). In this area the seagrass beds associated with dugongs are either linked with mangrove beds or a shallow, sandy bottom. Dugongs in Australia have not been shown to choose feeding sites on the compaction or grain size of bottom sediment. However, the most favored sites are located in areas where the grain size of the sand is medium or fine (Preen 1992).

In mangrove associated seagrass beds, narrow bands of seagrass lie perpendicular to mangrove beds that are within sheltered shorelines or bays. Sediments usually consist of very fine sand that changes towards offshore to less fine sand or mud. The seagrass beds generally begin at the mangrove edge. Water depth increases relatively rapidly. Eight species of seagrass have been found in these kinds of beds. Cover percentage here is variable, with a mean coverage of 54%. The species that extend furthest into intertidal mangrove associated seagrass beds are *Halophilia ovalis* (to a maximum depth of 4.8 m), and *Enhalus acoroides* (to 4.7 m) (Poochaviranon and Chansang 1994). The largest mangrove associated seagrass bed along this coast, at the southeast tip of Libong Island (6.00 kilometers^2) is sampling block 4 of this survey. The southeast tip of Libong Island is where I saw the largest number of dugongs feeding during this project.

Seagrass beds with shallow sandy bottoms are the most common association found along the Andaman coast. These beds are found in low exposure areas on the lee side of coastal islands, along the shore, or semi-enclosed bays. The substrate fluctuates between very fine to medium fine sand. Ten species of seagrass have been found in these areas. Cover percentage is higher than the mangrove associated beds, averaging 67%. *Enhalus acoroides*, *Halophilia ovalis*, and *Cymodocea rotundata* are the most prevalent species. The second largest seagrass bed on the Andaman coast has a shallow sandy bottom. Leam Yong Lam beach in Had Chao Mai National Park (6.36 $kilometers^2$) is in sampling block 1 (Chansang and Poochaviranon 1994).

The most common species found in various sites along the Andaman coast in 2000 is *Halophilia ovalis*, followed by *Enhalus acoroides*. This pattern of distribution is found in both mangrove and sandy bottom associated seagrass beds. *H. ovalis* was found in all sites and *E. acoroides* in 9 out of 10 seagrass beds. In the more detailed study around Libong Island in 2001, *H. ovalis* and *E. acoroides* predominate in the amount of presence and the density of cover percentage in each site. The next most common species found in 2001 are *Cymodocea rotundata* and *Thalassia hemprichii*. This configuration of species is common in most inter-tidal and sub-tidal seagrass beds along the Andaman Sea. In another tropical feeding area, Calauit Island in the Philippines, Aragones (1994) found that the majority of feeding trails were in seagrass beds containing shorter, more easily digested species such as *H. ovalis*, *Halodule uninervis*, *Cymodocea serrulata*, *C. rotundata*, and *T. hemprichii*. *E. acoroides*, the predominant species, with a higher fiber content and less nutrients, was rarely touched.

Lower fiber content, highly nutritious seagrass species are essential in the foraging strategy of the dugongs, as well as their tendency for cultivation grazing that favors more competitive and nourishing species, such as *H. ovalis* (Aragones 1996). In Australia, Preen (1992) noted that areas more persistently used as feeding sites were dominated by *H. ovalis*. Seventy-six percent of the more than 8000 dugongs he sighted on aerial surveys, and 75% of the locations of satellite-tracked dugongs were in *H. ovalis* dominated areas. The prevalence and density of *H. ovalis* in seagrass beds frequented by dugongs along the Andaman coast is either an indication of the quality of the habitat as forage or an indication of how the continued presence of dugongs feeding in the area has affected the seagrass species in the beds, or both.

Interview Responses

Seventy-seven percent of the interview respondents felt that population numbers of dugongs were decreasing. This is also the opinion of the government officials, scientists, and the staff of NGO's who were consulted. I found, both in the latter discussions, and in the interviews, a strong awareness of the importance of dugong conservation. Ninety-seven percent of those villagers interviewed felt dugong conservation was important. The most frequent comments made to the question emphasize wanting to be able to show the dugong to children and grandchildren, and reflect the importance of saving the dugong, especially because of the population decline.

The dugong is an important presence in the lives of the villagers, a significant part of their immediate surroundings. Most interview respondents have been aware of dugongs at least since childhood. The livelihoods of these people depend on their awareness of life in the near shore and ocean environment. Half of the interview respondents have personally seen dugongs within the past year. When a dugong is seen, alive or dead, the entire village hears about it. In Yao Noi Island, a group of women fishers I interviewed claimed to see dugongs every time they went fishing. When a stranded or caught dugong is found dead in the area around Kuraburi, the whole village gathers to pray for it. Half of the respondents knew stories or legends about the dugong, and 41% admitted to having knowledge of medicinal use for dugongs. This type of knowledge is traditional.

Overall, I believe that the people I interviewed are aware of the conservation issues affecting their lives. Ninety-seven percent of the villagers interviewed were conscious of the importance of conserving other endangered species (dolphins, whales, turtles, and whale sharks). Comments made in regards to this question also addressed wanting to see the animals in the future, and knowledge of the critical nature of declining populations.

Seagrass conservation was important to 90% of the interview respondents, who see it as an important source of food and shelter for dugongs, fish, and other animals. One man remarked "seagrass is like rice for fish". Eighty-nine percent of respondents consider mangroves critical because they are homes and breeding grounds for fish, and supply villagers with wood for building homes and fuel. Sixteen percent of these people commented on the role of mangrove systems as water filters, coastal and wind protection, and on the interrelationships of the mangrove beds with coral reefs and seagrass.

Marsh and Lefebvre (1994) state that many of the countries within the range of the dugong report numbers of accidental drownings because of incidental catches in gill nets. One of the largest problems for the dugong along the Andaman coast is certainly that of being caught in stationary and gill nets and push-net trawlers. The villagers interviewed were aware and concerned about this problem, especially as the illegal fishing was destructive to their fishing beds and depleted fish in nearby waters. Only 16% of respondents replied negatively to the idea of establishing off-limits areas for conservation. Even though the most common comments addressed concerns about loss of income, food, and space for fishing, others talked about the need for enforcement against illegal and destructive fishing, and agreed with the need to create such areas.

An accurate estimate of dugong mortalities caused by fishing cannot be made because many of these incidents are not reported. According to the interviews, 12% of dugong strandings that are found are reported to local authorities. What percentage of those incidents is then reported to the MESU at the PMBC for inclusion in their strandings database? It is difficult to speculate how many of these carcasses are not found at all. Due to this lack of information I cannot estimate how long the dugong population has been declining, the rate of decline, or what percentage is remnant. I heard stories from all interview locations about larger groups of dugongs seen in the past.

Another significant problem is the belief in the medicinal and amulet use of body parts. It is a common belief all along the coast that various parts of a dugong are good for various ailments, as aphrodisiacs, and for protection. Trade in dugong tusks, and even tears, in certain areas is common and quite profitable. According to both interview respondents and NGO representatives, enforcement of the Fisheries Act of 1947 is either not happening, not an effective deterrent, or both.

Within the different areas in which I conducted interviews stranded or incidentally caught dugongs are treated in various ways. In Kuraburi, a dead animal's meat is distributed throughout the village, and the bones and tusks are kept, and not sold. Medicinal use is known here, but not widely practiced. In Thap Lamu, neither of the men interviewed would keep the body. In the Yao Islands, the proximity to and presence of the PMBC staff (Kanjana Adulyanukosol and her team had come over with posters several times), and the presence of the Small Scale Fisheries Network members in every village, led to most incidents being reported, and most carcasses given to the PMBC. Knowledge of the use of dugong body parts here is common. I was shown a vial of dugong tears in the Yao Islands by a seven-year-old girl.

In the Three Islands, the open participation of village officials in the amulet industry, and the ready market nearby in Krabi, means that the profits are too big to ignore. Belief in the protective powers of bones and tusks, and the actual use of dugong-based medicine is prevalent here. In Satun province, the most common belief that I found was the use of dugong tears as an aphrodisiac. Most villagers said that dugongs were hunted for tears in the past, but that the practice was not common any more. One villager mentioned the use of a dugong spine for waist pain, but others had not heard of using bones or tusks or oil as medicine. In Ban Tanyong Uma, I was told of a stranded dugong that was found in 2000 and released alive. Later, respondents in 2 other villages mentioned that this dugong was killed, and its meat sold.

In Trang, due to the presence of the National Park, the Non-Hunting Area, the MNPEC, Yadfon, and the work that Suwan Pitaksintorn has been doing (aerial survey, behavioral surveys, interviews, seagrass monitoring) for the past several years, villagers are very aware of dugong conservation issues. The MNPEC has also initiated meetings and educational programs in the area, and housed various research teams, including Koike *et al.* and interns. The presence of Tone, the dugong calf that was in the village of Ban Chao Mai for 2 years, has also raised the intrinsic value of dugongs in the area. Several villagers told us that the local people who take body parts to sell have to hide these actions, as they would be forced to stop by the villagers themselves if exposed.

Earlier however, I described carcasses found without tusks or heads, which shows there is still profit in the use of dugong tusk amulets.

4.5.3 Research Needs

Radio or GPS tagging should be done to determine where the dugongs travel at low tide levels, and whether or not they move between the different habitat areas. This information and further research into habitat mixing is crucial for the determination of home ranges, the monitoring of possible population group mixing, and in the establishment of adequate protection areas.

The transect methodology created here should be continued to increase the validity of knowledge about the number of dugongs in these areas. It is also important to establish transects and do microlite surveys in the other areas where dugongs have been seen. These areas include Ranong, Kuraburi, Thap Lamu, Banthalane in Krabi Province, and Satun. Funding for regular aerial surveys should be explored. While a statistically powerful trend estimate is not possible with this small a population and the necessary intervals between surveys, more assessments are still needed to provide a complete picture of dugong habitat and animal distribution (Taylor and Gerrodette 1993, Marsh 1995*a*).

To reduce the coefficients of variation in the population abundance estimations, the transect metholodogy should be refined to line transects in order to include an estimate of distance from the microlite. A truncated distance estimation system could be introduced as in Buckland *et al.* (1993). Observers could be trained to estimate distance ranges more accurately. Sampling protocol also needs to be designed to determine the influences of factors of availability and absence bias such as tide levels, water turbidity, glare, and the limited numbers of surveys.

All transect and aerial survey information from this project has been entered into a geographic information systems database for mapping and spatial analysis. As myself and other observers gather further information, data should be shared and entered into this system. Both MESU and the RFD have this software and trained staff and are being sent this database.

Interviews should be continued, especially in areas of changing protected status. The combination of structured and unstructured questions should be continued, using local translators or students fluent in the local dialect who are not from Thai government agencies. Emphases of the interviews should be on information about the dugongs themselves as well as to gain knowledge of local historical and present day perspectives on dugong conservation and resource issues. As mentioned in Hudson (1981), interviews can also be used as vehicles for conservation education.

Mapping the distribution of seagrasses in dugong habitats or in habitats that could have significant amounts of species of seagrass favored by dugongs (*Halophilia sp.*) ought to be a high priority (Marsh *et al.* 1994). Seagrass bed distribution and species composition along the Andaman coast has been the subject of much research, and is well documented (Poochaviranon 2000, Poochaviranon *et al.* 1994). However, accurate maps of the seagrass beds for realistic management, impact analysis, and monitoring are still lacking due to limitations of staff and funding (Poochaviranon and Adulyanukosol 1999). Even with aerial photography at low tide, the seagrass is sometimes too deep to detect, or the water too turbid, or the glare of the sun prohibitive. Therefore these images do not show the full extent of the seagrass beds. I believe that the most rapid and accurate way to map the extents of the seagrass beds is through high resolution remotely sensed video or satellite imagery, which can be formulated to penetrate the water column above the seagrass. From these images, specific research can also be conducted to determine the amount of seasonal change for those seagrass beds exposed to storms in the rainy season.

It is important also to determine the parameters of seagrass bed species and distribution for quality dugong habitat. A combination of the field research that has been ongoing, used in conjunction with remotely sensed imagery could be used for this purpose. It would also be valuable to document the presence of seagrass beds that are suitable for dugong foraging that have no dugongs feeding on them. This empty habitat could have supported dugongs in the past. Due to destructive fishing or hunting the animals in this area could have been killed.

4.5.4 Summary of Discussion

It is critical that measures be begun quickly to reduce dugong mortality. I estimate that the present population of dugongs along the Andaman coast is approximately 200 animals, with a minimum population abundance estimate of 123 animals in Trang province. Since I am unaware of the extent of intermixing along the coast, protecting only some of these habitats, even those with a larger population of dugongs, will not ensure the recovery of the entire population, even if local extinction is prevented. Both past and present habitat areas need to be considered for protection (Preen 1998, Preen and Morissette 1997).

A small population is always in danger. The high levels of mortality that I do know about, especially as reported in Trang province, definitely place the dugong in danger of eventual extirpation from this coast. Destructive fishing and the use of dugong body parts as medicine and amulets are critically endangering the dugongs and their habitats along the Andaman coast. The most difficult challenge is that, in order to conserve the dugong along this coast, all stakeholders need to be willing to participate towards this goal. Fishing gear will have to change; fishing and seagrass destruction in critical habitat areas will have to stop. Illegal and destructive push-net trawlers will have to be prevented from fishing in near-shore areas. The amulet trade will have to come to an end. Education is needed to instill a realization of the long-term benefits to such changes in the communities around dugong habitats, and these communities need to take some responsibility for protecting their local seagrass beds. Otherwise, the dugong along the Andaman coast will keep being caught in fishing nets, and their tusks will be taken, and their habitats destroyed, and eventually the population will slowly become locally extinct.

5.0 THE INTEGRATION OF CONSERVATION AND BIOLOGY IN MARINE MAMMAL RESEARCH

Dugongs along the Andaman coast are in danger of extinction because of factors common not only to other marine mammals, but also to endangered species worldwide: habitat destruction, and directed or incidental killing. Specific circumstances may change, but the results are the same. In all of the examples cited in chapter 2, and as stated in Figure 1, the problems behind endangered species habitat and population decline are derived from human values, beliefs, and practices. This is particularly clear for marine mammals (Domning 1999). Human exploitation of marine mammals, killing them for meat, oil, skins, and capturing them for entertainment or learning has brought many species to or near extinction (Domning 1999, Twiss & Reynolds 1999, Duffus 1988). The majority of marine mammal species have had individuals killed in fishing procedures, and most types of fishing impact marine mammals. Habitat loss or degradation can be caused by pollution, both chemical and noise-related, overfishing, and ship traffic in pelagic areas. Nearer to the coast, all of the latter factors apply, in addition to the effects of human development (Northridge & Hofman 1999). .

Out of 79 known cetacean species, the World Conservation Union (IUCN) lists 5 as 'endangered', and 7 as 'vulnerable' (Hilton-Taylor 2000). The population status of the majority, or 92 species of cetaceans and seals are classified as 'insufficiently known' by the IUCN. All manatee and dugongs are classified as 'vulnerable' (Castello 1996, Jefferson *et al.* 1993). Both the magnitude of the threats listed above, and certain aspects of marine mammal biology magnify the risks inherent in this lack of knowledge. Examples of these aspects include (Castello 1996):

- Larger marine mammals have a slow reproductive rate that causes populations to recover slowly from losses.
- Some species have intricate family groups and social structures that are especially vulnerable to disruption.
- Many marine mammals are dependent on sound for foraging, navigation, echolocation, and social communication. Human-generated noise can disrupt these interactions, and has been hypothesized as being physically harmful. This damage can range from acute physical damage to temporary or permanent deafness (Notarbartolo di Sciara & Gordon 1997).
- A high trophic level in feeding chains that exposes animals to bioaccumulating pollutants.
- A limited ability to detect fishing nets.

The aforementioned reasons for endangerment combine to form a net of factors intricately tangled into the structure of modern human society. As marine mammal scientists, therefore, to be preoccupied only with biological assessments, and dependent on biological solutions ignores the risks to these animals associated with the social, economic, and political factors that are threatening them. Consideration of these factors deserves a central role in any understanding of marine mammal endangerment. This understanding is a prerequisite for their inclusion in strategies to formulate solutions (Kellert 1986). In Figure 1, the consideration of social, economic, and other related issues are as important a consideration as animal biology in information gathering for endangered species conservation planning. Michael Soulé, who argued for the creation of the discipline of conservation biology in the 1980's, thought of conservation-oriented biology as a crisis science, a mixture of science and art, requiring intuition as well as information, in addition to the integration of biological and social sciences (Coleman *et al.* 1996, Soulé 1985). In his 1991 paper entitled "Conservation: tactics for a crisis science", Soulé (p. 744) stated:

> "...reappraisal (of conservation's goals and tactics) would be more fruitful if there were a deeper appreciation of the biological and social contexts of

> conservation actions, particularly how both biogeography and political geography dictate different conservation tactics in different situations."

Therefore, in the next section, I first revisit the case study within the context of the larger sociological, temporal, and economic issues affecting the people along the Andaman coast. While I have discussed some of these topics previously, in this section I write more widely about the historical and political situation from which dugong endangerment originated. Without the context of history, conservation problems can neither be fully understood nor can effective conservation planning be developed. In the rest of the chapter, using the examples of three concepts that are relevant to information gathering and conservation planning for endangered species, I discuss the ways in which biological assessments and solutions mix with social issues.

The first concept I look at, focal species, is a tool for discerning the significance of the interactions or the ecological role of animals (Figure 1) within their biotic and abiotic environments. One focal species concept, the flagship species, relies on the symbol or image of an animal as a way to generate support for conservation (Simberloff 1998). Other focal species theories, such as umbrella, keystone, and indicator species, which attempt to explain and categorize the ecological interaction between an animal and its biological and physical surroundings (Zacharias 2000), can have specific relevance to conservation planning.

The case study and examples of research in this dissertation show that it is critical for conservation-oriented scientists to understand the social context behind actions that deplete wildlife and degrade natural systems. To achieve conservation goals, however, the results of scientific inquiry also need to be communicated to all people affected by or involved with management planning. The second concept, collaboration between scientists and government, management, educators, and the community is an important step in increasing communication and education for conservation.

The designation of reserves to protect marine resources has increased considerably during recent decades (Allison *et al.* 1998), and is the third concept I examine. Some protected areas have been allocated and more suggested as a means to protect marine mammals from human activities that threaten their survival (Blaine 1997). However, marine protected areas are dynamic and complicated, and lack of attention to considerations of management, the community, or local ecology has limited their success as a factor in conservation-based management plans, for endangered species (Alder 1996).

5.1 Re-examination of the Case Study.

In order to put the ecological concepts into a workable context, historical, political, and economic contexts surrounding the dugong's endangerment need to be considered for effective conservation planning. Dugongs along the Andaman coast of Thailand, and their seagrass bed habitats, are affected by many of the same circumstances as the rural people who fish along the coast. The indigenous fishers who live along this coast are mostly Muslims, who migrated from islands in Northern Malaysia approximately 200 years ago. Their economy was based on a traditional system of exchange, and dependent on subsistence level fishing (Charnsoh 1998). The gear they used was simple, mostly bamboo traps and set nets, and purse seines cast from small boats (Flaherty & Karnjanakesorn 1993).

Until the 1960's, most fishing in Thailand was done by small-scale fishing methods. In 1961, a German aid program introduced powered fishing vessels, as well as the use of synthetic nets, trawls, and purse seines (Charnsoh 1998, Chua & Garces 1994). Fish production increased significantly, the number of boats grew to over 20 000 by the 1980's, and fishing became a lucrative industry, attracting investors interested in quick profits (Flaherty & Karnjanakesorn 1993, Chua & Garces 1994).

At the same time, between the 1940's and the 1990's, the population of Southeast Asia doubled (Chua & Garces 1994). A large percentage of these people migrated to the coast. In Thailand, as land grew less and less available to farmers, marine and coastal areas provided open access to fishing resources (Torell 2001, Chua & Garces 1994, Flaherty & Karnjanakesorn 1994). Most of the fish are found in the shallow continental shelf, within 5 kilometers of the coast (Chua & Garces 1994). Therefore, the large trawler fleets compete with increasing numbers of small-scale fishers for the diminishing fish resources, and the small-scale fishers are losing. A small percentage of trawlers catch 92% of the total catch, while a large proportion (72%) of artisanal fishers catch 8% (Thai Department of Fisheries 1997).

As a result, small-scale fishers have been unable to support themselves more than marginally, and have had little alternative but to continue fishing, sometimes using explosives and poisons, further endangering the systems they depend on. They are trapped between impoverished migrants coming to fish as a source of subsistence and commercial fishers searching for valuable coastal species (Torell 2001, Panayotou 1980). Some stay because they have never known anything else, and others because they cannot afford to go anywhere. Farming is generally not an option as most of the land near the coast is ill suited for agriculture (Torell 2001, Flaherty & Karnjanakesorn 1994).

Few small-scale fishers complain to local authorities about illegal commercial trawlers, even when trawlers destroy their fish traps. Sometimes, every trap set by an individual fisher is ruined by trawlers, resulting not only in loss of catch, but the added expense of replacement (Flaherty & Karnjanakesorn 1993). Small-scale fishers commonly have ready access only to local authorities, who, if the owners of trawlers do not bribe them, can only pass the complaint to higher authorities. These higher authorities, if they are not corrupt, have no clear recourse, as there is no agency clearly responsible for coastal and fishing resources in Thailand (Flaherty & Karnjanakesorn 1993).

While overfishing depletes fish populations, there are other consequences. As fish stocks decline, commercial trawlers both decrease the mesh size on their nets, and increase fishing effort. This not only additionally reduces fish stocks, but also increases the amount of 'trash' fish bycatch, and further disturbs both pelagic and demersal food webs (Dayton *et al.* 1995, Flaherty & Karnjanakesorn 1994). The trawlers then fish closer to shore to catch demersal fish and prawns. By this action they compete with small-scale fishers, which aggravates the conflict between them (Flaherty & Karnjanakesorn 1994). In 1972, in an attempt to protect fish stocks, and ease the escalating disagreement, the Thai government prohibited commercial trawlers from fishing closer than 3 kilometers to shore. This is rarely enforced due to corruption and limited policing capacity over a large area (Flaherty & Karnjanakesorn 1994).

The effect of mobile fishing gear on the seafloor is likened to clearcutting or strip mining in terrestrial areas (Watling & Norse 1998, Dayton *et al.* 1995). Trawls, traps, and push nets scrape and plow the substrate to depths of up to 30 centimeters, and cause the resuspension of sediment as well as the destruction of bottom organisms (Dayton *et al.* 1995). The resuspension of sediment creates turbidity that has been found to reduce or eliminate seagrass beds.

A long-term effect of this substrate disturbance to bottom organisms is reduced heterogeneity within benthic communities. Eventually these communities will most likely become dominated by more mobile, or rapidly colonizing species. While researchers believe that these changes will impact the marine ecosystem, it is difficult to predict how (Watling & Norse 1998, Dayton *et al.* 1995). Dayton *et al.* (1995, p. 216) state:

> "Certainly it is clear that food web changes and cascading ecological effects of heavy fishing are likely to impact the ecosystem. Simply because such impacts were exerted in the past and old or recent field data are lacking does not imply that the effects are any less important. This issue must not be ignored."

The condition of mangroves, seagrass, and coral reef areas along the Andaman coast has been degraded as a result of overfishing and destructive fishing methods. The growing population and increased development along the coast also causes degradation or destruction of these resources. Tin mining, which occurs in Ranong, Phang-nga, and Phuket along the Andaman coast, kills seagrass beds and damages mangroves by the increased resuspension of sediment in the water from digging in the substrate (Chua & Garces 1994). Mangrove areas are logged for charcoal, firewood, and building materials, and especially converted for shrimp cultivation (Flaherty & Karnjanakesorn 1995, Chua

& Garces 1994). Other than overfishing, coral reefs are destroyed primarily by siltation, coral mining, as well as tourism related activities and pollution (Chua & Garces 1994).

As long as the government is not able to put a stop to this destruction of natural resources, the conflict between commercial and small-scale fishers will grow, as will the poverty of a growing number of people in coastal communities (Flaherty & Karnjanakesorn 1995). Dugongs are caught in the middle of this conflict. They are trapped in the nets of illegal commercial gillnet and push net trawlers. Interview respondents report that they find these animals floating, sometimes with the head cut off so that tusks can be sold. If the commercial fishers reported the incidental catch, they would also have to admit to fishing within the 3-kilometer shoreline limit. Small-scale fishers who find dugongs trapped or stranded are apt to be tempted by the money they can receive for selling tusks. They can use bones for medicine, the tears as an aphrodisiac, and eat or share the meat. Reporting the incident is often at the expense of time spent fishing. There is also the risk of being fined. Anyone found with a dead dugong could face a 4 year jail term or a 40 000 baht ($1600 CDN) fine (Bangkok Post, April 29, 2000). Another reason these occurrences are not reported is the marginality of small-scale fishers. This marginality is not only economic, but also social, and it creates an atmosphere where these fishers have been powerless against those with political power (Pauly 1997).

There are signs that this situation is changing. In 1981, with the assistance of local NGO's, small-scale fishers created a coastal resource conservation group. At first this group was based on neighborhood and family committees and focused on local problems. A meeting was held in 1986 with representatives from 8 southern Thai provinces, and a regional group was formed known as the Federation of Fisher Folk of the South. The goals of the group are to protect corals, seagrass, and mangroves, as well as preventing destructive and illegal fishing. Six NGO's work with the Federation to support their work (Federation of Fisher Folk of the South, 2000).

Two of those NGO's in particular are actively working with small-scale fishers along the Andaman coast of Thailand: the Andaman Project, and Yadfon. The Andaman Project was started in 1989 by Wildlife Fund Thailand, the Phuket Environmental Conservation Club, and a group of concerned professionals in Krabi (Pingkan Phang-nga Group). They have representatives in villages along the coast to educate local fishers about the ecology and conservation of nearshore areas (Tupazc, Nabnien, pers. comm. 2000). In the Yao Islands, the representative, also the local teacher, started a community center, where villagers can gather, and the women run a money-sharing group that local people can borrow from. A weaving project was also started for local women. Another goal of the Andaman Project is to empower and assist fishers to patrol for and turn in illegal push net trawlers. Villagers remain dedicated to controlling destructive fishing techniques and conserving the nearby seagrass beds. Local residents believe that if the seagrass beds increase the dugongs would return to the area.

In Satun, the Andaman Project first went to the fishing community of Ban Hua Hin in 1996. Project representatives worked with the villagers to set up a coastal conservation group to stop destructive fishing both by the villagers and commercial fishers. A revolving aid fund was set up here. Fishers here have successfully stopped commercial trawlers from entering the 3-kilometer limit, and have not themselves used cyanide or explosives for fishing since 1998. Now there are 18 other villages in Satun who have joined the conservation group. Representatives from the Andaman project travel throughout the coast, working with the fishers and teaching workshops (from interviews and conversations with Andaman Project Staff, Lagnu, Satun).

In Trang in 1985, the Yadfon (Raindrop) Association, started community well projects in 7 remote, impoverished fishing villages in Sikao district. In one village, Laem Makham, a pilot revolving loan fund was created so fishers could improve their equipment. Small community organizations were set up in the villages to discuss ways to restore the marine environment and increase the security of small-scale fishers (Charnsoh 1998). The first activity was the restoration of mangrove forests near the villages. Villagers also cut coconut trees and put them in the water to mark the boundaries of the seagrass beds and keep trawlers out of the area. Between 1988 and 1990, fishers would patrol the 3-kilometer zone and go out to negotiate with commercial trawlers. At first, this was a failure until the local authorities and government agencies began to cooperate (Charnsoh 1998).

Yadfon began to expand these activities and increase community education in other villages, and was supported by academics and some government agencies. They also held seminars so that 120 villagers and scientists from PMBC and two local universities could promote awareness of seagrass conservation. Buoys were used to mark seagrass beds for conservation in Sikao Bay, as well as Libong and Muk Islands (Charnsoh 1998).

As the seagrass beds became more healthy and larger, the villagers noticed that they did not need to go as far from shore to catch fish. As I saw in 2001, dugongs were seen in seagrass beds at Ban Chao Mai estuary that had grown considerably since 2000.

As a result of these activities, the Trang provincial government has supported the villagers in trying to prohibit illegal fishing activities. However, push net trawlers are still found in some areas in Trang and nearby provinces.

Small-scale fishers have been forced by circumstance and desperation into an increased awareness of the nearshore environment and the critical and immediate need for conservation action. This situation is not unique in Thailand. Artisanal fishers throughout tropical oceans have been confronted with similar issues of marginalization, lack of political power, and poverty (Pauly 1997). Through the efforts of Yadfon and other NGO's, three workshops have been held in the past 2 years with small-scale fishers from Thailand, Cambodia, Sri Lanka, Indonesia, and Malaysia (In the Hands of the Fishers, 2000). Within their declarations is a call "to commit to protecting against all coastal or marine natural resource destruction, and commit to taking care of our resources" (Mangrove Action Project 2000, p. 5).

5.2 Focal Species Concepts and their Relevance in the Applied Conservation of Marine Mammals.

In Figure 1, the ecological role of an animal is paired with animal biology as inputs into the information gathering process. Focal species patterns of abundance or presence are thought of as a tool for understanding the relationships of species with their habitats and communities (Zacharias & Roff 2001). Simberloff (1998, p. 247) talks of focal species concepts as "shortcuts…whereby we monitor and protect single species". Focal species concepts can be considered tools for the understanding, management, and conservation of environments as well (Zacharias 2001).

Concepts such as flagship, indicator, keystone, and umbrella species have potential in marine conservation strategies. A flagship species is not an ecological concept, but a social one. A flagship species is a charismatic animal that can be used to arouse public interest in conservation (Simberloff 1998). Indicator species are those whose presence or absence suggests the presence or condition of a particular habitat or community. A keystone species is critical to the ecological functioning of a community. The significance of that role is beyond what is expected in relation to the animals' biomass and abundance. Umbrella species need such a large habitat area that other species dependent on that habitat will be protected (Zacharias & Roff 2001, Simberloff 1998).

In marine science, Zacharias & Roff (2001) see possible roles for focal species concepts in determining areas for marine reserves, habitat characterization and monitoring, identifying and monitoring biological communities, and integrated coastal zone management. However, the use of focal species concepts depends on an understanding of their interactions with their environment. There is little empirical evidence to explain the roles or influence of marine mammals on the structure and function of the marine environment (Bowen 1997, Katona & Whitehead 1988). Bowen (1997, p. 267) states that knowledge of the functional significance of marine mammals is central to conservation as

> "it provides a context through which to evaluate the potential impact of their predations on prey populations and community structure, and the impact of variation in prey populations, of harvesting by humans, and environmental change on the dynamics of marine mammals."

While this understanding is important, it is difficult to measure system properties over such a great distance, with such variable temporal and spatial scales (Bowen 1997). Food webs and trophic levels are complex in the marine environment, so that the ability to determine if any given species represents the structure or functioning of a community may be weakened. Marine mammals are also difficult and expensive to observe and census (Zacharias & Roff 2001).

Community awareness of the significance of threats to the environment can be triggered by the presence of a species whose existence or habitat is in danger. Knowledge of an endangered species can enhance perception of the environment and the effects of continued deleterious use. A flagship species can serve as the representative of environmental conservation in educational processes. There are well-known precedents in both popular and academic literature as to the value of a flagship species to draw attention to problems of resource exploitation (Simberloff 1998, Downer 1996, Durbin *et al.* 1996, Dietz *et al.* 1994, Johnsingh and Joshua 1994, Panwar 1987).

The tiger (*Panthera tigris tigris*) and elephant (*Elephas maximus*) in India (Johnsingh and Joshua 1994, Panwar 1987), the panda (*Ailuropoda melanoleuca)* in China (Schaller 1993), the panther (*Felis concolor coryi*) in Florida (Simberloff 1998), and 3 species of lion tamarins (*Leontopithecus* spp.) in Brazil (Dietz *et al.* 1994) are examples of this process. Flagship species can also publicly represent their own depletion and threats from fishing or hunting, pollution, and loss of habitat.

Flagship species have been shown to contribute to the successful conservation of natural systems (Simberloff 1998, Dietz *et al.* 1994). The manatee (*Trichechus manatus*) in Florida, and the dugong (*Dugong dugon*) in Australia are recognized as flagship species representing coastal conservation efforts (Marsh and Lefebvre 1994). Dugongs on the Andaman coast of Thailand can be considered a flagship species based on their place in the cultures of the residents of nearby coastal settlements, and the concern of an international community.

Yadfon has received funding for a Dugong Conservation & Habitat Protection project. In this proposal, they mention that the dugong is well known by the Thai people, and has become commercialized along the Andaman coast as a representative of tourism in Trang. The dugong can be used to draw people's attention to the issues of coastal conservation, and perhaps represent the protection of the seagrass ecosystem as a whole as well as other species of marine life.

The use of flagship species as an advocacy tool for the preservation of habitat has drawbacks. The notion of flagship species can be seen as more a means for advocating public support than an ecological concept. The animal's popularity can be based more on political or management strategies than a scientific foundation of information about the species' needs and vulnerabilities (Zacharias & Roff 2001, Simberloff 1998). Flagship conservation can also be expensive, and if not well planned can de-emphasize the inherent importance of the ecological systems and other species it should represent (Simberloff 1998). In the case of the dugong in southern Thailand, the use of the dugong as a flagship species is already starting to bring tourists to an area without the infrastructure to support them without environmental degradation. Dugong watching by boat and microlite aircrafts has begun without consideration of 1) the futility of seeing dugongs by boat, 2) the extent and effects of disturbance to dugongs from noise and the shadows of both boats and microlites, 3) damage to and pollution of seagrass from the boats, and 4) increased danger of striking a dugong with boats.

Simberloff (1998, p. 250) asks

> "But what happens when the flagship sinks...Will public emotional investment in this species turn to despair and disenchantment with conservation in general?"

There is a real possibility that the dugong in Thailand will go extinct. Even though there may be 123 animals remaining in Trang province, increasing development and tourism alone are enough to destroy local seagrass beds. The construction of a pier in Ban Chao Mai village is an indication of the importance placed on short-term economic development over careful expansion that considers the long-term well being of the coastal environment. Most local people, even those who belong to conservation groups, welcome the pier as a boom to the local economy. Use of the dugong as a flagship will not overcome the effects of ongoing poverty.

When a flagship species becomes the basis for a recreational experience that a local population expects to benefit from economically, there is a potential for both the animal and its habitat to be seriously disturbed (Duffus & Dearden 1990). For other marine mammals, the question of long-term disturbance from recreational whale watching has been a concern of both the whale-watching public and researchers (Bass 2000, Duffus 1996, Corkeron 1994, Duffus 1988). Researchers have been unable to establish concrete tools with which to detect changes in whale behavior associated with boats with any certainty. It is difficult to establish cause and effect relationships or to ascertain long-term biological significance based on measurable behavioral parameters (Bass 2000, Duffus 1996, Corkeron 1994, Hines *et al.* in preparation).

There is a risk involved in utilizing the flagship species concept for management without consideration of species ecology. As Duffus and Dearden (1992) discuss for various species of whales in Canada who are subject to whale watching, when human interaction is involved, there is a need for both single species and synecological information in order to plan effectively for animal protection. Though there are numerous examples of marine mammals as flagship species, even with comprehensive education programs and enforceable management planning, changing human perceptions and attitudes towards animals will be difficult. Especially as wildlife conservation is usually pitted against the interests of economic development and resource exploitation, any management effort will be inadequate without public interest acting on behalf of an endangered species and its habitat (Dietz *et al.* 1994, Simberloff 1987, Kellert 1986).

The keystone species concept can be explained using the example of the sea otter (*Enhydra* lutris) (Zacharias & Roff 2001, Bowen 1997). Sea otters forage on sea urchins. Urchins usually graze on kelp forests, but when otters come into a community, the larger urchins decline in abundance and kelp forests increase in abundance. Fish species that inhabit kelp forests increase, and the community changes. Recent research is finding however, that outside influences such as storms, currents, or temperature changes can also have strong influences on the growth of kelp forests (Bowen 1997). Recently, killer whale predation on sea otters in Alaska has caused a decline in otter population abundance and reduced or eliminated the keystone role of the sea otter (Estes *et al.* 1998).

Zacharias & Roff (2001) argue that: 1) complex communities are rarely controlled by a single species, 2) all species are keystones to some degree, 3) identifying true keystones is difficult, 4) keystone species are only keystones in specific situations, 5) conservation centered around a keystone species does not guarantee that conservation objectives are met, especially in as variable and complex an area as the marine environment, and 6) most importantly, the presence or absence of a keystone species changes relative abundance in a community, not the community structure itself. Dugongs, as obligate herbivores in seagrass, and possibly as cultivation grazers, do have an influence on the species distribution within the seagrass beds (Peterkin & Conacher 1997, Aragones 1996, Preen 1992). However, dugong grazing temporarily changes the relative abundance of species, and is not a strong enough influence to create a change in community structure. Therefore a dugong is an unlikely candidate for a keystone species.

Marsh *et al.* (1999) identify the dugong as an umbrella species, because the large extent of reserve area required for dugong conservation will bring other species under protection. Characteristics of umbrella species have been described by Zacharias & Roff (2001) as animals that:

1) demonstrate fidelity to particular types of habitats,
2) are non-migratory,
3) are specialists rather than generalists,
4) decline in disturbed habitats,
5) require large areas of relatively natural habitat, and
6) will minimally affect community and habitat structure if they disappear from an area.

The dugong fits these criteria perfectly. The problem with using the present distribution of dugongs as a decisive factor in the selection of protected areas is that dugongs are often found in groups that are remnants of their former distribution. Little is known of dugong movement and distribution outside of Australia. Ideally, conservation of dugongs considers past, present, and future habitat areas. I recommend that, in this case, the umbrella species should be seagrass beds that contain species of seagrass suitable for dugong foraging (Zacharias & Roff 2001, Ryti 1992).

The indicator species concept in application can be further delineated as either composition or condition indicators. Composition indicators are representative of the presence of a habitat or community. A condition indicator can be used to monitor the condition, or the environmental change in a habitat or community resulting from either anthropogenic or natural disturbances (Zacharias & Roff 2001). The concept of composition indicator is more relevant for marine mammals as it is independent of spatial scale, and relatively independent of sample size. It demands that the species demonstrate a definable range of ecological tolerances, and show fidelity to specific community and habitat types. While the latter two qualifications are general enough to be widely applicable, they fit the migratory lifestyle and shifting environment of many marine mammals. This concept also corresponds to research directions and methodology to determine the nature, and possible predictability of marine mammal use of habitat. As far as applicability for conservation, habitat use of a composition indicator species can demarcate a community type or habitat area that can be mapped. Examples of critical habitat areas could include distinct areas based on courting, mating, nursing, or foraging behaviors (Zacharias & Roff 2001).

Condition indicators are the only one of these concepts that is focused on monitoring the effects of natural and anthropogenic stress on the habitat and the animal. Also independent of spatial scale and sample size, this concept is a tool for measuring ecologically significant change. The presence, absence, abundance, or behavior of a condition indicator can be considered representative of specific environmental factors. Condition indicators can also be used to evaluate conservation efforts once habitat areas have been identified (Zacharias & Roff 2001). As the dugong is a species with specialized foraging needs, habitat areas used for grazing are easily identified. Continued research characterizing the specialized foraging of the dugong in seagrass would more firmly establish the importance of the dugong as a conditional indicator, and increase knowledge about the significance of dugongs within a coastal ecological system.

In my opinion these two indicator concepts have the most utility of all focal species concepts in marine mammal conservation planning, management and monitoring. As a focal species tool based on testable ecological theory, these concepts can be used in concert with flagship species to protect against some of the problems facing marine mammals such as the dugong. Determination of both composition and condition indicator properties can answer basic questions about species ecology and behavior that are necessary both for conservation and scientific inquiry. Examples of such questions include the species' behavioral correlation with measurable habitat variables, or how the presence or absence of an animal indicates anthropogenic stress (Zacharias & Roff 2001).

5.3 The role of collaboration.

The role and reason for scientific collaboration with government, management, community, and educational organizations is communication. A definition of communication in this context is (Borrini-Feyerabend *et al.* 2000, p. 11):

"Bridging understanding within a human community, exchanging messages to create meaning and enrich common knowledge, often in order to face change." If, as quoted earlier, people are the problem, there is no solution without their understanding and cooperation. Conservation planning is a balancing act between the needs of species, the systems they depend on, and the needs of surrounding human communities, both locally and globally. Decisions should be based on the best available scientific findings (Weeks & Packard 1997).

Scientific findings are not the only knowledge basis for management decisions. In both the developed and developing world people have developed local knowledge systems based on their interactions with the natural world. These systems are not based on scientific method and do not necessarily rely on an understanding of scientific concepts (Johannes 1981). Preference is not automatically given to scientific knowledge over local, more customary information. Therefore, in order to meet conservation and management goals, information based on local knowledge has to be accepted as well as understood (Weeks & Packard 1997).

The extent of discrepancies between scientific models and the perspective of resource users can be a major determinant of local acceptance of scientific information and the success of subsequent management strategies. Other factors that influence local user approval include: 1) different perceptions on the relationship between humans and nature; for example, small-scale fishers will primarily see coastal resources from a utililitarian point of view as compared to a scientific perspective focused on ecological processes, 2) the magnitude of changes that communities will be expected to make, and how those changes will affect them politically, culturally, and economically, and 3) the social relationship and amount of trust between users and authorities. This last relationship can be complicated by a history of corruption, or a lack of enforcement on the part of government representatives (Weeks & Packard 1997). A history of such interactions can further alienate already politically and economically marginalized people.

Efforts at effective communication can be empowering, promoting social solidarity and importantly, collaboration with conservation strategies. What is the role of a conservation-oriented scientist in collaborating and contributing to this communication process? Orr (1991) believes that the failure of scientists to communicate to society comes from inadequate efforts by scientists to talk to the public or government in understandable terms. In his opinion, efforts of scientists to remain reasonable and objective have by default led to support of environmental degradation, and damaged the standing of science as a source of common sense. There are, however, examples of individuals who have communicated widely the importance of the implications of their research, and become catalysts for social change. Scientists such as Rachel Carson, Paul Ehrlich, and George Schaller have brought a wider awareness of critical environmental issues to the public as a whole, and influenced the directions of natural and social sciences, as well as attitudes towards conservation.

The extent and details of involvement of each scientist depend, of course, on the nature of the circumstances. To be an effective catalyst in any situation, however, a conservation-oriented scientist will be working with people with widely differing views, and must acknowledge the validity of a diversity of values in order to work successfully. Research results must to be communicated even where the fundamental values of essential collaborators differ, and conservation plans negotiated to meet the needs of all constituencies (Maguire 1996). The quality of conservation science should be judged not only by high-quality empirical work, but also by "a thoughtful evaluation of the research in the context of the social-scientific community in which it was carried out" (Maguire 1996, p. 915, Meffe & Viederman 1995).

By this criterion, one of the most important avenues of communication is with the local community. In the marine environment, there is a rising realization by governments and researchers of the importance of the role of community participation in community-based coastal resource management (CBCRM) (Alcala 1998, Rivera & Newkirk 1997, Pomeroy 1995). Local non-governmental organizations (NGO's) have increasingly been the impetus for community organization, mobilization, and education (Rivera & Newkirk 1997). This is as true in developed as in developing countries. The Save the Manatee Club in Florida is a vast organization built around manatee conservation, which also generates public support to fund a large quantity of applied and basic research (Domning 1999). The Rainforest Action Network is a major factor in recent grizzly bear legislation in British Columbia. According to Perrin (1999, p. 306) "NGO's help keep us as scientists accountable and focused in the right direction." Grassroots NGO's are prominent advocates for marmot protection in British Columbia and dugong conservation along the Burrum River in Queensland, Australia. In the Philippines, NGO's are crucial to establishing and gaining community support for CBCRM's (Rivera & Newkirk 1997).

The NGO's in Thailand are dedicated to alleviating poverty and empowering villagers as well as supporting long-term conservation strategies. My role in collaborating with these NGO's has been made clear by their interest in my research and their willingness to translate my results and recommendations to villagers and managers. Both Yadfon and the Andaman Project have been working with local communities for several years. They have created partnerships that have benefited villagers, and can present suggestions in a culturally appropriate manner. As part of Yadfon's Dugong Conservation & Habitat Protection project, they have hired local students to establish dugong conservation clubs in schools, and assisted in creating community protected seagrass beds and mangrove forests. A series of stakeholder workshops on dugong protection and conservation policy, including fisherfolk organizations, community leaders, scientists from PMBC and local universities, local government officials, officials from Had Chao Mai Marine National Park and the Libong Island Non-Hunting Area, the

Trang Office of Primary Education, the Trang Tourism Association, Wildlife Fund Thailand, the Andaman Project, and media representatives have also achieved positive results.

I do feel strongly however, that for a conservation process in a developing country, the role of scientific advisor should fall on local scientists. This process can include the cooperation of the outside scientific community. Outside scientists may have skills or technology that can augment local scientific work limited by economic or political realities. Unfortunately, governments will sometimes listen to the recommendations of outside scientists or give projects more credibility once they have attracted outside researchers or funding. Therefore, collaboration between scientists from abroad and local scientists should be done carefully.

Data and specimens from developing countries still flow for the most part to the developed nations, though the days of the worst exploitation are largely over. Some scientists will do their research; publish in academic publications, and leave (Colvin 1992). Research results will not be disseminated locally, leaving the local scientists who assisted them feeling exploited. This research has little if any conservation value. A conservation-oriented scientist must establish rapport in the communities, both scientific and local, where they work. This can take time, faith, and effort to learn how to cope in a country where tasks are approached very differently.

Every year when I return to Thailand, the scientists at PMBC share more of their research and knowledge. When I wrote and received funding to work with Kanjana Adulyanukosol as co-investigators on this project for the 2001 field season, I arrived in Thailand to find a team of scientists and technicians ready and excited about working together. Ms. Adulyanukosol and I will publish our results together in local and international journals. This collaboration with Thai scientists is crucial to expand the use of the methodology created here into other areas of Thailand.

The extent of collaboration with governments, NGO's, local scientists, educators, and communities in both native and foreign countries depends on many factors, personal and political. Long-term, multinational, collaborative research projects are needed that train native scientists and work closely with local NGO's. While challenging, such collaborations are necessary in order to increase sensitivity and achieve effective communication within the social parameters surrounding conservation needs throughout the world.

5.4 Protected areas for marine mammals.

Conservation-based management planning for dugongs in Thailand will likely include a recommendation for a system of Dugong Conservation Areas and Sanctuaries along the Andaman coast (Adulyanukosol, Charnsoh, pers. comm. 2001). The main reason for these protected areas is the shelter of dugongs from incidental bycatch, and increased habitat protection from destructive fishing methods. A similar network of refuges has been suggested for manatees along the coast of Florida (Reeves 2000). The use of marine protected areas (MPAs) is increasingly being promoted as a tool for marine conservation. MPAs are advocated by scientists, managers, and local people as offering protection for critical areas, refuge for threatened species, prevention of overfishing, enhancement of depleted fisheries resources, and buffers against future coastal development or unforeseen events (Alison *et al.* 1998).

The IUCN has defined an MPA as (Hooker *et al.* 1999, p. 597):

> "any area of inter-tidal or sub-tidal terrain, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation to manage or protect part or all of the enclosed environment."

This definition includes two important points. The first is legislation. "...reserved by legislation" implies that the protected area has the committed support and enforcement of and by the government (Reeves 2000, Hooker *et al.* 1999). As stated by Perrin (1999, p. 305):

> "Laws without the will and resources to enforce them are worse than no laws at all."

Legal restrictions without enforcement can create profitable black markets that encourage hunting. As in the case study, non-enforcement of bans against commercial trawlers fishing within 3 kilometers of the coast creates a situation where conflicts between small-scale fishers and push net fishers can escalate into violence.

The second point involves the words "...manage or protect part or all...". While there are now over 4000 marine sanctuaries, parks, and reserves throughout the world (World Conservation Monitoring Centre 2002), the formulation and implementation of management has fallen behind (Alder 1996). Limitations on the successful realization of both these points has been hindered by factors such as (Reeves 2000, Alder 1996, White 1986):

- lack of a clear working definition for the MPA,
- limited knowledge of marine and fisheries resources,
- conflicts about funding,
- unsystematic site and boundary selection (for example, selection of least controversial areas),
- limited knowledge of the dynamic nature of the marine environment, of ecological linkages in the marine environment,
- limited knowledge of the needs and behavior of focal species,
- inadequate management and enforcement,

- no criteria for feedback and monitoring of management procedures,
- corruption at various levels of local and regional government,
- confusing and undefined government responsibilities,
- lack of local community input in planning and implementation, leading to non-acceptance of management schemes.

Researchers have found that the most common critical factors in successful MPAs include the participation of the local community in formulation, management, and enforcement, well-established education and community awareness programs, and NGO involvement (Alcala 1998, Rivera & Newkirk 1997, Alder 1996, Persoon *et al.* 1996, Pomeroy 1995, White 1986). Without the support of the community, as in any other conservation program, enforcement will fail.

This is as true for marine mammals that rely on coastal resources such as dugongs or manatees, as it is for more pelagic or migratory species. Any marine mammal species can be subject to direct take, ship strikes, incidental catch, or pollutants. The general lack of information of species' biology as well as the high degree of dispersion in marine mammals makes it difficult to measure the conservation benefits of MPAs on marine mammals (Reeves 2000). MPAs alone are insufficient protection for marine mammals because they cannot protect the animals from all critical impacts. MPAs directed at effective fisheries management can be advantageous to marine mammals by 1) reducing incidences of bycatch by restricting gear and fishing effort, 2) increasing the amount and variation in marine mammal prey, and 3) reduced disturbance to pupping or calving areas (Reeves 2000). Dugong conservation on the Andaman coast would definitely benefit from MPAs that reduced fishing pressure, enhanced fish production and stopped the destruction of fish habitat and seagrass.

The highly variable conditions of the water masses that pass through an area will have a strong affect on the animals within them (Allison *et al.* 1998). Better use of current scientific understanding of these conditions in the design of MPAs would greatly improve the design and effectiveness of reserves (Allison *et al.* 1998, Dayton *et al.* 1995). For example, seasonal monsoon storms in Thailand can destroy seagrass beds where dugongs have been foraging, such as in Kao Bae Na, in Trang province. While this is within Had Chao Mai National Park, dugongs who now forage in nearby seagrass do not have the same degree of protection.

Threats to protected areas that are critical in marine mammal protection, such as the spread of pollutants or chemicals are not stopped by an MPA boundary. Therefore, unless the protection of areas outside the reserve boundaries is considered, MPAs could be largely ineffective (Allison *et al.* 1998). Protection of areas outside of MPAs as well as within protected areas is as dependent on the surrounding community as it is on ecological knowledge.

The designation of an area to protect the critical habitat of a marine mammal has to also consider more than protecting enclaves of marine mammal populations. Ray *et al.* (1978) describe the need to take into account areas where important supporting processes originate. These processes include consideration of life-history strategies, such as breeding, foraging, and calf or pup raising. Other important support systems are the physical oceanographic mechanisms that influence the spatial and temporal movements and distributions for these activities (Hyrenbach *et al.* 2000). Due to the sometimes erratic and unpredictable variation in these mechanisms, pelagic MPAs will require dynamic boundaries, with extensive buffers to account for both deviation and uncertainty

(Hyrenbach *et al.* 2000, Reeves 2000). While these requirements are challenging, researchers believe that they are necessary, achievable, and can be effective if designed using current scientific understanding and technology (Hyrenbach *et al.* 2000, Allison *et al.* 1998, Mills & Carleton 1998).

5.5 Chapter summary

In any conservation or management planning process, it is necessary to take a detailed view of the historical and socioeconomic perspective of the issues that have been influencing the interactions between people and nature (Srichai *et al.* 1994). Along the Andaman coast of Thailand, a rapidly increasing human population has resulted in the degradation of coastal resources that were historically sustainable. Immigration from overcrowded provinces elsewhere into an open-access fishery, and a destructive and corrupt commercial fishing industry has created an atmosphere of desperation that places the dugong and its habitat at risk. With support from local NGO's, small-scale fishers have begun to learn about the environment they depend on, and empower themselves to defend it.

Every region will have unique issues owing to its distinctive geography, biological resources, political structure, and social concerns. Thorough analysis, awareness, and consideration of all these parameters can reveal the necessities and constraints necessary for developing successful conservation and management strategies (Schelhas 1992).

The use of focal species concepts and marine protected areas for the conservation of dugongs and other marine mammals demands an integrated approach that combines biological assessment and an awareness of socio-economic context. Further research is needed to define marine mammal behavior and life history in relation to habitat distribution and oceanographic parameters.

The literature reviewed and the case study shows a need for scientists to collaborate with agencies, users, educators, and other research institutions. The roles of each need to be clearly defined and by necessity, integrated. Science is only one part of marine mammal conservation; its function is the investigation and objective description of specific phenomena and processes. Effective conservation entails "interactive, reciprocal, and continuous" communication and education of scientific findings to the public and decision makers (Meffe *et al.* 1999, p. 451).

Political commitments and secure funding are important for the long-term success of any management strategy. Crucial also to the success of conservation planning is the meaningful participation of the community. Just as necessary as the outreach of scientists into the community is the realization by community planners and NGO's of the importance of the role of science in community based conservation planning. In Thailand, the dugong has the potential to be a useful flagship species. However, the attraction of a flagship species can threaten both species and habitat without knowledge of the effects of developmental and recreational planning on both the species in question and the local coastal environment. The concepts of composition and conditional indicators as the basis for ecological research can be used to structure research methodology, and could be a useful tool in directing future dugong research that could be used to intelligently plan future development in known dugong habitat areas.

The objective of this dissertation is to create a general framework to integrate the myriad issues surrounding endangered marine mammal conservation in the developing world into a template for cross cultural application. The elements and relationships for this framework are derived from both the elements discussed in the case study and the issues discussed in the literature review and this chapter. Figure 51 is an amended version of the process outlined in Figure 1.

A major addition to the original framework is the inclusion of time as a key factor. The elements of Figure 1 are adapted to fit along a time line. The vertical dotted lines in the middle of the diagram show the present. Conservation-based management and education planning decisions made in the present need to be filtered through lenses (the gray ellipses) of both the past events that have created the current situation, and realistic goals for the future. In each concentric circle, the goal of a sustainable population remains, as well as the elements comprising causative processes and constituencies. The vertical arrows connecting these elements stand for the need to connect knowledge of biophysical and socioeconomic considerations to all stakeholders through education and collaboration. The horizontal arrow with arrowheads in both directions represents the necessity for an ongoing process of conservation planning and implementation amended based on continual information gathering, evaluation, and monitoring.

The three concepts of focal species, collaboration, and marine protected areas fit into the framework implicitly. Focal species concepts are included in causative processes. A flagship species such as the Thai dugong is related to both socioeconomic and biophysical considerations, as knowledge of cultural roles as well as habitat requirements are pertinent. Exploration of the dugong's role as an umbrella or conditional indicator species can be a guide to research questions and management decisions throughout present and future planning. The collaboration between constituencies, including a realization of cultural values and ethics is addressed here, and in this framework, is ongoing throughout each stage. If a marine protected area is prescribed during the development of plans and actions, the protected area will be planned and implemented using the information gathered considering the combined causative processes; past, present, and anticipated. This MPA would also address the concerns arrived at as a result of the collaboration of all constituencies. The marine protected area will be ideally continually evaluated by a succession of monitoring and information gathering.

For example, for a marine protected area created to conserve dugong and seagrass habitat in Trang province to be successful, the fishing communities adjacent to and within the MPA would have to support the protected area. The needs, values, and environmental education of villagers will have to be considered. NGOs in this area have a strong relationship with local fishers and can assist in both environmental education, and with representing villagers' issues. Planning a protected area in Trang would have to be a collaborative effort, with representation by all constituencies. Enforcement of an MPA in this area would only be practical with the assistance and support of local people. Both provincial and federal government scientists would have to combine efforts in monitoring and evaluating the success of the MPA.

This framework is a tool to help organize and guide research and conservation planning for an endangered marine mammal, especially when incorporating the element of time. For example, as well as research on the animals themselves across time, which

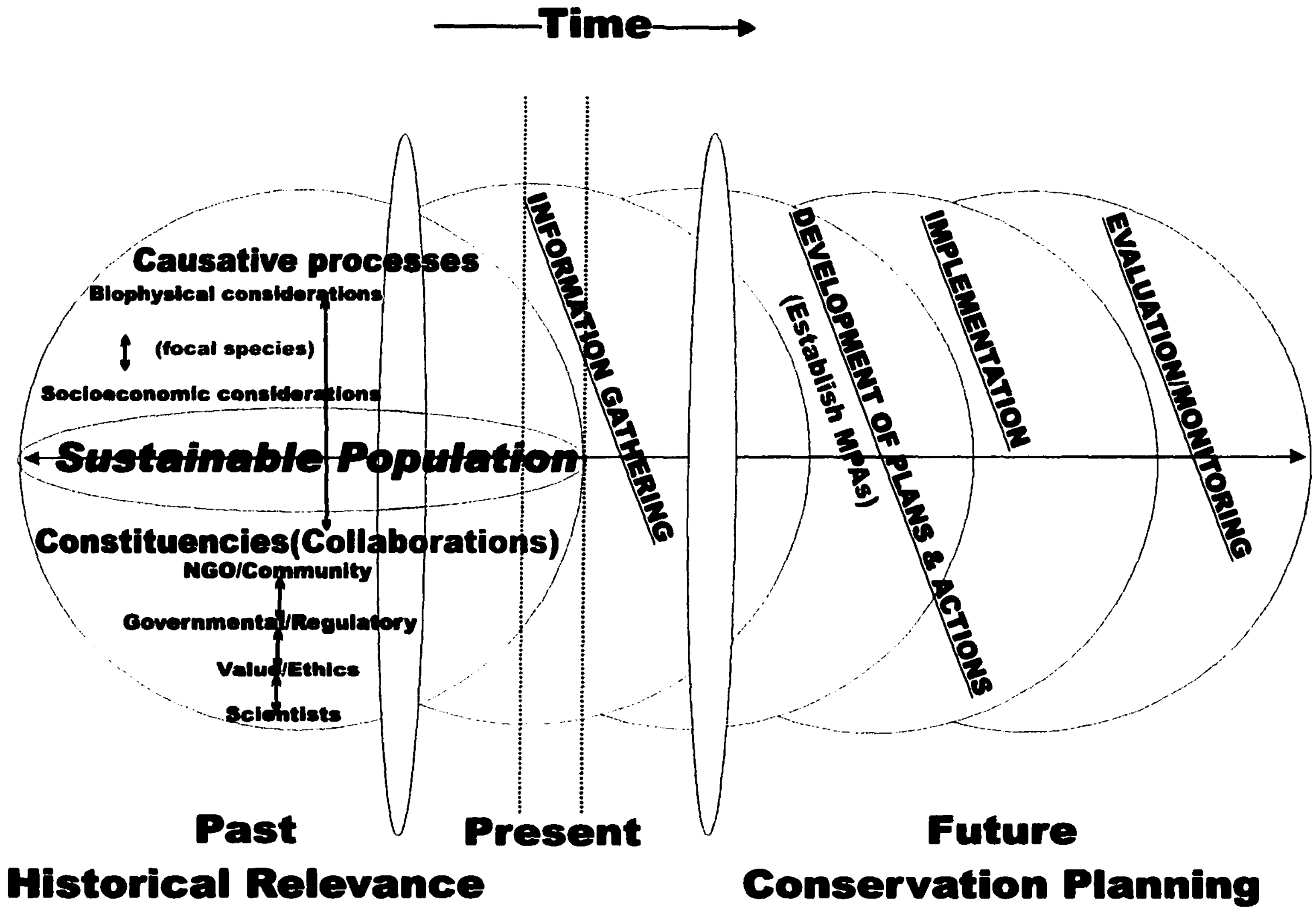


Figure 51. An example of an integrated framework for endangered marine mammal conservation (adapted from Kellert 1996). The three concepts discussed in this chapter are shown in red where they fit into the framework.

is a requirement for most ecological process-based research, research conducted within this framework will include exploration of past and present socioeconomic considerations that may have caused destructive fishing practices, or incidental catch: factors that have degraded habitat or depleted a population. The key is that both ecological and social research look to history and toward the future in tandem. At each stage both of these domains have interacted to produce the conditions of endangerment.

If future conservation planning is to be successful it too should function by linking ecological and social factors. Much of the conservation planning literature seems fully cognizant of the need to incorporate social and ecological elements, yet few frameworks integrate them well, and fewer still give adequate consideration to incorporating them in the analysis of cause (the past), and in the planning of a solution (the future). In the case study, I conducted interviews with villagers, NGO representatives, scientists, and government workers to complete a picture of the status of dugongs along the Andaman Sea that was first revealed by population and habitat research. Future research on causative processes based on this framework will be directed at gathering specific data to test hypotheses regarding the ecological role of the dugong through a more detailed investigation of the relationship between dugongs and seagrass. The information gathering as outlined in the framework is ongoing, as are the management and education plans and actions that the information contributes to, which are in turn continually adjusted by evaluation and monitoring.

Perhaps a key to the framework I present here is the idea that the research methods are open to local knowledge and continual review. Of course, the population and habitat issues are best studied by scientific methods. But science can be informed and supported by local knowledge to greater or lesser degrees depending on the setting. Social research can be carried on under a wide variety of methodological approaches. In my study a particular kind of social survey was used, in other studies a statistical sample or an attitude survey may expose the required information.

A final point is the role of the researcher as catalyst. In this arena there is no method per se. Each individual who involves himself or herself in this sort of work has to build a suite of skills and develop their judgment and sensitivity as to how to approach the various stakeholders. As a scientist I contribute to understanding causative processes, but in the processes of doing so, information is created that is used by many parties, some of whom have competing goals. In fact, some of the users may have goals that directly compete with the conservation goals that I hold for the site and the species. Thus, conservation biologists are faced with a conundrum. Within those two dashed lines (Fig. 51) while gathering information one enters into the interactive social sphere of conservation. In my case, I attended meetings, made plans, discussed and cajoled government figures, built relationships with local scientists. In different cases each individual involved will also cut through the layers of human interaction and process and try to cast a line towards preserving species and natural areas within which the future of all species depend.

Long-term planning requires long-term research. Government funding for dugong and seagrass research in Thailand is increasing, and in February of 2002, I was asked by the director of the Phuket Marine Biological Center to act as an advisor for continued dugong research. Collaboration between constituencies is crucial for future conservation planning. For the dugong in Thailand, these associations are strengthening.

In Bangkok, on February 14, 2002, a second meeting was held on dugong conservation, this time on a national basis with local advocates, NGO representatives, government workers, scientists, and the press to further discuss actions needed to save dugongs from habitat losses and entanglement in fishing nets (Adulyanukosol, pers. comm. 2002). Whether this increased interest is in time to save Thailand's approximately 200 dugongs is unclear. Without sound conservation planning and effort, I believe this animal will be extirpated from Thailand before the end of this century.

6.0 SUMMARY

The goals of this research were twofold: first, to gather knowledge that would assist in conservation strategy for the dugong along the Andaman coast of Thailand, and second, from within that context, to expand that knowledge into a generally applicable framework to guide the interactions necessary for an integrated system of conservation-oriented scientific planning for endangered marine mammals. Methodology analogous to that created for the dugong study as well as similar research into the issues influencing relevant social circumstances can then be applied as a resource for conservation and management processes for other marine mammals.

The case study is a clear example of the complex challenges that confront wildlife researchers working with endangered species. Solutions to conservation problems are not scientific, but social, economic, and political (Schaller 1992). Scientists must work with moral ambiguity, and uncertainty. Not only the biological uncertainty that comes naturally from working with complex systems, but also from the momentous shifting of values that comes with changing paradigms.

In chapter 1, I introduce these concepts, and discuss the impact of a rapidly growing human population within coastal areas. Extinction risks to marine mammals are escalating as a result of this rising population, widespread overfishing, incidental and direct catch, habitat destruction, and pollution. The slow growth rate, low reproductive rate, large size at sexual maturity of most marine mammals impedes their recovery from these problems. Their generally high trophic level, and degree of habitat specificity make them more vulnerable (Roberts & Hawkins 1999). Scientific knowledge of any species must be combined with consideration of the issues that are responsible for their endangerment.

Chapter 2 provided an overview of literature that describes research on endangered and threatened large mammals. While the major threats to all these animals are analogous, habitat destruction or degradation, direct or incidental take, the long-term solutions are complicated. While some scientists have become closely involved in conservation and management strategies, working with technological innovations, as well as with communities and educators to find solutions, others do little more than make suggestions, or talk about the need for enforcement.

The conservation and biology of the dugong along the Andaman coast of Thailand is an example of a situation where I believe that effective conservation strategy includes the active participation of scientists. The two years of field research on the dugong along the Andaman coast comprise chapters 3 and 4. There were three elements to this research: 1) dugong population assessment and distribution, 2) seagrass habitat assessment and distribution, and 3) interviews with villagers living in coastal fishing villages in areas where dugongs have been seen or reported.

Each year I flew reconnaissance surveys by helicopter to determine areas of dugong presence based on the results of previous surveys and the existence of seagrass beds. On the basis of these surveys I then flew strip transects over areas with larger extents of seagrass beds, or high numbers of dugongs. I found that dugongs are distributed unevenly along the coast, in scattered groups. The largest group, estimated at a minimum of 123 animals, feeds in the seagrass beds adjacent to Muk and Libong Islands in Trang province. The dugongs will feed in these seagrass beds at the highest tides. Their movement and feeding areas during lower tides is not known. I estimate that there are approximately 200 dugongs along the Thai section of the Andaman coast. There is no current information on dugongs in Myanmar, or in northern peninsular Malaysia.

The seagrass beds in Trang province have the largest extent and most dense cover percentage of any on the Andaman coast. Eleven species of seagrass have been found in Trang and other seagrass beds scattered along the coast. The species most commonly found is *Halophilia ovalis*, which is the species most often found in dugong foraging sites, and feeding trails both here and in Australia. Various researchers believe that dugongs will graze purposefully to increase the prevalence of this nutritious and competitive species.

I also interviewed villagers to determine population numbers and distribution of the dugong both modern and historically in the fishing villages which border dugong populations. The interviews were also used to appraise opinions about local conservation issues. In interviews with 145 villagers, 77% were of the opinion that the dugong population was decreasing. Government officials, Thai scientists, and NGO representatives agreed. Ninety-seven percent of interview respondents considered dugong conservation important, and are concerned with this decline. Large percentages of the villagers were also aware of the ecosystem benefits of healthy mangroves and seagrass, and therefore of their conservation importance. Strandings and incidental catches of dugongs are common, but are only reported 12% of the time. This confounds any accurate estimate of population losses and trends.

The use of dugong body parts as medicine and amulets is common knowledge along the coast, and the sale of these items can be profitable. In villages where NGO's had done educational programs, and the villagers had a higher awareness of conservation issues, dugong medicinal and amulet use and sales was not as evident a practice.

In chapter 5, I revisit the case study within the larger context of the historical patterns that have created the issues confronting the people and the environment along the Andaman coast today. Because of unregulated access to local fisheries, immigrants have crowded the coastal areas and are competing with indigenous fishers. There is also the problem of commercial trawlers who fish close to shore using destructive fishing methods, further depleting coastal fish stocks, as well as degrading the environment. These commercial trawlers also incidentally catch dugongs and dolphins. Small-scale fishers have been assisted by local NGO's to form resource conservation groups that work to protect the coastal environment and prevent destructive fishing.

Also in chapter 5, I discuss the utility of three concepts that are present in the research and conservation of endangered species. I first examine the use of focal species concepts as tools with relevance to conservation planning. A flagship species can be a way to arouse public interest in the conservation of endangered species. However, unregulated public attention and tourism can be risky to the animal unless management strategies also consider ecological knowledge about habitat needs, and methods to monitor habitat condition (Duffus 1996, Duffus & Dearden 1992).

In Trang province, where the dugong is presented as a symbol to increase tourism, a pier is being built that will harm dugongs by destroying seagrass beds, increasing boat traffic through habitat areas, and disturb the dugongs while feeding. Further research on dugongs in Thailand can be guided by consideration of the dugong as a conditional indicator species, or a species with specialized habitat needs, whose presence, absence, or behavior can represent specific environmental factors. The conditional indicator concept could drive more specific studies of dugong foraging ecology and habitat needs in relation to the effects of natural and anthropogenic stress on spatial distribution and dissemination of seagrass species.

Second, I look at how communication and collaborations between scientists, government, management, educators, and the community is critical to the success of any conservation process. This must be done with a realization of different perceptions on the relationship between humans and nature, as well as the historical relationship between users and authorities. Lastly, marine protected areas can be viable shelters for some endangered species if they are based on scientific knowledge. Clear management objectives and government support, as well as the cooperation of the local community are also vital to their success.

The strong relationships that have grown between villagers and NGOs in southern Thailand are an important step in the collaboration process. NGO representatives here are an important and useful conduit for the communication of scientific information from scientists to educators to villagers, and from villagers to management and government. In southern Thailand NGOs have also been instruments through which villagers have become motivated to become activists and collaborators themselves, as in the Small Scale Fisheries Network in the Yao Islands and Satun. Marine protected areas in Thailand will only be feasible if supported by NGOs and local communities.

Chapter 5 ends with a revised framework for endangered marine mammal conservation integrating the principles of collaboration between all constituencies. This framework also incorporates both past and projected biophysical and socioeconomic causative factors for endangerment into conservation planning. While no one knows how many dugongs are trapped in fishing gear each year along this coast, it is probable that such a small population cannot sustain this extent of loss without being extirpated. All are needed to come together and take responsibility to make whatever changes are necessary to protect the dugong and its habitat. An example of a basic change would entail not using harmful or destructive fishing gear in seagrass areas. The most difficult and important challenge is the conflict between small-scale and commercial fishers.

This case study certainly exemplifies the urgent need for integrated conservation. I cannot prescribe activism or even advocacy as a universal solution, as I believe these terms imply the imposition of personal values that might not be shared, or relevant in all situations. I am however, proposing that we, as conservation scientists, become aware of the social relevance and structure integral to the conservation process, and that we each generate within ourselves an imperative to contribute whatever we can "to help fragments of wilderness endure" (Shaller 1992, p. 47).

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8.0 APPENDICES

8.1 Interview forms

8.1.1 English form
8.1.2 Thai form

Interviews with villagers living close to dugong habitats.

Questions will address the following major issues:

- **history**

1. how long have dugongs been there,
2. have people ever hunted them,
3. are there any legends or rituals or stories about dugongs?

- **patterns**

1. where do dugongs occur,?
2. what seasons do you see dugongs?
3. are they in big or small groups?
4. do you notice calves?
5. how many dugongs do you see?
6. What other sea mammals or sea turtles do you see?

- **threats**

1. are numbers declining, increasing, staying the same?
2. Do dugongs interfere with fishing or boating activities?
3. are they caught in fishing nets?
4. what would you do if you found one stranded?

- **conservation:**

    - is it important to conserve dugongs?

    1. Very important
    2. Important

3. Neutral

4. moderately negative

5. very negative

- comments?

  - or other endangered species?

1. Very important

2. Important

3. Neutral

4. moderately negative

5. very negative

- comments?

  - Seagrass?

1. Very important

2. Important

3. Neutral

4. moderately negative

5. very negative

- comments?

  - mangroves?

1. Very important

2. Important

3. Neutral

4. moderately negative

5. very negative

- Comments?

- how would you feel if an area was designated off-limits for fishing to conserve an endangered animal or system?

1. Extremely positive
2. Moderately positive
3. Neutral
4. Moderately negative
5. Extremely negative

- Comments?

- **locations and history of strandings:**

1. have you found any dugongs or dolphins stranded?
2. Where?
3. What kind of animal?
4. When and how many?
5. How big were they?
6. Were they dead?
7. Did you notify any officials?
8. What happened to the animal or the body?

- **Medicinal use**

1. have you used any parts of a dugong's body as medicine?
2. have you heard of using any parts of a dugong's body as medicine?
3. what body part was used, for what purpose, and how was it prepared?

แบบสัมภาษณ์ชาวบ้านที่พักอาศัยใกล้ถิ่นที่อยู่ของปลาพะยูน

โปรดตอบคำถามตามหัวข้อต่อไปนี้

1. ท่านเคยเห็นปลาพะยูนไหม ?
1.1 ท่านเคยได้ยินว่าคนอื่นเห็นปลาพะยูนไหม ?
1.2เคยเห็นคนล่าปลาพะยูนเหล่านี้หรือไม่ ?
❑ เคย ❑ ไม่เคย
1.3เคยมีตำนานหรือเรื่องเล่าเกี่ยวกับปลาพะยูนหรือไม่ ?
❑ ไม่เคย
❑ เคย
โปรดระบุ...
....
....
....
....

2. รูปแบบถิ่นที่อยู่อาศัยของปลาพะยูน
2.1 ท่านมักเห็นปลาพะยูนบริเวณใด?
....
2.2 ท่านเคยได้ยินว่าผู้อื่นพบปลาพะยูนในบริเวณใด?..........................
....
2.3 กลุ่มปลาพะยูนที่ท่านพบมีขนาดเล็กหรือใหญ่ กี่ตัว(ขนาดใหญ่=มากกว่า 3 ตัว) ?
....
2.4 ท่านเคยเห็นลูกปลาพะยูนหรือไม่?
❑ เคย ❑ ไม่เคย
2.5 ในรอบปีที่ผ่านมาท่านเคยเห็นปลาพะยูนเป็นจำนวนกี่ตัว และกี่ครั้ง?
.... ตัว
2.6 ท่านเคยพบเห็นสัตว์ทะเลเลี้ยงลูกด้วยนมชนิดอื่น ๆเช่นปลาโลมา ปลาวาฬ หรือเต่าทะเลหรือไม่?
❑ ไม่เคย
❑ เคย โปรดระบุชนิดที่เคยพบเห็น
....
....
....

3. ท่านคิดว่าพะยูนมีประโยชน์อย่างไร

3.1 ท่านคิดว่าจำนวนของปลาพะยูนมีอัตราเพิ่มขึ้น ลดลง หรือคงที่ในช่วง 5 ปีที่ผ่านมา และคิดว่าเพราะอะไร?

❑ เพิ่มขึ้น เพราะ... ❑ คงที่ เพราะ... ❑ ลดลง เพราะ...

3.2 เคยมีปลาพะยูนติดขึ้นมากับอวนจับปลาหรือไม่ หรือเคยได้ยินว่ามีปลาติดอวนขึ้นมาไหม ที่ไหน เมื่อใด?

❑ ไม่เคย

❑ เคย โปรดระบุจำนวนครั้งโดยประมาณ .... ครั้ง / ปี

3.3 คุณจะทำอย่างไรถ้าหากคุณพบปลาพะยูนมาเติดอวน?
(ถามความคิดเห็นเชิงอนุรักษ์)

....

....

....

....

4. ความคิดเชิงอนุรักษ์

4.1 ท่านคิดว่าการอนุรักษ์ทรัพยากรเหล่านี้มีความสำคัญแค่ไหน?

ประเภทการอนุรักษ์ทรัพยากร	*สำคัญมาก*	*สำคัญ*	*เฉย ๆ (ไม่มีความเห็น)*	*ไม่ค่อยสำคัญ*	*ไม่สำคัญเลย*	*ข้อคิดเห็น / ข้อเสนอแนะอื่น ๆ*
1. การอนุรักษ์ป่าพะยูน						
2. การอนุรักษ์สัตว์ป่าและสัตว์น้ำที่ใกล้จะสูญพันธุ์ เช่น ปลาโลมา เต่าทะเล ฯลฯ						
3. การอนุรักษ์หญ้าทะเล						
4. การอนุรักษ์ป่าชาย						

เลน						

4.2 ท่านคิดว่าพะยูนมีประโยชน์อย่างไรกับท่าน?

....

4.3 ท่านเห็นด้วยกับการอนุรักษ์พะยูนหรือไม่ เพราะอะไร?

....

4.4 ท่านคิดว่าควรอนุรักษ์พะยูนด้วยวิธีใด?

....

5. ท่านมีความคิดเห็นอย่างไรถ้าจะมีการกำหนดพื้นที่ห้ามจับสัตว์น้ำเพื่อการอนุรักษ์พันธุ์สัตว์น้ำและระบบนิเวศน์?

- ❑ เห็นด้วยอย่างยิ่ง
- ❑ เห็นด้วย
- ❑ เฉย ๆ
- ❑ ไม่เห็นด้วย
- ❑ ไม่เห็นด้วยอย่างยิ่ง

ความคิดเห็นเพิ่มเติม

....

....

....

6. ท่านมีความคิดเห็นอย่างไรถ้าจะมีนักท่องเที่ยวมาเยือนหมู่บ้านของท่านเพื่อดูปลาพะยูน ?

- ❑ เห็นด้วยอย่างยิ่ง เพราะ...
- ❑ เห็นด้วย เพราะ...
- ❑ เฉย ๆ เพราะ...
- ❑ ไม่เห็นด้วย เพราะ...
- ❑ ไม่เห็นด้วยอย่างยิ่ง เพราะ...

ความคิดเห็นเพิ่มเติม

....

....

....

7. ประวัติและพื้นที่ที่เกยตื้น

7.1 คุณเคยพบปลาพะยูนหรือปลาโลมาเกยตื้นหรือไม่ ?

- ❑ ไม่เคย (ไม่ต้องตอบข้อ 7.2-7.8)
- ❑ เคย

7.2 ท่านคยพบที่ไหน?

....

7.3 ปลาชนิดใดที่ท่านเคยพบ?

....

7.4 พบเมื่อไหร่และมีจำนวนเท่าใด? ปี พ.ศ.
........................จำนวน .... ตัว

7.5 ปลาที่พบมีขนาดประมาณเท่าไหร่ ?

....

7.6 ปลาที่พบตายหรือยังมีชีวิตในขณะที่พบ?

❑ ตายแล้ว ❑ ยังมีชีวิตอยู่

7.7 ท่านได้แจ้งให้หน่วยงานที่มีส่วนเกี่ยวข้องทราบหรือไม่ ?

❑ แจ้ง ❑ ไม่ได้แจ้ง

7.8 ท่านทำอย่างไรกับปลาที่พบ ?

....

7.9 ท่านเคยใช้ชิ้นส่วนของพะยูนทำเครื่องลางของขลังหรือไม่ ใช้ชิ้นส่วนใดบ้าง ทำอะไร?

....
....

8.2 Aerial Survey Effort Logs

8.2.1 Helicopter 2000
8.2.2 Helicopter 2001
8.2.3 Trang 2000
8.2.4 Trang 2001
8.2.5 Krabi 2000
8.2.6 Phuket & Yao Islands 2001

Helicopter Effort Log 2001

Marine Mammal Survey Effort Log

Date March 26,27,28 2001

Series	Leg	Date	Time Started	Start Position	Course	Beaufort	Fog/ Rain	Visibility	End Leg Time	End Leg Position	Sight #	Start Location	End Location	Distance
1	1	3/26	10:00	8.779N \ 98.565E	S	1 to 3	1	C	1224	8.110N \ 98.383E	1 turtle/3 dolphins inc. 1 yoy	Ranong Airport	Phuket Airport	343 km
	2	3/26	14:27	8.110N \ 98.383E	E	2 to 3	1	C	1626	8.110N \ 98.383E	feeding trails Ao Labu/Ban Thalane	Phuket Airport	Phuket Airport	294.2 km
2	1	3/27	9:50	8.110N \ 98.383E	ES	2 to 3	3	LOW	1230	7.444N \ 99.345E	no sightings	Phuket Airport	Trang Airport	340.9 km
	2	3/27	14:13	7.444N \ 99.345E	WN	2 to 3	1	PC	1530	8.110N \ 98.383E	*min4/max5 dugongs inc. 1 calf*	Trang Airport	Phuket Airport	268.4 km
3	1	3/28	9:13	8.110N \ 98.383E	ES	2 to 3	3	PC	1129	6.938N \ 100.385E	feeding trails at Laem Ju Hui	Phuket Airport	Had Yai Airport	407.1 km
	2	3/28	13:05	8.097N \ 98.983E	NE	2 to 4	3	LOW	1400	8.110N \ 98.383E	Songkhla Lake, water turbid,	Had Yai Airpot	Phuket Airport	393.8 km

Fog/Rain Codes: 1 = no fog or rain, 2 = fog, 3 = rain, 4 = fog and rain, 5 = hazy but no fog or rain

Marine Mammal Survey Effort Log

Dates March 6,7,8,9,10,13,17,18,19,20 2000 **Begin Location** Ko Bae Na **End Location** Ko Bae Na

Leg	Time On	Time Off	Distance (km)	Speed	Beau	Fog/ Rain	Visib	Observers 1	Observers 2	Alt. (m)	Sight #*	Comments
6-Mar	1009	1156	162.50	45kn	1	1	C	eh	ns	182.88	62	
7-Mar	1124	1159	57.46	45kn	1	1	C	eh	ns	182.88	7	off transect
7-Mar	1331	1455	105.04	45kn	1	1	C	eh	ns	182.88	29	continue transect
8-Mar	1151	1402	162.50	45kn	1	1	PC	eh	ns	182.88	37	
9-Mar	1215	1419	162.50	45kn	1	1	PC	eh	ns	182.88	34	
10-Mar	1246	1455	162.50	45kn	1	1	PC	eh	ns	182.88	21	
13-Mar	1500	1635	162.50	45kn	1	1	C	ak	ns	182.88	15	
17-Mar	0854	1104	162.50	45kn	1	1	C	eh	ns	182.88	23	
18-Mar	0905	1135	162.50	45kn	1	1	PC	eh	ns	182.88	45	
19-Mar	0918	1139	162.50	45kn	1	1	PC	eh	ns	182.88	66	
20-Mar	1014	1244	162.50	45kn	1	1	PC	eh	ns	182.88	41	

Fog/Rain Codes: 1 = no fog or rain, 2 = fog, 3 = rain, 4 = fog and rain, 5 = hazy but no fog or rain

*Sighting # = dugong adults + calves

Microlite Survey Effort Log Trang 2001

Marine Mammal Survey Effort Log

Dates March 31, Apr 1,2,3,4,5,6,7,8,10,11,12 2001 **Begin Location** Ko Bae Na **End Location** Ko Bae Na

Leg	Time On	Time Off	Distance (km)	Speed	Beau	Fog/ Rain	Visib	Observers 1	Observers 2	Alt. (m)	Sight #*	Comments
31-Mar	1204	1348	169.53	45kn	2 to 3	1	C	eh	ns	152.4	10	
1-Apr	1044	1242	169.53	45kn	2	1	PC	ka	ns	152.4	11	
2-Apr	1340	1545	169.53	45kn	2	3	PC	eh	ns	152.4	5	intermittent rain
3-Apr	644	843	169.53	45kn	1	1	PC	ka	ns	152.4	7	
4-Apr	713	916	169.53	45kn	1	1	C	eh	ns	152.4	7	
5-Apr	815	1025	169.53	45kn	1 to 2	1	C	ka	ns	152.4	45	
6-Apr	855	1119	169.53	45kn	1 to 2	1	C	eh	ns	152.4	79	
7-Apr	0939	1134	169.53	45kn	1 to 2	1	C	ka	ns	152.4	88	
8-Apr	0954	1204	169.53	45kn	1	1	C	eh	ns	152.4	57	
10-Apr	1030	1245	169.53	45kn	2 to 3	1	PC	ka	ns	152.4	43	
11-Apr	1055	1305	169.53	45kn	1 to 2	1	C	eh	ns	152.4	35	
12-Apr	1109	1319	169.53	45kn	1 to 2	1	C	ka	ns	152.4	16	

Fog/Rain Codes: 1 = no fog or rain, 2 = fog, 3 = rain, 4 = fog and rain, 5 = hazy but no fog or rain
*Sighting # = dugong adults + calves

Microlite Survey Effort Log, Krabi 2000

Marine Mammal Survey Effort Log

Dates March 22,23,24,25,26 2000 **Begin Location** Sriboya Island **End Location** Sriboya Island

Leg	Time On	Time Off	Distance (km)	Speed	Beau	Fog/ Rain	Visib	Observers 1	Observers 2	Alt. (m)	Sight #*	Comments
22-Mar	1015	1107	75.49	45kn	1	1	C	eh	ns	182.88	2	
23-Mar	1052	1150	75.49	45kn	1	1	C	eh	ns	182.88	0	
24-Mar	1048	1222	75.49	45kn	3	3	LOW	ka	ns	182.88	0	storm
25-Mar	1133	1232	75.49	45kn	2	1	PC	ka	ns	182.88	5	
26-Mar	1100	1252	75.49	45kn	1	1	PC	eh	ns	182.88	5	

Fog/Rain Codes: 1 = no fog or rain, 2 = fog, 3 = rain, 4 = fog and rain, 5 = hazy but no fog or rain

*Sighting # = dugong adults + calves

Microlite Survey Effort Log Phuket and Yao Islands 2001

Marine Mammal Survey Effort Log

Dates March 23,24,25 2001 **Begin Location** Ban Pak Lok **End Location** Ban Pak Lok

Leg	Time On	Time Off	Distance (km)	Speed	Beaufort	Fog/ Rain	Visibility	Observers 1	2	Alt. (m)	Sight #*	Comments
23-Mar	923	946	29.70	45kn	3	3	LOW	eh	ns	152	0	cut short by rain
24-Mar	916	1006	134.00	45kn	2	1	LOW	eh	ns	152	0	water very turbid
24-Mar	1032	1208	159.54	45kn	2	1	PC	ka	ns	152	1	
24-Mar	1424	1528	159.54	45kn	2	1	PC	eh	ns	152	0	
24-Mar	1546	1618	159.54	45kn	2	1	PC	ka	ns	152	0	
25-Mar	825	1025	159.54	45kn	2	3	PC	eh	ns	152	1	intermittent rain
25-Mar	1044	1211	159.54	45kn	2	3	PC	ka	ns	152	1	intermittent rain

Fog/Rain Codes: 1 = no fog or rain, 2 = fog, 3 = rain, 4 = fog and rain, 5 = hazy but no fog or rain

*Sighting # = dugong adults + calves

8.3 Aerial Survey Sightings Logs

8.3.1 Helicopter 2000
8.3.2 Helicopter 2001
8.3.3 Trang 2000
8.3.4 Trang 2001
8.3.5 Krabi 2000
8.3.6 Phuket & Yao Islands 2001

Helicopter Sightings Log 2000

Date	Area	Province	Observers	Beaufort	Visibility	weather	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Latitude	Longitude	Comments
2/22	Ko Phayam	Ranong	eh, sp, bs	1	C	S	304.8	70	10:08:00	Dugong	1	0	9.7492	98.4269	South of Ranong
2/22	Ko Sai Dam	Ranong	eh, sp, bs	1	C	S	304.8	70	10:11:00	Turtle	2	0	9.7333	98.5500	
2/22	Laem Manao	Ranong	eh, sp, bs	1	C	S	304.8	70	10:31:00	Turtle	1	0	9.5500	98.4333	
2/22	Hin Pla	Phangnga	eh, sp, bs	1	C	S	304.8	70	10:32:00	Turtle	3	0	9.5167	98.4000	
2/22	Ko Ra	Phangnga	eh, sp, bs	4	Pc	Rain	304.8	70	10:53:00	Turtle	3	0	9.2333	98.3167	
2/22	Tap Lamu	Phangnga	eh, sp, bs	3	Pc	Cloudy	304.8	70	14:40:00	Turtle	1	0	8.4830	98.2160	
2/22	Tap Lamu	Phangnga	eh, sp, bs	3	Pc	Cloudy	304.8	70	14:46:00	Dolphin	6 to 8	0	8.5840	98.2100	Tursiops aduncus
2/22	Phuket	Phuket	eh, sp, bs	4	Pc	Cloudy	304.8	70	16:12:00	Dolphin	4 to 6	0	8.0766	98.4430	Sousa Chinensis
2/23	Ko Lanta (?)	Krabi	eh, sp, bs	1	Pc	Cloudy	304.8	70	12:57:00	Dugong	1	0			No position/unconfirmed
2/23	Ko Muk	Trang	eh, sp, bs	3	Pc	Cloudy	304.8	70	14:47:00	Dugong	1	0	7.3807	99.3112	
2/23	Ko Muk	Trang	eh, sp, bs	3	Pc	Cloudy	304.8	70	14:47:00	Turtle	1	0	7.3728	99.3294	
2/23	Ko Talibong	Trang	eh, sp, bs	3	Pc	Cloudy	304.8	70	14:47:00	Dugong	3	1	7.2561	99.4670	
2/23	Ko Talibong	Trang	eh, sp, bs	3	Pc	Cloudy	304.8	70	15:22:24	Dugong	1	0	7.2350	99.4410	
2/23	Ko Talibong	Trang	eh, sp, bs	3	Pc	Cloudy	304.8	70	15:34:30	Dugong	2 to 3	1	7.2350	99.4170	cow/calf pair/1 subadult\1 adult
2/23	Ko Yaratot Noi	Satun	eh, sp, bs	3	Pc	Cloudy	304.8	70	16:06:03	Dolphin	7 to 9	0	6.6773	99.8818	Tursiops Aduncus
2/24	Ko Sriboya	Krabi	eh, ak, bs	2	Pc	Cloudy	304.8	70	10:02:00	Dugong	1	0	7.9030	98.9658	
2/24	Ko Pu	Krabi	eh, ak, bs	2	Pc	Cloudy	304.8	70	10:21:55	Dugong	1	0	7.8717	98.9566	
2/24	Ko Pu	Krabi	eh, ak, bs	2	Pc	Cloudy	304.8	70	10:31:18	Dolphins	2	0	7.7930	98.9745	Orcaella brevirostris/S.chinensis
2/24	Ko Sriboya	Krabi	eh, ak, bs	2	Pc	Cloudy	304.8	70	10:46:00	Dugong	1	0	7.8840	98.9710	
2/24	Ko Sriboya	Krabi	eh, ak, bs	2	Pc	Cloudy	304.8	70	10:46:00	Dugong	1	0	7.8710	98.9669	
2/24	Ko Muk	Trang	eh, ak, bs	2	Pc	Cloudy	304.8	70	11:35:51	Dugong	3	0	7.3964	99.3434	
2/24	Ko Muk	Trang	eh, ak, bs	2	Pc	Cloudy	304.8	70		Dolphin	1	0	7.3863	99.3275	Species not clear
2/24	Ko Talibong	Trang	eh, ak, bs	1	Pc	Cloudy	304.8	70	13:20:00	Dugong	3	2	7.2569	99.4641	
2/24	Ko Talibong	Trang	eh, ak, bs	1	Pc	Cloudy	304.8	70	13:35:47	Dugong	1	0	7.2314	99.4258	
2/24	Ko Talibong	Trang	eh, ak, bs	1	Pc	Cloudy	304.8	70	13:47:27	Dolphin	4	2	7.2693	99.4290	Tursiops aduncus
2/24	Ko Muk	Trang	eh, ak, bs	1	Pc	Cloudy	304.8	70	14:05:47	Dugong	1	0	7.3888	99.3155	
								totals			21-22 dugongs	4 dugong young			
											11 turtles				
											24-30 dolphins	2 dolphin young			

Helicopter Sightings Log 2001

Date	Area	Province	Observers	Beaufort	Visibility	weather	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Latitude	Longitude	Comments	
3/26	Ko Phayam	Ranong	eh,ka,hp	1 to 3	C	cloudy	121	55-80	10:54	dolphins	2	1	9.37139	98.39464	Tursiops aduncus	
3/27	Ko Talibong	Trang	eh,ka,hp	2 to 3	PC	cloudy	121	50-80	14:27	dugongs	3 to 4	1	7.25919	99.45689		

Trang Sightings Log, March 6, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong
3/6	Ko Bae Na	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45	1014	dugong	1	0	7.3987	99.3447
3/6	Ko Bae Na	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45	1015	dugong	2	0	7.4001	99.3313
3/6	Ko Bae Na	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45	1017	dugong	1	0	7.3940	99.3316
3/6	Ko Muk	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45		dugong	2	0	7.3838	99.3176
3/6	Ko Muk	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45		dugong	1	0	7.3862	99.3056
3/6	Laem Yong Lan	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45	1033	dugong	1	0	7.3676	99.3425
3/6	Hat San	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45	1044	dugong	1	0	7.3563	99.3548
3/6	Hat San	Trang	micro	eh, ns	2.7	clear	sunny	1	182.88	45		dugong	4	0	7.3442	99.3598
3/6	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		dugong	1	0	7.2748	99.3956
3/6	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	1	1	7.2716	99.4026
3/6	Ko Talibong	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		turtle	1	0	7.2716	99.4026
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		turtle	1	0	7.2766	99.4161
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2653	99.4137
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		turtle	3	0	7.2682	99.4152
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2644	99.4278
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45	1119	dugong	5	1	7.2643	99.4531
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45	1125	dugong	22	4	7.2553	99.4631
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	3	0	7.2540	99.4582
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2435	99.4501
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	4	0	7.2382	99.4421
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45	1137	dugong	1	0	7.2331	99.4314
3/6	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45	1143	dugong	3	0	7.2001	99.4123

Trang Sightings Log, March 7, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/7	Ko Bae Na	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45	1128	dugong	1	0	7.3983	99.3417	
3/7	Ko Bae Na	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		dugong	2	1	7.4007	99.3191	
3/7	Ko Bae Na	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		dugong	1	0	7.3891	99.3324	
3/7	Ko Bae Na	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		turtle	1	0	7.3846	99.3190	
3/7	Laem Yong Lam	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		dugong	1	0	7.3681	99.2376	
3/7		Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		turtle	1	0	7.3654	99.3419	between Laem Yong Lam and river mouth
3/7		Trang	micro	eh, ns	3.2	clear	sunny	1	182.88	45		dugong	1	0	7.3654	99.3419	dead animal tied to mooring buoy
3/7	Hat San	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45	1337	dugong	3	0	7.3521	99.3576	tide out, glare on both sides of micro
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		turtle	3	0	7.2743	99.3760	north side of island
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		turtle	1	0	7.2722	99.4027	
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		dugong	6	1	7.2713	99.4815	glare
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		dugong	1	0	7.2655	99.4660	
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		dugong	1	0	7.3682	99.4684	
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		dugong	1	0	7.2610	99.4568	
3/7	Ko Talibong	Trang	micro	eh, ns	3.3	clear	sunny	1	182.88	45		dugong	3	1	7.2561	99.4826	
3/7	Ko Talibong	Trang	micro	eh, ns	3.2	clear	sunny	1	182.88	45		dugong	2	1	7.2584	99.4651	
3/7	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2419	99.4549	started other side of island at 1425
3/7	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2404	99.4459	
3/7	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2332	99.4341	
3/7	Ko Talibong	Trang	micro	eh, ns	3.1	clear	sunny	1	182.88	45		dugong	1	0	7.2286	99.4313	
3/7	Ko Talibong	Trang	micro	eh, ns	3.0	clear	sunny	1	182.88	45		dugong	1	0	7.2325	99.4296	
3/7	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	3	1	7.2259	99.4250	
3/7	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		turtle	2	0	7.2242	99.4180	

Trang Sightings Log, March 8, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/8	Ko Muk	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1202	dugong	1	0	7.3902	99.3100	glare
3/8	Ko Muk	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1204	dugong	1	0	7.3928	99.3270	
3/8	Ko Muk	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45		dugong	1	0	7.3934	99.3363	
3/8	Ko Muk	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45		dugong	1	0	7.3813	99.3089	
3/8	Ko Muk	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1221	dugong	1	0	7.3683	99.3215	tip of Ko Muk
3/8	Hat San	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1238	dugong	1	0	7.3625	99.3525	maybe 2, I confirmed
3/8	Hat San	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45		dugong	2	0	7.3564	99.3542	
3/8	Ko Talibong	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1249	turtle	1	0	7.2736	99.3783	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1304	turtle	1	0	7.2793	99.4227	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2674	99.4572	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2724	99.4724	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	2	0	7.2644	99.4653	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	15	2	7.2667	99.4627	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	2	0	7.2571	99.4624	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1330	dugong	1	1	7.2546	99.4629	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2535	99.4597	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2538	99.4574	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2398	99.4540	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1340	dugong	1	0	7.2315	99.4455	
3/8	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2133	99.4099	

Trang Sightings Log, March 9, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3997	99.3459	
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		turtle	1	0	7.3988	99.3443	
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3939	99.3418	subtract 10 min from effort, around ko muk in wind
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3918	99.3349	
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3910	99.3304	
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3876	99.3354	repeat?
3/9	Laem Yong Lam	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		turtle	1	0	7.3865	99.3315	
3/9	bet KM & LYL	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		dugong	1	0	7.3883	99.3164	
3/9	bet KM & LYL	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45		turtle	1	0	7.3846	99.3074	
3/9	bet KM & LYL	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3791	99.3262	saw dive as approached
3/9	bet KM & LYL	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45		turtle	1	0	7.3725	99.3227	
3/9	bet KM & LYL	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.3669	99.3398	
3/9	bet KM & LYL	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.3611	99.3314	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1314	turtle	2	0	7.2653	99.4130	south coast of KT
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	4	0	7.2657	99.4669	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	2	2	7.2550	99.4556	adult with both yoy and another calf
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	6	1	7.2546	99.4609	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2592	99.4643	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2592	99.4643	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	2	0	7.2682	99.4673	mating in water
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2620	99.4622	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2438	99.4482	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2439	99.4473	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2428	99.4435	feeding plume in water
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2354	99.4498	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2354	99.4498	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2197	99.4425	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	3	0	7.2108	99.4356	
3/9	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2134	99.4331	
3/9	Ko Talibong	Trang	micro	eh, ns	3.5	clear	PC	1	182.88	45		turtle	1	0	7.2307	99.4192	
3/9	Ko Talibong	Trang	micro	eh, ns	3.5	clear	PC	1	182.88	45		dugong	2	0	7.2333	99.4140	e of Laem Buda, 1/2way down island

Trang Sightings Log, March 10, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/10	Khao Bae Na	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1250	dugong	1	0	7.3991	99.3400	
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3920	99.3163	
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3881	99.3223	between KM & LYL
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		turtle	1	0	7.3881	99.3223	between KM & LYL
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		turtle	1	0	7.3880	99.3037	
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3878	99.3025	front of east KM
3/10		Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3787	99.3117	off KM village
3/10	Hat San	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.3557	99.3580	
3/10	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		turtle	1	0	7.2840	99.3925	north end of KT
3/10	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		turtle	1	0	7.2803	99.3929	near KT
3/10	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1341	turtle	1	0	7.2802	99.4146	
3/10	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1345	dugong	1	0	7.2796	99.4263	1/2way betwn east KT & mainland
3/10	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2661	99.4673	
3/10	Ko Talibong	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45		dugong	5	2	7.2556	99.4619	
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2557	99.4670	
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2375	99.4280	
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2354	99.4167	1/2way betwn Ban Laem Buda & point
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	2	1	7.2209	99.4099	1/2way betwn Ban Laem Buda & point
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		dugong	1	0	7.2264	99.4093	1/2way betwn Ban Laem Buda & point
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	2	0	7.2276	99.4098	
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2161	99.4214	
3/10	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2334	99.4094	

Trang Sightings Log, March 13, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong
3/13	Khao Bae Na	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1519	dugong	1	0	7.2656	99.4729
3/13	Khao Bae Na	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1520	dugong	1	0	7.2630	99.4686
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1524	dugong	1	0	7.2713	99.4577
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1524	turtle	1	0	7.2560	99.4657
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1526	dugong	1	0	7.2571	99.4701
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1526	turtle	1	0	7.2571	99.4701
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1527	dugong	1	1	7.2643	99.4807
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1531	dugong	1	0	7.2526	99.4640
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1533	turtle	1	0	7.2516	99.4601
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1537	dugong	1	0	7.2449	99.4574
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1537	turtle	1	0	7.2449	99.4574
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1540	dugong	1	0	7.2404	99.4564
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1541	dugong	1	1	7.2282	99.4635
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1542	dugong	1	0	7.2623	99.4910
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1548	turtle	1	0	7.2327	99.4436
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1554	dugong	1	0	7.2691	99.4316
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1558	dugong	1	0	7.2167	99.4245
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1601	turtle	1	0	7.2223	99.4149
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1604	turtle	1	0	7.2268	99.4132
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1609	dugong	1	0	7.2108	99.4095
3/13		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1614	turtle	1	0	7.2141	99.4081

Trang Sightings Log March 17, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong
3/17	Khao Bae Na	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		dugong	1	0	7.4063	99.3363
3/17	Khao Bae Na	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	859	dugong	1	0	7.3951	99.3355
3/17	Ko Muk	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	910	turtle	1	0	7.3789	99.3129
3/17	Ko Muk	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	919	dugong	1	0	7.3580	99.3232
3/17		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	924	dugong	1	0	7.3591	99.3228
3/17	Hat San	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	932	dugong	1	0	7.3533	99.3569
3/17		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	936	dolphins	3	0	7.3222	99.3801
3/17		Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	936	turtle	1	0	7.3222	99.3801
3/17	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		turtle	1	0	7.2801	99.3902
3/17	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		dugong	1	0	7.2761	99.3948
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	1	0	7.2695	99.4278
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1010	dugong	1	1	7.2614	99.4572
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	1	1	7.2593	99.4603
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1015	dugong	1	0	7.2664	99.4694
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1021	dugong	1	0	7.2585	99.4615
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1024	dugong	1	0	7.2570	99.4708
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		turtle	1	0	7.2486	99.4628
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		turtle	1	0	7.2444	99.4604
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	1	0	7.2707	99.4764
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1044	dugong	1	0	7.2382	99.4326
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1045	dugong	1	0	7.2357	99.4234
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45		dugong	2	0	7.2333	99.4252
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1049	dugong	2	0	7.2137	99.4252
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1049	turtle	1	0	7.2148	99.4236
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1052	turtle	1	0	7.2226	99.4094
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1054	dugong	1	0	7.2039	99.4103
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1054	turtle	2	0	7.2039	99.4103
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1055	turtle	1	0	7.2072	99.4085
3/17	Ko Talibong	Trang	micro	eh, ns	2.9	clear	sunny	1	182.88	45	1055	dugong	1	0	7.2109	99.4064
3/17	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45		turtle	1	0		
3/17	Ko Talibong	Trang	micro	eh, ns	2.8	clear	sunny	1	182.88	45	1102	turtle	1	0	7.1858	99.3896

Trang Sightings Log March 18, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/18	Had Chao Mai	Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	906	turtle	1	0	7.4186	99.3451	
3/18	Khao Bae Na	Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	911	dugong	1	0	7.4017	99.3361	
3/18		Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	912	turtle	1	0	7.3975	99.3322	
3/18		Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	915	turtle	1	0	7.3898	99.3161	
3/18		Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	921	dugong	1	0	7.3881	99.3338	
3/18	Ko Muk	Trang	micro	eh, ns	2.8	clear	cloudy	1	182.88	45	932	turtle	1	0	7.3765	99.3116	
3/18	Ko Muk	Trang	micro	eh, ns	3.0	clear	cloudy	1	182.88	45	945	turtle	1	0	7.3556	99.3331	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1019	dugong	2	1	7.2684	99.4449	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1024	dugong	2	0	7.2615	99.4582	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	3	1	7.2618	99.4577	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1028	dugong	1	0	7.2627	99.4581	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		turtle	1	0	7.2620	99.4604	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	1	0	7.2552	99.4601	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	2	0	7.2642	99.4671	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	1	1	7.2547	99.4608	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	3	1	7.2580	99.4643	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1034	dugong	2	1	7.2570	99.4620	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		turtle	1	0	7.2570	99.4620	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1042	dugong	3	2	7.2569	99.4643	seagrass south of Hin Sae
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		turtle	1	0	7.2486	99.4623	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		dugong	1	0	7.2486	99.4623	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45		turtle	1	0	7.2537	99.4578	
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1055	dugong	1	1	7.2393	99.4425	a bit east of KBB
3/18	Ko Talibong	Trang	micro	eh, ns	3.1	clear	cloudy	1	182.88	45	1059	dugong	4	2	7.2360	99.4357	3 distinct groups in same area
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1104	dugong	1	0	7.2369	99.4278	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45		dugong	1	0	7.2355	99.4280	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1109	dugong	1	0	7.2333	99.4247	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1113	turtle	1	0	7.2142	99.4290	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1118	dugong	1	0	7.2237	99.4102	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1122	dugong	1	0	7.2135	99.4145	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1126	dugong	1	0	7.2071	99.4159	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45		dugong	1	0	7.1998	99.4185	
3/18	Ko Talibong	Trang	micro	eh, ns	3.2	clear	cloudy	1	182.88	45	1129	dolphins	2	0	7.1801	99.4243	no clear species id

Trang Sightings Log March 19, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/19	Khao Bae Na	Trang	micro	eh, ns	2.1	clear	PC	1	182.88	45	920	dugong	1	0	7.4098	99.3416	
3/19	Khao Bae Na	Trang	micro	eh, ns	2.1	clear	PC	1	182.88	45	924	dugong	1	0	7.3988	99.3366	
3/19	Khao Bae Na	Trang	micro	eh, ns	2.2	clear	PC	1	182.88	45	925	dugong	1	0	7.3948	99.3340	
3/19	Laem Yong Lam	Trang	micro	eh, ns	2.2	clear	PC	1	182.88	45	928	dugong	1	0	7.3909	99.3342	
3/19	Ko Muk	Trang	micro	eh, ns	2.4	clear	PC	1	182.88	45	937	turtle	1	0	7.3813	99.3223	betwn KM & LYL
3/19	Ko Muk	Trang	micro	eh, ns	2.5	clear	PC	1	182.88	45	938	dugong	1	0	7.3808	99.3101	
3/19	Ko Muk	Trang	micro	eh, ns	2.6	clear	PC	1	182.88	45	945	turtle	1	0	7.3702	99.3220	
3/19	Ko Muk	Trang	micro	eh, ns	2.7	clear	PC	1	182.88	45	952	turtle	1	0	7.3618	99.3236	
3/19	Ko Muk	Trang	micro	eh, ns	2.8	clear	PC	1	182.88	45	957	turtle	1	0	7.3589	99.3343	
3/19	Ko Muk	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1001	dugong	1	0	7.3527	99.3157	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1024	turtle	1	0	7.2828	99.3985	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1031	turtle	1	0	7.2811	99.4166	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1033	turtle	1	0	7.2771	99.4175	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1036	dolphins	3	0	7.2809	99.4321	species unclear, aduncus?
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1036	turtle	1	0	7.2809	99.4321	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1046	turtle	1	0	7.2644	99.4653	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1047	dugong	1	1	7.2682	99.4577	calf looks bigger than yoy
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1051	turtle	1	0	7.2702	99.4589	
3/19	Ko Talibong	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1053	turtle	1	0	7.2648	99.4612	
3/19	Ko Talibong	Trang	micro	eh, ns	3.0	clear	PC	1	182.88	45	1056	dugong	2	0	7.2644	99.4636	
3/19	Ko Talibong	Trang	micro	eh, ns	3.0	clear	PC	1	182.88	45	1056	turtle	1	0	7.2617	99.4602	
3/19	Ko Talibong	Trang	micro	eh, ns	3.0	clear	PC	1	182.88	45	1057	dugong	1	0	7.2516	99.4597	
3/19	Ko Talibong	Trang	micro	eh, ns	3.1	clear	PC	1	182.88	45	1058	turtle	1	0	7.2746	99.4672	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1103	dugong	25	5	7.2581	99.4623	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1104	turtle	2	0	7.2581	99.4623	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1112	dugong	2	3	7.2559	99.4677	in two groups one cow has 2 calves
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	2	0	7.2553	99.4647	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	3	4	7.2552	99.4650	in two groups, one cow has 2 calves
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1116	dugong	1	0	7.2500	99.4631	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1117	dugong	6	0	7.2555	99.4667	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2642	99.4465	betwn KBB & KT
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2409	99.4323	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2313	99.4254	
3/19	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2306	99.4137	in small seagrass patch near village

Trang Sightings Log March 20, 2000

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong	Comments
3/20	Laem Yong Lam	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1021	dugong	1	0	7.3932	99.3414	beginning of LYL
3/20	Laem Yong Lam	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1021	dugong	1	0	7.3974	99.3330	
3/20	Laem Yong Lam	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1025	dugong	1	0	7.3905	99.3309	further into LYL
3/20	Laem Yong Lam	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45	1025	turtle	1	0	7.3907	99.3199	
3/20	Ko Muk	Trang	micro	eh, ns	2.9	clear	PC	1	182.88	45		turtle	1	0	7.3899	99.3057	
3/20	Ko Muk	Trang	micro	eh, ns	3.0	clear	PC	1	182.88	45	1034	dugong	1	0	7.3828	99.3101	north side KM
3/20	Hat San	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1100	dugong	1	0	7.3621	99.3495	before river mouth
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1132	turtle	1	0	7.2715	99.4239	north end of KT
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1141	dugong	2	0	7.2686	99.4604	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1141	turtle	1	0	7.2686	99.4604	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1144	turtle	1	0	7.2632	99.4591	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1144	dugong	1	0	7.2688	99.4635	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1146	turtle	1	0	7.2628	99.4594	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1148	dugong	2	1	7.2507	99.4575	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1150	dugong	2	0	7.2564	99.4605	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1151	turtle	1-	0	7.2624	99.4646	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1151	dugong	1	1	7.2650	99.4673	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1151	turtle	1	0	7.2681	99.4700	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45	1152	dugong	1	0	7.2520	99.4602	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	1	0	7.2491	99.4567	
3/20	Ko Talibong	Trang	micro	eh, ns	3.2	clear	PC	1	182.88	45		dugong	2	0	7.2464	99.4541	Ko Bang Bong
3/20	Ko Talibong	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1156	dugong	1	0	7.2454	99.4541	
3/20	Ko Talibong	Trang	micro	eh, ns	3.3	clear	PC	1	182.88	45	1159	dugong	1	0	7.2443	99.4569	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45		turtle	1	0	7.2517	99.4646	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1201	dugong	1	0	7.2550	99.4668	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1205	dugong	1	0	7.2420	99.4567	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1206	dugong	1	0	7.2441	99.4491	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1210	dugong	5	1	7.2432	99.4455	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1215	dugong	1	0	7.2335	99.4436	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1215	turtle	1	0	7.2335	99.4436	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1216	dugong	1	0	7.2415	99.4380	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1217	dugong	1	1	7.2394	99.4338	white scar on back of cow
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1219	dugong	3	1	7.2406	99.4311	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1227	dugong	1	0	7.2325	99.4278	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1229	dugong	1	0	7.2189	99.4286	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1233	dugong	1	0	7.2160	99.4251	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1233	turtle	1	0	7.2160	99.4251	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1237	turtle	1	0	7.2223	99.4080	
3/20	Ko Talibong	Trang	micro	eh, ns	3.4	clear	PC	1	182.88	45	1241	turtle	1	0	7.2128	99.4049	

Trang Sightings Log March 31, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong
3/31	Ko Muk	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1208	turtle	1	0	7.4033	99.3321
3/31	Ko Muk	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1209	dugong	1	0	7.4028	99.3408
3/31	Ko Muk	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1216	turtle	1	0	7.3990	99.3174
3/31	Laem Yong Lam	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1230	dugong	2	0	7.3853	99.3407
3/31	Laem Yong Lam	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1240	turtle	1	0	7.3669	99.3341
3/31	Laem Yong Lam	Trang	microlite	eh, ns	2.3	clear	sunny	2 to 3	152.4	45	1243	dugong	1	0	7.3689	99.3423
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1311	dugong	1	0	7.2702	99.4644
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1333	dugong	1	0	7.2415	99.4382
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1335	turtle	1	0	7.2234	99.4363
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1336	dugong	1	0	7.2348	99.4239
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1337	dugong	1	1	7.1398	99.4290
3/31	Ko Libong	Trang	microlite	eh, ns	2.7	clear	sunny	2 to 3	152.4	45	1345	dugong	1	0	7.2254	99.4078
												total	10 dugongs (inc 1 calf)			
													1 turtle			

Trang Sightings Log April 1, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/1	Ko Bae Na	Trang	microlite	ka,ns	1.5	clear	pc	2	152.4	45	1049	dugong	1	0	f	7.4053	99.3380
4/1	Ko Muk	Trang	microlite	ka,ns	1.6	clear	pc	2	152.4	45	1053	dugong	1	0	s	7.4008	99.3335
4/1	Ko Muk	Trang	microlite	ka,ns	1.7	clear	pc	2	152.4	45	1106	dugong	1	0	t	7.3942	99.3290
4/1	Ko Muk	Trang	microlite	ka,ns	1.7	clear	pc	2	152.4	45	1106	dugong	1	0	t	7.3833	99.3312
4/1	Ko Muk	Trang	microlite	ka,ns	1.7	clear	pc	2	152.4	45		dugong	1	0	t	7.3765	99.3279
4/1	Ko Muk	Trang	microlite	ka,ns	1.8	clear	pc	2	152.4	45	1121	dugong	1	0	t	7.3640	99.3406
4/1	Ko Muk	Trang	microlite	ka,ns	1.8	clear	pc	2	152.4	45	1121	dugong	1	0	t	7.3643	99.3383
4/1	Ko Libong	Trang	microlite	ka,ns	2.3	clear	pc	2	152.4	45	1241	dugong	1	1	t	7.2197	99.4253
4/1	Ko Libong	Trang	microlite	ka,ns	2.3	clear	pc	2	152.4	45	1245	dugong	1	0	t	7.2256	99.4341
4/1	Ko Libong	Trang	microlite	ka,ns	2.4	clear	pc	2	152.4	45	1254	dugong	1	0	t	7.2189	99.4117
													total	11 dugongs inc. 1 calf			

*Behavior: f=feeding, t=travelling, s=resting, r=rolling

Trang Sightings Log April 2, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1356	dugong	1	0	f	7.3902	99.3256
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1356	turtle	1	0		7.3902	99.3256
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1408	turtle	1	0		7.3929	99.3387
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1411	turtle	1	0		7.3796	99.3358
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1413	turtle	1	0		7.3753	99.3248
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1418	turtle	1	0		7.3673	99.3313
4/2	Ko Muk	Trang	microlite	eh,ns	2.2	low	int. rain	2	152.4	45	1422	dugong	1	0	f	7.3624	99.3168
4/2	Ko Muk	Trang	microlite	eh,ns	2.3	low	int. rain	2	152.4	45	1426	turtle	1	0		7.3644	99.3345
4/2	coastline	Trang	microlite	eh,ns	2.3	low	int. rain	2	152.4	45	1437	turtle	1	0			
4/2	Ko Libong	Trang	microlite	eh,ns	2.4	low	int. rain	2	152.4	45	1458	turtle	1	0		7.2772	99.4542
4/2	Ko Libong	Trang	microlite	eh,ns	2.4	low	int. rain	2	152.4	45	1511	dugong	1	0	f	7.2732	99.4813
4/2	Ko Libong	Trang	microlite	eh,ns	2.4	low	int. rain	2	152.4	45	1516	turtle	1	0		7.2504	99.4732
4/2	Ko Libong	Trang	microlite	eh,ns	2.5	low	int. rain	2	152.4	45	1534	dugong	1	0	f	7.2383	99.4201
4/2	Ko Bae Na	Trang	microlite	eh,ns	2.6	low	int. rain	2	152.4	45	1600	dugong	1	0	s	7.4001	99.3426
												total	dugongs 5				
													turtles 9				

*Behavior: f=feeding, t=travelling, s=resting, r=rolling

Trang Sightings Log April 3, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat
4/3	Khao Bae Na	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	646	dugong	1	0	f	7.4013
4/3	Leam Yong Lam	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	711	dugong	1	0	f	7.3690
4/3	Ko Libong	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	803	dugong	1	0	t	7.2765
4/3	Leam Ju Hui	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	821	dugong	1	0	f	7.2760
4/3	Ao Tong Gin	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	836	dugong	1	0	t	7.2303
4/3	Ko Libong	Trang	microlite	ka, ns	2.4	clear	pc	1	152.4	45	845	dugong	1	0	t	7.2404
4/3	Ban Chao Mai	Trang	microlite	ka, ns	2.3	clear	pc	1	152.4	45	857	dugong	1	0	f	7.3077
4/3	Ko Muk	Trang	microlite	ka, ns		clear	pc	1	152.4	45		turtle	3			
4/3	Ko Libong	Trang	microlite	ka, ns		clear	pc	1	152.4	45		turtle	2			
4/3	Ko Libong	Trang	microlite	ka, ns		clear	pc	1	152.4	45		turtle	1			
												total	dugongs 5			
													turtles 6			

*Behavior: f=feeding, t=travelling, s=resting, r=rolling

Trang Sightings Log April 4, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat
4/4	Ko Muk	Trang	microlite	eh,ns	2.5	clear	sunny	1	152.4	45	723	turtle	1	0		7.3885
4/4	Ko Muk	Trang	microlite	eh,ns	2.5	clear	sunny	1	152.4	45	729	turtle	1	0		7.3800
4/4	Ko Libong	Trang	microlite	eh,ns	2.7	clear	sunny	1	152.4	45	824	dugong	1	0	f	7.2750
4/4	Laem Ju Hui	Trang	microlite	eh,ns	2.7	clear	sunny	1	152.4	45	845	dugong	1	0	f	7.2595
4/4	Ao Tong Gin	Trang	microlite	eh,ns	2.8	clear	sunny	1	152.4	45	904	dugong	1	0	f	7.2253
4/4	Ao Tong Gin	Trang	microlite	eh,ns	2.8	clear	sunny	1	152.4	45	905	dugong	1	0	f	7.2370
4/4	Ao Tong Gin	Trang	microlite	eh,ns	2.8	clear	sunny	1	152.4	45	911	dugong	1	0	s	7.2225
4/4	Ao Tong Gin	Trang	microlite	eh,ns	2.8	clear	sunny	1	152.4	45	913	dugong	1	0	f	7.2272
4/4	Laem Yong Lam	Trang	microlite	eh,ns	2.8	clear	sunny	1	152.4	45	931	dugong	1	0	f	7.3587
												total	dugongs 7			
													turtles 2			

*Behavior: f=feeding, t=travelling, s=resting, r= rolling

Trang Sightings Log April 5, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat
4/5	Ko Muk	Trang	microlite	ka,ns	2.7	clear	sunny	1 to 2	152.4	45	829	dugong	1	0	t	7.3841
4/5	Ko Muk	Trang	microlite	ka,ns	2.8	clear	sunny	1 to 2	152.4	45	841	dugong	1	0	f	7.3661
4/5	Ko Muk	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	856	dugong	1	0	f	7.3537
4/5	Ko Muk	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	857	dugong	1	0	f	7.3553
4/5	Ban Chao Mai	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	912	dugong	1	0	f	7.3139
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	934	dugong	1	0	f	7.2697
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	943	dugong	1	0	f	7.2692
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	948	dugong	1	1	t	7.2575
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	948	dugong	1	1	t	7.2573
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	951	dugong	1	0	f	7.2469
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	952	dugong	1	0	f	7.2494
4/5	Ko Libong	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	954	dugong	1	1	f	7.2691
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	955	dugong	1	0	f	7.2735
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	957	dugong	1	0	f	7.2492
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1000	dugong	1	0	f	7.2494
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1000	dugong	1	0	f	7.2506
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1002	dugong	1	0	f	7.2691
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1007	dugong	1	0	f	7.2398
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1010	dugong	1	0	f	7.2364
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1011	dugong	1	0	f	7.2309
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1011	dugong	1	0	f	7.2303
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1012	dugong	1	0	f	7.2283
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1013	dugong	1	0	f	7.2358
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1013	dugong	1	0	f	7.2362
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1015	dugong	1	0	f	7.2278
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1017	dugong	1	1	f	7.2256
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1017	dugong	1	0	f	7.2301
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1019	dugong	1	0	f	7.2277
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1021	dugong	1	0	f	7.2155
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1021	dugong	2	0	f	7.1520
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1021	dugong	1	0	f	7.2150
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1022	dugong	1	0	t	7.2088
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1022	dugong	1	1	t	7.2083
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1023	dugong	1	0	t	7.2219
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1025	dugong	1	0	t	7.2188
4/5	Ko Libong	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1026	dugong	1	0	f	7.2123
4/5	Laem Ju Hui	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1037	dugong	1	0	f	7.2639
4/5	Laem Ju Hui	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1037	dugong	1	0	f	7.2667
4/5	Ban Chao Mai	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	1043	dugong	1	0	f	7.3059
												total dugongs 46 including 5 calves				
4/5	Ko Muk	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	12			
4/5	ne Ko Libong	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	4			
4/5	Laem Ju Hui	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	3			
4/5	Ao Tung Gin	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	8			
												total	turtles 27			

*Behavior: f=feeding, t=travelling, s=resting,r=rolling

Trang Sightings Log April 6, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	900	dugong	1	0	f	7.3979	99.3445
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	909	turtle	1	0		7.3818	99.3320
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	913	turtle	2	0		7.3744	99.3293
4/6	Ko Muk	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	916	dolphin	3	2		7.3707	99.3252
4/6	Ko Muk	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	921	dugong	1	0	f	7.3742	99.3317
4/6	Ko Muk	Trang	microlite	eh,ns	3.1	clear	sunny	1 to 2	152.4	45	926	dugong	1	0	f	7.3678	99.3165
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.1	clear	sunny	1 to 2	152.4	45	931	dugong	1	0	f	7.3637	99.3473
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.2	clear	sunny	1 to 2	152.4	45	940	dugong	1	0	f	7.3590	99.3428
4/6	Laem Yong Lam	Trang	microlite	eh,ns	3.2	clear	sunny	1 to 2	152.4	45	943	dugong	1	0	f	7.3512	99.3137
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1028	dugong	1	0	f	7.2530	99.4563
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1030	dugong	1	0	f	7.2694	99.4678
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1036	dugong	1	0	f	7.2522	99.4596
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1036	dugong	1	0	f	7.2519	99.4589
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1038	dugong	36-46	7	f	7.2533	99.4631
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1058	turtle	2	0		7.2341	99.4536
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1059	turtle	1	0		7.2298	99.4499
4/6	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1059	turtle	1	0		7.2348	99.4464
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1100	dugong	2	0	f	7.2405	99.4427
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1100	dugong	1	0	f	7.2429	99.4377
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1103	dugong	3	1	not noted	7.2336	99.4426
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1107	dugong	1	0	f	7.2255	99.4288
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1109	dugong	2	1	t	7.2323	99.4211
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1110	dugong	1	0	f	7.2319	99.4147
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1110	dugong	1	0	f	7.2316	99.4151
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1111	turtle	1	0		7.2224	99.4192
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1111	dugong	1	0	t	7.2206	99.4200
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1113	dugong	1	0	f	7.2179	99.4131
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1113	turtle	1	0		7.2179	99.4131
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1114	dugong	1	0	f	7.2174	99.4063
4/6	Ao Tong Gin	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1115	dugong	1	0	f	7.2121	99.4085

*Behavior: f=feeding, t=travelling, s=resting, r=rolling

totals		
	dugongs	70 to 80 inc 9 calves
	turtles	9
	dolphins	5

Trang Sightings Log April 7, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/7	Ko Muk	Trang	microlite	ka,ns	3.0	clear	sunny	1 to 2	152.4	45	943	dugong	1	0	f	7.3977	99.3474
4/7	Laem Yong Lam	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	953	dugong	1	0	f	7.3856	99.3319
4/7	Laem Yong Lam	Trang	microlite	ka,ns	3.1	clear	sunny	1 to 2	152.4	45	955	dugong	1	0	f	7.3808	99.3081
4/7	Ban Chao Mai	Trang	microlite	ka,ns	3.3	clear	sunny	1 to 2	152.4	45	1027	dugong	1	0	f	7.3045	99.4091
4/7	Ban Chao Mai	Trang	microlite	ka,ns	3.3	clear	sunny	1 to 2	152.4	45	1027	dugong	1	0	f	7.3061	99.4101
4/7	Ko Libong	Trang	microlite	ka,ns	3.3	clear	sunny	1 to 2	152.4	45	1034	dugong	1	0	t	7.2694	99.4297
4/7	Ko Libong	Trang	microlite	ka,ns	3.3	clear	sunny	1 to 2	152.4	45	1049	dugong	1	0	t	7.2640	99.4422
4/7	Ko Libong	Trang	microlite	ka,ns	3.4	clear	sunny	1 to 2	152.4	45	1051	dugong	1	0	f	7.2576	99.4435
4/7	Ko Libong	Trang	microlite	ka,ns	3.4	clear	sunny	1 to 2	152.4	45	1055	dugong	1	0	t	7.2632	99.4565
4/7	Laem Ju Hui	Trang	microlite	ka,ns	3.4	clear	sunny	1 to 2	152.4	45	1100	dugong	44-46	7	f	7.2530	99.4585
4/7	Ao Tong Gin	Trang	microlite	ka,ns	3.4	clear	sunny	1 to 2	152.4	45	1124	dugong	26	2	f	7.2445	99.4539
												total	dugongs 87-89 inc 9 calves				
4/7	Ko Muk	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	4	0			
4/7	North Ko Libong	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	5	0			
4/7	Laem Ju Hui	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	7	0			
4/7	Ao Tong Gin	Trang	microlite	ka,ns		clear	sunny	1 to 2	152.4	45		turtle	6	0			
												total	turtles	22			

*Behavior: f=feeding, t=travelling, s=resting, r= rolling

Trang Sightings Log April 8, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/8	Kao Bae Na	Trang	microlite	eh, ns	3.0	clear	sunny	1	152.4	45	959	dugong	1	0	f	7.4013	99.3375
4/8	Ko Muk	Trang	microlite	eh, ns	3.0	clear	sunny	1	152.4	45	959	turtle	2	0		7.4013	99.3375
4/8	Ko Muk	Trang	microlite	eh, ns	3.0	clear	sunny	1	152.4	45	1008	turtle	1	0		7.3880	99.3087
4/8	Ko Muk	Trang	microlite	eh, ns	3.0	clear	sunny	1	152.4	45	1014	turtle	2	0		7.3797	99.2151
4/8	Ko Muk	Trang	microlite	eh, ns	3.1	clear	sunny	1	152.4	45	1015	dugong	1	0	s	7.3787	99.3095
4/8	Laem Yong Lam	Trang	microlite	eh, ns	3.1	clear	sunny	1	152.4	45	1024	dugong	1	0	s	7.3673	99.3480
4/8	Laem Yong Lam	Trang	microlite	eh, ns	3.2	clear	sunny	1	152.4	45	1031	dugong	1	0	f	7.3603	99.3538
4/8	Laem Yong Lam	Trang	microlite	eh, ns	3.2	clear	sunny	1	152.4	45	1031	turtle	1	0		7.3603	99.3538
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1103	turtle	1	0		7.2688	99.4264
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1107	turtle	1	0		7.2678	99.4430
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1110	turtle	3	0		7.2646	99.4520
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1115	turtle	2	0		7.2624	99.4597
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1115	dugong	3	1	f	7.2576	99.4559
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1119	dugong	1	0	f	7.2669	99.4643
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1120	dugong	1	0	f	7.2663	99.4673
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1122	dugong	1	0	f	7.2498	99.4562
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1125	dugong	1	0	f	7.2712	99.4768
4/8	Ko Libong	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1125	turtle	2	0		7.2712	99.4768
4/8	Laem Ju Hui	Trang	microlite	eh, ns	3.4	clear	sunny	1	152.4	45	1126	dugong	2	1	f	7.2564	99.4594
4/8	Laem Ju Hui	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1129	dugong	27	5	f	7.2546	99.4626
4/8	Laem Ju Hui	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1129	turtle	1	0		7.2546	99.4626
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1142	dugong	3	1	f	7.2512	99.4660
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1149	dugong	1	0		7.2442	99.4488
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1152	turtle	1	0		7.2432	99.4399
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.5	clear	sunny	1	152.4	45	1153	dugong	1	0		7.2276	99.4482
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.6	clear	sunny	1	152.4	45	1156	dugong	1	0		7.2406	99.4288
4/8	Ao Tong Gin	Trang	microlite	eh, ns	3.6	clear	sunny	1	152.4	45	1157	dugong	1	0		7.2287	99.4279
												total	dugongs 55 inc 8 calves				
													turtles 17				

*Behavior: f=feeding, t=travelling, s=resting, r=rolling

Trang Sightings Log April 10, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/10	Ko Muk	Trang	microlite	ka,ns	3.0	clear	sunny/windy	2 to 3	152.4	45	1046	dugong	1	0	f	7.3901	99.3246
4/10	Ko Muk	Trang	microlite	ka,ns	3.1	clear	sunny/windy	2 to 3	152.4	45	1100	dugong	1	0	f	7.3630	99.3107
4/10	Laem Ju Hui	Trang	microlite	ka,ns	3.4	clear	sunny/windy	2 to 3	152.4	45	1152	dugong	1	0	f	7.2550	99.4607
4/10	Laem Ju Hui	Trang	microlite	ka,ns	3.5	clear	sunny/windy	2 to 3	152.4	45	1200	dugong	13	2	f	7.2511	99.4623
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.5	clear	sunny/windy	2 to 3	152.4	45	1214	dugong	1	0	f	7.2397	99.4523
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.5	clear	sunny/windy	2 to 3	152.4	45	1215	dugong	4	0	f	7.2363	99.4502
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.5	clear	sunny/windy	2 to 3	152.4	45	1218	dugong	3	0	f	7.2411	99.4374
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.5	clear	sunny/windy	2 to 3	152.4	45	1221	dugong	12	3	f	7.2437	99.4422
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.6	clear	sunny/windy	2 to 3	152.4	45	1235	dugong	1	0	p	7.2355	99.4145
4/10	Ao Tong Gin	Trang	microlite	ka,ns	3.6	clear	sunny/windy	2 to 3	152.4	45	1237	dugong	1	0	f	7.2301	99.4123
4/10	Ao Tong Gin	Trang	microlite	ka,ns		clear	sunny/windy	2 to 3	152.4	45		turtle	2	0			
												total	dugongs 43 inc 5 calves				
													turtles 2				

*Behavior: f=feeding, t=travelling, s=resting, r= rolling

Trang Sightings Log April 11, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/11	Ko Muk	Trang	microlite	eh,ns	2.7	clear	sunny	1 to 2	152.4	45	1057	dugong	1	0	f	7.3993	99.3293
4/11	Ko Muk	Trang	microlite	eh,ns	2.7	clear	sunny	1 to 2	152.4	45	1058	dugong	1	0	r	7.3998	99.3395
4/11	Ko Muk	Trang	microlite	eh,ns	2.7	clear	sunny	1 to 2	152.4	45	1101	turtle	2	0		7.3918	99.3230
4/11	Ko Muk	Trang	microlite	eh,ns	2.7	clear	sunny	1 to 2	152.4	45	1108	turtle	2	0		7.3781	99.3273
4/11	Ko Muk	Trang	microlite	eh,ns	2.8	clear	sunny	1 to 2	152.4	45	1115	dugong	1	0	f	7.3667	99.3165
4/11	Ko Muk	Trang	microlite	eh,ns	2.8	clear	sunny	1 to 2	152.4	45	1117	dugong	1	0	s	7.3624	99.3276
4/11	Ko Muk	Trang	microlite	eh,ns	2.9	clear	sunny	1 to 2	152.4	45	1120	turtle	1	0		7.3603	99.3439
4/11	Ko Muk	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	1121	dugong	1	0	f	7.3603	99.3276
4/11	Ko Muk	Trang	microlite	eh,ns	3.0	clear	sunny	1 to 2	152.4	45	1123	dugong	1	0	f	7.3566	99.3133
4/11	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1209	dugong	2	1	f	7.2678	99.4705
4/11	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1213	dugong	12	1	f&t	7.2524	99.4615
4/11	Laem Ju Hui	Trang	microlite	eh,ns	3.3	clear	sunny	1 to 2	152.4	45	1224	dugong	1	1		7.2519	99.4653
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.4	clear	sunny	1 to 2	152.4	45	1230	turtle	1	0		7.2460	99.4630
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.4	clear	sunny	1 to 2	152.4	45	1233	dugong	1	0	f	7.2433	99.4509
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.4	clear	sunny	1 to 2	152.4	45	1234	turtle	1	0		7.2363	99.4508
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.4	clear	sunny	1 to 2	152.4	45	1240	dugong	1	1	f	7.2435	99.4422
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.5	clear	sunny	1 to 2	152.4	45	1248	dugong	2	1	f	7.2279	99.4392
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.5	clear	sunny	1 to 2	152.4	45	1248	dugong	1	0	f	7.2292	99.4376
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.5	clear	sunny	1 to 2	152.4	45	1252	dugong	2	0		7.2263	99.4357
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.5	clear	sunny	1 to 2	152.4	45	1253	dugong	1	0		7.2246	99.4373
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.5	clear	sunny	1 to 2	152.4	45	1253	turtle	2	0		7.2246	99.4373
4/11	Ao Tong Gin	Trang	microlite	eh,ns	3.6	clear	sunny	1 to 2	152.4	45	1257	dugong	1	0	f	7.2302	99.4216

*Behavior: f=feeding, t=travelling, s=resting, r= rolling

total dugongs 35 inc 5 calves

turtles 9

Trang Sightings Log April 12, 2001

Date	Area	Province	Vehicle	Observers	Tide	Visibility	weather	Beaufort	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	Behavior*	DecLat	DecLong
4/12	Ko Muk	Trang	microlite	ka, ns	2.5	clear	sunny	1 to 2	152.4	45	1116	dugong	1	0	r	7.3980	99.3417
4/12	Ko Muk	Trang	microlite	ka, ns	2.6	clear	sunny	1 to 2	152.4	45	1123	dugong	1	0	t	7.3867	99.3354
4/12	Laem Yong Lam	Trang	microlite	ka, ns	2.7	clear	sunny	1 to 2	152.4	45	1125	dugong	1	0	f&t	7.3803	99.3368
4/12	Ko Muk	Trang	microlite	ka, ns	2.8	clear	sunny	1 to 2	152.4	45	1137	dugong	1	0	f&t	7.3642	99.3496
4/12	Ko Muk	Trang	microlite	ka, ns	2.9	clear	sunny	1 to 2	152.4	45	1141	dugong	1	0	t	7.3553	99.3115
4/12	Ban Chao Mai	Trang	microlite	ka, ns	3.0	clear	sunny	1 to 2	152.4	45	1153	dugong	1	1	t	7.3008	99.4125
4/12	Laem Ju Hui	Trang	microlite	ka, ns	3.3	clear	sunny	1 to 2	152.4	45	1241	dugong	1	0	t	7.2510	99.4585
4/12	Laem Ju Hui	Trang	microlite	ka, ns	3.3	clear	sunny	1 to 2	152.4	45	1248	dugong	1	0	f&t	7.2369	99.4499
4/12	Laem Ju Hui	Trang	microlite	ka, ns	3.4	clear	sunny	1 to 2	152.4	45	1255	dugong	3	2		7.2393	99.4277
4/12	Ao Tong Gin	Trang	microlite	ka, ns	3.4	clear	sunny	1 to 2	152.4	45	1315	dugong	1	0	t	7.2225	99.4025
4/12	Ao Tong Gin	Trang	microlite	ka, ns	3.4	clear	sunny	1 to 2	152.4	45	1317	dugong	1	0	t	7.2245	99.4068
4/12	Ko Muk	Trang	microlite	ka, ns		clear	sunny	1 to 2	152.4	45		turtle	3	0			
4/12	N. Ko Libong	Trang	microlite	ka, ns		clear	sunny	1 to 2	152.4	45		turtle	4	0			
4/12	Ao Tong Gin	Trang	microlite	ka, ns		clear	sunny	1 to 2	152.4	45		turtle	3	0			
												total	dugongs 16 inc 3 calves				
													turtles 10				

*Behavior: f=feeding, t=travelling, r= rolling

Krabi Sightings Log March 22-26 2000

Date	Area	Province	Vehicle	Observers	Beaufort	Visibility	weather	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	# of dugongs	DecLat	DecLong
3/22/2000 on effort		Krabi		eh, ns	1	clear	sunny	182.88	45	1015					7.9269	98.9651
3/22/2000		Krabi	micro	eh, ns	1	clear	sunny	182.88	45	1038	dugong	1	1	2	7.8539	98.9718
3/22/2000		Krabi	micro	eh, ns	1	clear	sunny	182.88	45		turtle	1	0	1	7.8569	98.9779
3/22/2000 off effort		Krabi		eh, ns	1	clear	sunny	182.88	45	1107				0		
										TOTAL ADULT DUGONGS		1	CALVES	0	1.0000	
3/23/00 on effort		Krabi		eh, ns	1	clear	sunny	182.88	45	1052				0	7.9233	98.9670
3/23/00 off effort		Krabi		eh, ns	1	clear	sunny	182.88	45	1150				0		
										TOTAL ADULT DUGONGS		0	CALVES	0	0.0000	
3/24/00 on effort		Krabi		eh, ns	3	low	stormy	182.88	45	1048				0	7.9345	98.9602
3/24/00 off effort		Krabi		eh, ns	3	low	stormy	182.88	45	1222				0		
										TOTAL ADULT DUGONGS		0	CALVES	0	0.0000	
3/25/00 on effort		Krabi		ka, ns	2	partial	cloudy	182.88	45	1133				0	7.9340	98.9625
3/25/2000		Krabi	micro	ka, ns	2	partial	cloudy	182.88	45	1153	dugong	1	0	1	7.8591	98.9617
3/25/2000		Krabi	micro	ka, ns	2	partial	cloudy	182.88	45	1202	dugong	1	0	1	7.8564	98.9798
3/25/2000		Krabi	micro	ka, ns	2	partial	cloudy	182.88	45	1218	dugong	1	0	1	7.8562	98.9784
3/25/2000		Krabi	micro	ka, ns	2	partial	cloudy	182.88	45	1221	dugong	1	1	2	7.8526	98.9865
3/35/00 off effort		Krabi		ka, ns	2	partial	cloudy	182.88	45	1232				0		
										TOTAL ADULT DUGONGS		4	CALVES	0	1.0000	
3/26/00 on effort		Krabi	micro	eh, ns						1100				0	7.9237	98.8670
3/26/2000		Krabi	micro	eh, ns	1	partial	cloudy	182.88	45	1129	dugong	1	1	2	7.8908	98.9290
3/26/2000		Krabi	micro	eh, ns	1	partial	cloudy	182.88	45	1205	dugong	1	0	1	7.8550	98.9803
3/26/2000		Krabi	micro	eh, ns	1	partial	cloudy	182.88	45	1209	dugong	2	0	2	7.8606	98.9610
3/26/00 off effort		Krabi		eh, ns						1252					7.8532	98.9808
										TOTAL ADULT DUGONGS		4	CALVES		1.0000	

Phuket and Yao Islands Sightings Log March23-26, 2001

Date	Area	Province	Vehicle	Observers	Beaufort	Visibility	weather	altitude(m)	speed(kn)	Time	Animal	# of adults	# of young	DecLat	DecLong
3/23/2001on effort		Phuket	micro	eh, ns	2 to 3	low	rainy	152.4	45	930					
3/23/2001off effort		Phuket	micro	eh, ns	2 to 3	low	rainy	152.4	45	946					
									TOTAL ADULT DUGONGS			no sightings	CALVES		
3/24/01on effort		Phuket	micro	eh, ns	2	clear	sunny	152.4	45	910					
3/24/01 off effort		Phuket	micro	eh, ns	2	clear	sunny	152.4	45	1006					
									TOTAL ADULT DUGONGS			no sightings	CALVES		
3/24/01 on effort		Phuket	micro	ka, ns	2	clear	sunny	152.4	45	1033					
3/24/2001	Ban Pak Lok	Phuket	micro	ka, ns	2	clear	sunny	152.4	45	1140	dugong	1	0	8.06469	98.45033
3/24/01 off effort		Phuket	micro	ka, ns	2	clear	sunny	152.4	45	1208					
									TOTAL ADULT DUGONGS			1	CALVES 0		
3/24/01on effort		Phuket	micro	eh, ns	2	clear	sunny	152.4	45	1424					
3/24/01 off effort		Phuket	micro	eh, ns	2	clear	sunny	152.4	45	1527					
									TOTAL ADULT DUGONGS			no sightings	CALVES		
3/24/01on effort		Phuket	micro	ka, ns	2	clear	sunny	152.4	45	1546					
3/24/01 off effort		Phuket	micro	ka, ns	2	clear	sunny	152.4	45	1618					
									TOTAL ADULT DUGONGS			no sightings	CALVES		
3/25/00 on effort		Phuket	micro	eh, ns	2	partial	cloudy	152.4	45	825					
3/25/2000	Ko Yao Yai	Phuket	micro	eh, ns	2	partial	cloudy	152.4	45	910	dugong	1	0	8.07417	98.59888
3/35/00 off effort		Phuket	micro	eh, ns	2	partial	cloudy	152.4	45	1025					
									TOTAL ADULT DUGONGS			1	CALVES		
3/26/00 on effort		Phuket	micro	ka, ns	2	partial	cloudy	152.4	45	1044					
3/26/2000	Ko Yao Yai	Phuket	micro	ka, ns	2	partial	cloudy	152.4	45	1131	dugong	1	0	8.07918	98.58776
3/26/01 off effort		Phuket	micro	ka, ns	2	partial	cloudy	152.4	45	1211					
									TOTAL ADULT DUGONGS			1	CALVES		