Title

Preliminary Report to the World Wildlife Fund on the Historical Ecology of the Sulu and Sulawesi Marine Ecoregion

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PRELIMINARY REPORT TO THE WORLD WILDLIFE FUND ON THE HISTORICAL ECOLOGY OF THE SULU AND SULAWESI MARINE ECOREGION

by

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ABSTRACT

A PRELIMARY REPORT TO THE WORLD WILDLIFE FUND ON THE HISTORICAL ECOLOGY OF THE SULU AND SULAWESI MARINE ECOREGION

by Morgan Richie

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A preliminary historical analysis of regions within and around the Sulu and Sulawesi Marine Ecoregion shows that trajectories of decline are, while unique in story, similar in trend to those exhibited in other marine ecosystems with the loss of certain desirable groups which can be significant at the system level. In Southeast Asia, and around the world, species such as sea turtles, sharks and pearl oysters were intensely harvested for centuries by indigenous people and colonists, often at levels which are underestimated today (Erlandson, unpublished data). The characteristic sequence of human disturbance provides a framework for remediation and restoration which would be invisible without the historical perspective (Jackson 2001). The natural world is changing so quickly that we run the risk of suffering from a "shifting baseline" (Pauly 1995) or lowered standards in conservation.

It is no mystery that things used to be different – there were larger creatures, more creatures, and more large creatures. The question is, how large? How many more? For the Sulu and Sulawesi Seas, there is an ancient history of trade in marine and jungle products which accelerated beginning in the 16th century by the arrival of Europeans looking to trade with China. In addition, the indigenous people, some of which were strictly sea-going, harvested at a considerable level for subsistence. The quantity of natural products that was taken from the jungle and the sea gained in magnitude as colonial powers became involved in the complex web of trade (Warren 1981). Based on the literature, the most exploited animals were pearls, pearl-shell, shark's fins, reef fish, trepang (sea-cucumber), coral, sea turtle, sea turtle eggs, and dugong.

Historical documentation of long term effects of fishing provides a perspective for management and restoration of coastal marine systems. Conservation plans have not traditionally included a historical ecology study in their methodology which is a primary reason that many marine management and conservation attempts have failed (Jackson 2001). Returning to a state in the past is not a reasonable goal and is not suggested here. Rather, this study intends to illuminate changes in ecosystem structure which have occurred over centuries in order to increase the chances of success in the region. Without this historical perspective, conservation organizations are acting in a partially blinded state, but one which can be readily addressed

Fig.1. The View of the Island of Ouby, from Freshwater Bay on Batchian, Forrest, Thomas, <u>A Voyage to New Guinea and the Moluccas 1774-1776</u> (Kuala Lumpur: Oxford University Press, 1969).

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Section 1

INTRODUCTION AND METHODOLOGY

In the heart of the coral triangle, the Sulu and Sulawesi Seas are the location of the world's greatest marine biodiversity. The seas contain approximately 450 species of coral, compared to 60 in the Caribbean, one of the world's greatest variety of reef fishes, and six of the world's eight species of sea turtle (www.wwf.org). These are just a few examples, as the region is a hotspot for marine biodiversity. It is for these reasons that the World Wildlife Fund and other non-government organizations have large conservation projects here, but they are working in the absence of historical baselines.

A shifted baseline (Pauly 1988) refers to our knowledge and how far it goes back. In science and conservation, if our data and memory only go back to 1970, then the baseline upon which conservation decisions are based is 1970. However, historical ecology reveals a completely different picture – one which is essential to understanding the magnitude and trajectory of anthropogenic change. For example, Figure 2 illustrates our knowledge of a species' trajectory with the baseline of 1970. It would seem that the stocks had recovered from a 1970's crash by the 1990's. Looking into deeper time in Figure 3, however, it becomes clear that the major decline in did not occur in the 1970's, but much earlier. It is for this reason that historical ecology is an essential component of conservation.

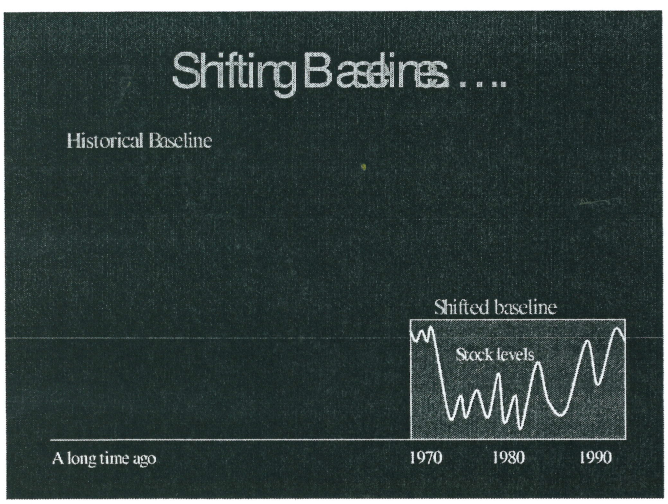

Fig. 2. Our knowledge with a baseline of 1970

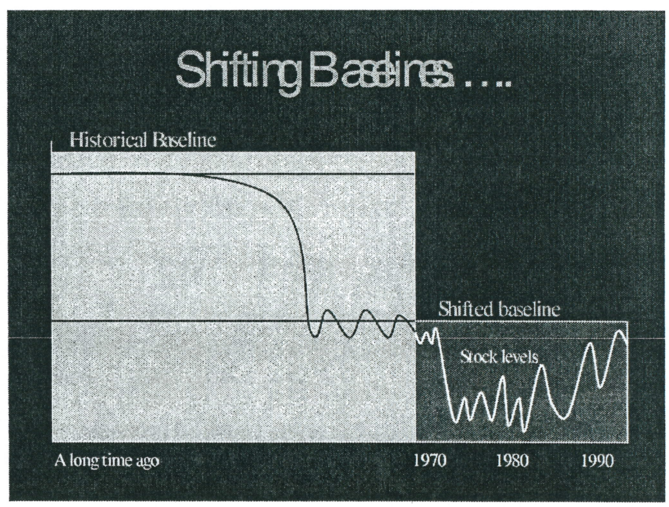

Fig. 3. Our knowledge with a historical baseline

For this project, historical data was mined with the intent to uncover the ecological stories associated with centuries of marine resource use and to provide this historical background to the World Wildlife Fund. The goals were to write a general economic overview of the region and then assemble a broad synopsis of ecosystem change due to fishing, using the arrival of Europeans as a benchmark. Adding this historical knowledge to the knowledge of the World Wildlife Fund's team of experts will help them establish conservations goals aimed at reversing the trajectory of decline (Pandolfi 2005). Currently, the goal of the Sulu-Sulawesi Marine Ecoregion Program is to "conserve the biodiversity of the Sulu and Suluwesi Seas" (Van Breda, personal correspondence). To date, no historical ecology has been done as part of their conservation program (Jackson, personal correspondence). The World Wildlife Fund is interested in the process of historical ecology so that they might incorporate it into their methodology (Van Breda, personal correspondence).

The main challenge with this project was starting with little knowledge of the region, without a current baseline for the resources. After acknowledging this limitation, the focus turned to the history with the anticipation of combining historical knowledge with the World Wildlife Fund's present-day knowledge. It quickly became evident that the scope of a project that included all historical changes in Malaysia, the Philippines, and Indonesia was far too broad to be accomplished in three months.

The scope was initially narrowed to historical fishing efforts, and then to Malaysia. Malaysia was chosen for two reasons: 1) the source materials were most readily available, and 2) Malaysia was a colony of England, so most of the travel journals and trade records are in English rather than Spanish or Dutch. The next step was to read and outline a general history of Malaysia, which took about two weeks. This was an important exercise as it provided an overall understanding of the cultural and economic history of the region. Again it was necessary to narrow the geographic scope to the state of Malaysia (Sabah) along the Sulu and Sulawesi Seas and the Sulu archipelago. Until the 20th century, Sulu resisted colonial rule and used the coast of Sabah as one of its primary collecting centers, so the two areas were naturally tied together (Warren 1981). In some cases when little information on Sabah or Sulu was available, examples of nearby areas were used to show possible analogs.

Every relevant description was recorded, with the criteria being a qualitative description or quantitative estimate. Natural history information was used to extrapolate information about populations based on quantitative historical estimates. Peaks and collapses in both the ecological and social context were sought. This is one of the most important parts of the research and that which requires the most time and synthesis. Future research would benefit from an analysis of the volumes of goods passing through trading centers and their "producing ranges" in order to get a feel for where the materials were coming from and in what volume.

Historical ecology is a process of collecting verbal "snapshots" in order to see the entire picture. Sometimes the "snapshots" are in poor resolution, in scarce supply, or not in the location expected. The data are, in many cases, anecdotal but are still very valuable when looking at gross magnitudes of populations and extraction. Future work will draw from archaeological journal articles, archived trade records, travel journals, diaries of colonists, menus, and the memories of native fishermen. Time spent in the area, talking with academics, graduate students, and fishermen, would be the most productive next step to bring these broad studies into sharper focus.

Section 2

HISTORICAL BACKGROUND

The countries surrounding the Sulu and Sulawesi Seas, Malaysia, the Philippines and Indonesia, have been participants in an active web of trade for many centuries, with archaeological evidence of trade with India as early as 200 BCE. Trade with China by sea began around the fifth century. In fact, trade is a theme that defines the area over centuries, with highly sophisticated cultures and governance built around commercial interaction with other regions. Entrepôt states (dominant trade centers) would rise and fall and be replaced by others in a pattern that is referred to as the "rhythm of Malaysian history." This social structure refers to Indonesia and the Philippines as well – the modern country divisions are largely a result of European involvement. Entrepôts were the collecting centers for jungle and marine produce which were highly desired in China. Local jungle and sea people would collect their produce and trade in the central entrepôt, and the local produce would be shipped to China and after the 15th century, Europe (Andaya 2001).

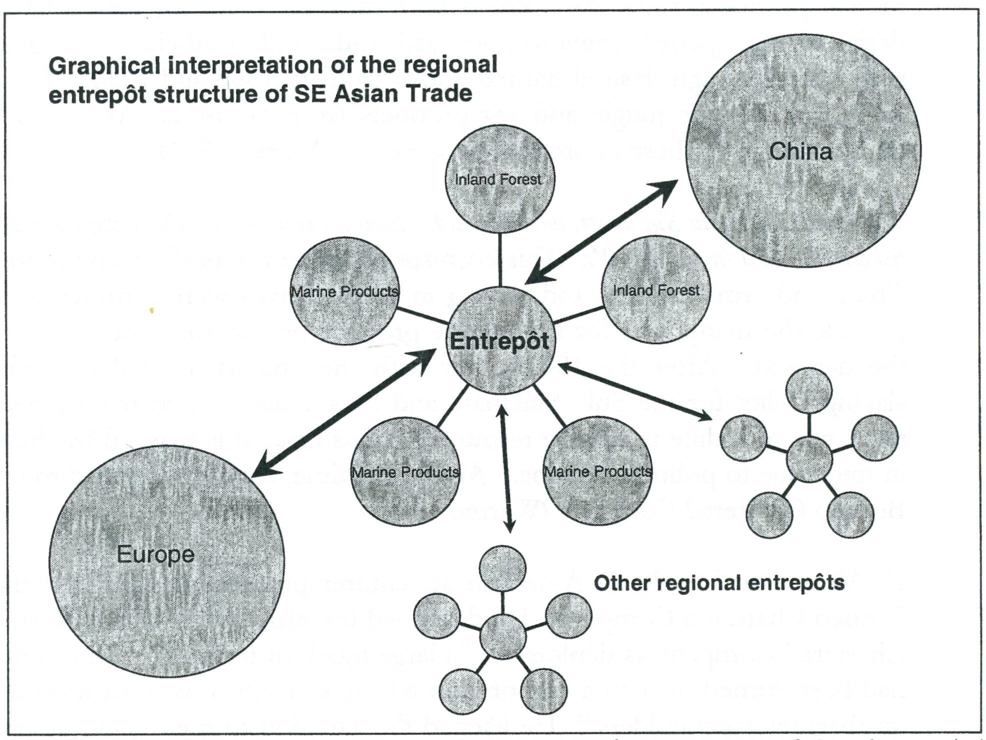

Fig. 4. Graphical interpretation of the entrepôt structure of Southeast Asian trade.

In the Malaysian Peninsula, starting in the 7th century, the dominant entrepôt was Srivijaya, followed by Melaka, Johor and Singapore. Sarawak and Sabah have a distinct history from Peninsular Malaysia which is important to consider when looking at the historical ecology of the region. Sabah, or North Borneo, has a coastline on the Sulu Sea. These two regions were far less exploited than peninsular Malaysia, especially by Europeans. Interestingly, in Sarawak, there was a period of white raja rule when James Brooke, an Englishman, established a white dynasty which persisted for three generations. Sarawak's relative isolation from English influence is largely attributed to the protection provided by the white dynasty. In Sabah, after the collapse of the Sulu Sultanate, the North Borneo Chartered Company from England was established, but they never achieved the level of trade and resource extraction that Peninsular Malaysia reached. They were predominantly interested in timber (Andaya 2001).

Jolo, in the Sulu Archipelago, was a regional entrepôt from 1768 – 1898. This region was ruled by the Sulu Sultanate, which remained independent from European control until the late 19th century, when they went to war with Spain and were eventually conquered. Prior to 1768, Sulu had been involved in an expansive network of maritime trading in Southeast Asia. Indirectly, it was the insatiable demand for tea which indirectly drove Europe's interest in Sulu's marine products, since these could be traded to China for tea. The incessant desire for tea opened China to trade with India and Southeast Asia. There were simply not enough desired natural goods from Europe and India. The Chinese wanted the exotic jungle and sea products from Southeast Asia, so European traders turned to these in order to procure tea (Warren 1981).

While ruled by Sulu Sultanate, which included local harvest in both the archipelago and Sabah, fisheries peaked in the 1840's. This corresponds with the peak in opium imports to China and arms imports and slaving in Sulu. Slaves were captured in order to provide the manpower for the marine produce procurement necessary to satisfy the demand. After the 1840's, war with the Spanish caused the decrease in slaving ability for the Sulu Sultanate and thus a decrease in marine harvest. If there was a decline in marine resources at this time, it is masked by the decrease in trade due to political reasons. About this time, Sabah was ceded to the North Borneo Chartered Company (Warren 1981).

E. Alexander Powell, an American adventurer provided insight into the North Borneo Chartered Company. He described the jurisdiction of the North Borneo Chartered Company as deplorable, "a large block of territory, with its inhabitants, had been turned over to a corporation whose sole aim was to earn dividends for its absentee stockholders." He likened the situation to the United States turning

Puerto Rico over to Standard Oil, with full authorization to make its own laws, import slaves and encourage opium addiction and gambling (Powell 1921).

Because the native people were uncooperative, large numbers of Chinese "coolies" were brought in as laborers. According to Powell, the lifestyle that was promised by the Company was, in practice, much different. The laborer would arrive, of their own volition, and immediately be given an advance in pay, which he was encouraged to spend in opium dens and gambling houses maintained on the plantation. Soon, he found himself so deeply indebted to the Company, that there was little option for leaving. Circumstantially, he had indentured himself and now had a drug addiction. No health or justice system was afforded them (Powell 1921).

Sulu traded internally with Bugis from Sulawesi and groups from the southern Philippines for local produce to provide to European and Chinese traders. Sulu also had an active external trade. Country traders (independent Europen traders) were very active in the Sulu Zone. Sulu also traded actively with Manila until relations with the Spanish began to deteriorate (Warren 1981).

Reliable figures for the number of junks which visited Sulu from China's maritime provinces for the first half of the 18th century are very scarce. It is thought that there were about 1-4 junks which came to Sulu, with a decrease in the number of small boats, but an overall increase in trade. Each junk would be laden with about 3,000-7,000 piculs (200-465 tons) of materials. By 1830, the conduct of this commerce was limited to two of the largest type junk which could hold 800 tons each (Warren 1981).

Exact figures for the volume of country traders (independent traders from England) are not available because they would not keep records and would even falsify records in order to keep secrets. It is possible to get a feel for the magnitude of the increase in trade between 1760 and 1840. From 1761 to 1835, the primary European good desired by the Taosug (of Sulu) were munitions. The amounts ordered increased from 4-six lb. cannons in 1760 to 1000 25-lb. kegs of gunpowder, 6 swivel guns, 100 pistols, 4 bags of shot, gun flints, 2 dozen boxes of percussion caps, and 8 dozen matchlets in 1840. These are only partial estimates, because large amounts of arms reached Sulu through the Bugis (Warren 1981).

By and large, Northeast Borneo was the core of the Sulu Sultanate's procurement trade (Warren 1981). Items that were traded in quantity were trepang (sea cucumber), pearls, mother-of-pearl, shark fin, cockles (giant clams), tortoiseshell, turtle eggs, reef fish (dried fish and gas bladders), seaweed, and corals. Dugong is rarely mentioned in the history books that I have read, although there are several references to the abundance of dugongs in travel journals. The indigenous Bajau eat dugong now, especially in celebrations and ceremonies (Jaaman 2003), so it is likely that this has been part of their culture for a long time. In the Sulu Sultanate, the most important fisheries were, without a doubt, pearls and trepang. These items were exclusively for export – the local people do not eat trepang. Most of the subsistence fishing was reef fish, turtle eggs, and most likely dugong, based on current dugong use among the Orang Laut. Largely, all other marine resources were for trade (Warren 1981).

Following is a table from Warren's book, The Sulu Zone. It is a comparison for the volume of exports cited by Sultan Bantilan to Dalrymple (an Englishman who was highly involved with the Sulu Sultanate) with those in the Datu (local, highly-ranked business leader) Emir Bahar's list. This provides an approximate measure of the intensity of the littoral procurement trade from1761 to 1836.

Produce	**Lbs. as cited by Bantilan in 1761**	**Lbs. as cited by Bahar in 1835**	**~# animals 1835**
Trepang	133 – 1,330,000 lbs (numbers are uncertain)	1,330,000 lbs.	~10,000,000
Pearlshell	266,000 lbs	120,000,000 lbs.	TBD
Tortoiseshell	13,300 lbs.	79,800 lbs.	TBD
Sharks fin	13,300 lbs.	79,800 lbs.	~325,000

Table 1. Marine Produce Annually Exported From Jolo in 1835. James Warren. The Sulu Zone 1768-1898 (Singapore: Singapore University Press, 1981).

As stated before, there is a drop in trade after it peaked in 1840 due to political problems with the Spanish in the Philippines. Sulu simply could not keep the manpower necessary to sustain their harvest levels if they were not allowed to bring in slaves (slaving was outlawed by the Spanish.) Trade between other ports remained the same, as did demand for the marine products, indicating that the fisheries had not collapsed in Sulu and North Borneo at the time of the collapse of the Sulu Sultanate (Warren, personal correspondence).

The scale at which resources were harvested at the height of the Sulu Sultanate's trading (1840) would have likely had an effect on the stocks but there were several natural factors that limited human extractive efforts: diving limits, traditional gear, and seasonality of the fishery due to monsoons. Diving limits and seasonality would provide "hiding places" for the stocks which are necessary for the persistence of prey, according to the Lotka-Volterra model (Gause 1934).

Diesel engines and better gear would lengthen the harvesting season and expand the territory which could be accessed easily.

In Sulu and Sabah, after the collapse of the Sulu Sultanate, Chinese fishermen, followed by Japanese fishermen, became the predominant fishing entities. This may have corresponded with an increase in harvest, due to their technologically advanced gear (Tregonning 1965). Based on the numbers of references encountered, there seems to have been a shift to fishing for reef fish, although this is inferred. K.G. Tregonning reports in reference to North Borneo (Sabah): "The economy of the territory was further diversified by marine products, particularly the export of dried fish from the east coast, where the lumbering Chinese junks made Sandakan their home port from 1880 onwards, while Japanese motor fishing fleets began competing from 1926 with a base at Tawau and a cannery on Si Amil Island. Exports in the 20th century rose steadily, and the Japanese, highly organized and benefiting for the extensive research of their government, encroached more and more on the preserve of the uncoordinated and non-powered junks of the Chinese. *By 1940 exports of dried fish were valued at $551,528.00 and it had become the fifth largest export in the State, only rubber, timber, cutch and hemp surpassing it*" (Tregonning 1965).

In 1949, the fishing industry of the colony of North Borneo was described as "in an extremely primitive condition, with practically no mechanization of either boats of equipment. The industry depends almost wholly upon the inshore and estuarine stocks of commercial species, and except for 2 minor excursions, does not extend more than four miles from the coast." In dramatic fashion, after WW2, the Allied nations organized and mechanized the Southeast Asian fisheries to combat the widespread starvation caused by the war (Kesteven 1949).

During the war, fishing boats were sunk or damaged, and gear was destroyed, which left the people with a reduced ability to feed themselves. The situation was aggravated by the removal of Japanese operations which were important because pre-war fishing fleets from Japan had operated in many areas of the Philippines, Borneo and Malaya. "They had operated widely and with energy, and had employed techniques and equipment that enabled them to both catch more fish in existing fishing grounds and to operate in waters generally neglected by local fishermen" (Kesteven 1949).

Japanese operations ceased entirely by the end of the war which meant the withdrawal of a quite substantial supply of food. Famine ensued through many Southeast Asia countries which required outside assistance. The Allied Nations founded the UNRRA (United Nations Relief and Rehabilitation Administration) which was charged with relief and economic restoration. After several conferences in 1946, recommendations were "that all possible steps are taken to alleviate the food crisis in these areas in SE Asia where shortages exist or are likely to arise; that maximum supplies of all kinds of foodstuffs, including rice, are produced and made available from the producing areas in SE Asia with maximum efficiency and speed for use both in SE Asia and elsewhere." Fisheries received heavy attention as a way for the Malayan people to feed themselves and measures were put into place to restore fisheries through the "building of boats, the procurement of tackle, the restoration of processing, transport, and marketing facilities, and the establishment of schools for training in more up to date methods of fishing" (Kesteven 1949).

At the Singapore Conference, it became apparent that the problems of rehabilitation were mixed with re-orientation and development of the industry. In other words, fishermen wanted the Western technologies that they had seen used by the Japanese. "The deficiencies caused by the war have set up demands for renewal, but also for a replacement by different equipment of greater efficiency." This demand was viewed as highly challenging and the commission called for greater international collaboration. In the Singapore meeting in 1947, it was recognized that diets in Southeast Asia were deficient in good quality protein and calcium, both of which could be supplied by fish, and that fishing materials were in short supply. They resolved to supply more cotton yarn and import No.2 Diesel engines (Kesteven 1949).

Delegates emphasized that they regarded the native fishing methods to be successful within the terms of the existing economy. Attention was directed to the western methods of fishing that might be introduced. Bottom-fish trawling was not recommended because it was generally unsuccessful due to the coral and the nature of the fish stocks. Long-lining had been successful in the area, as had purse-seining. Most of the traditional purse-seine fisheries were hand operated and the delegates felt that mechanization would have a "considerable effect." Surface fishing was recommended and considered to be the best prospect. Trolling and Japanese fishing methods (not described) were considered possible, but with limitations (Kesteven 1949).

Other measures were resolved which would help develop the fisheries including subsidies on salt, promotion of aquaculture in ponds, paddies, and rivers, utilization of fish waste as fertilizers, development of marine product markets, development of marketing and transportation facilities, training for fishermen, low interest loans to fishermen, discouragement of dynamite fishing, and international cooperation (Kesteven 1949).

In the Baguio Meeting in February 1948, the Indo-Pacific Fisheries Council was drafted. The Interim Working Committee on Biology urged that the principal immediate concern of the council should be to stimulate and assist member governments in their assessments of the aquatic resources of the area and the development and maintenance of *maximum* production from these resources (Kesteven 1949).

In the Buitenzorg Meeting of October, 1948, they considered the problems of the marine fishery resources of the Sulu and Celebes seas and adjacent waters and the various possible development programs. A symposium was held on "methods of investigation of deep-sea areas for fisheries work." The relevant resolutions of this meeting included urging all governments with data to make it freely available, recommendations for subsidies to the fishery, coordination of oceanographic programs which would contribute information to fisheries, and the development of pelagic fisheries (Kesteven 1949).

An interpretation of intensity of extractive activity through time is shown below, with peaks in 1840, pre-WW2, and finally a post-WW2 escalation in response to industrialization.

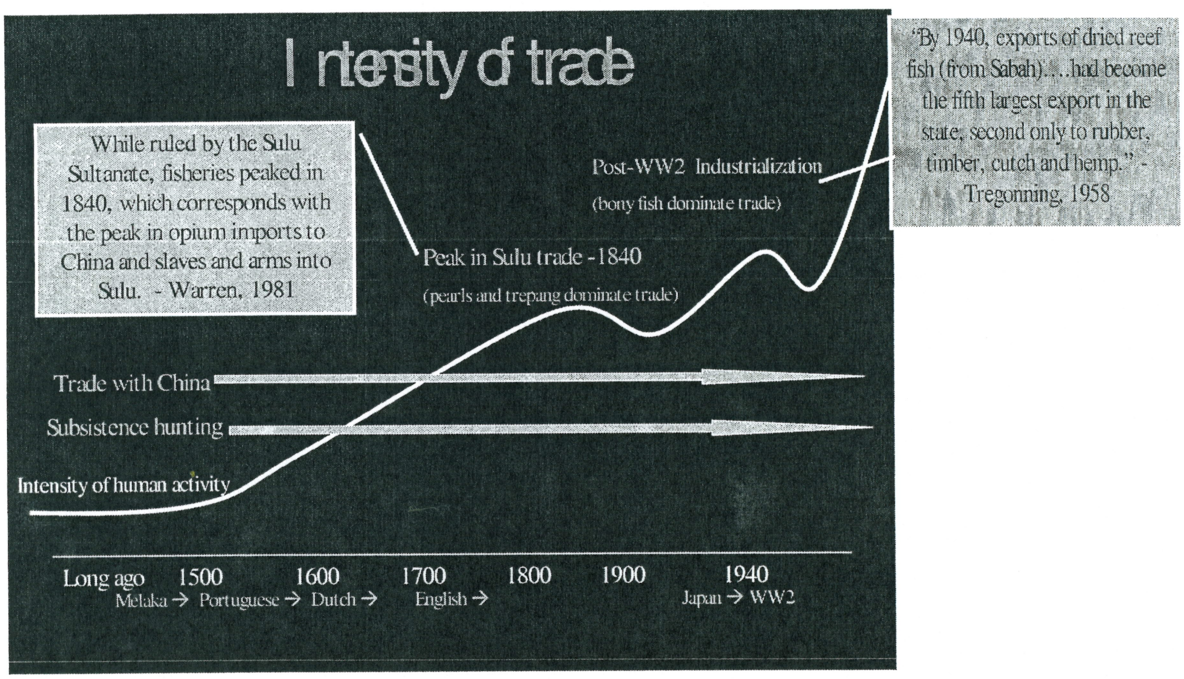

Fig. 5. Graphical interpretation of the intensity of trade through time.

The forces that have shaped the modern day Sulu and Sulawesi took place at many levels and scales. This paper focuses on human disturbance through fishing, but climate and plate tectonics are obviously deserving of attention. For example, Wallace's line runs between Bali and Lombok, between Sulawesi and Borneo and between Sulawesi and the Philippines.

Barber et al. studied genetic variation of mantis shrimp, *Haptosquilla pulchella*, on either side of Wallace's line and found distinct genetic differences that mirrors the separation of ocean basins during the Pleistocene low sea-level stands. Strong currents in these waters should facilitate long distance dispersal, and in some cases larvae is known to travel long distances. *H. pulchella* was chosen as a study subject for its 600 km dispersal potential and planktonic larval phase of 4-6 weeks. Despite the potential to disperse, populations as close as 300 kilometers were shown to have broad genetic breaks which suggested the presence of a marine equivalent of Wallace's line. Not all populations are genetically distinct across Wallace's line, however it cannot be assumed that all reefs are interconnected units (Barber 2000). Barber suggests that as marine reserves are designed, that biogeography and oceanographic history should be taken into account.

Section 3

PEARLS AND PEARL SHELL

Sulu's pearl fisheries were renowned in Asia and there are many accounts of the extensive pearl banks around the Sulu Archipelago. Dalrymple's account of the pearl fisheries in his "Account of Some Natural Curiosities at Sooloo (Sulu)" contain clear awe at the size and richness of the pearl banks, which spanned nearly the entire length of the archipelago and were nearly 25 miles wide. The pearl fishery was seasonal, except at Tawi-Tawi which had more protected pearling grounds. About 1 in a 1000 oysters would yield a pearl, but mother of pearl, used for making buttons, also comes from these shells. Several varieties were harvested: teepye bato, teepyecapis, syseep, belong, bincong, seedap, and manangancy (Dalrymple in Pires 1971).

"There are two proper seasons for the fishery, three months at the termination of the SW winds and four months at the expiration of the NE winds. These seasons alter according to the continuance of the monsoons, but in general, the first may be reckoned for the middle of September to the middle of December, and the second from February – May. But at Tavitavee (Tawi-Tawi), surrounded with an infinity of shoals and at similar places, they can fish at all times, except when the current is very strong. The pearl banks seem almost inexhaustible, not only as no dimunition is found in the quantity of fishing, but as they extend almost over the whole Sooloo dominions, particularly from Sangboy to Tawi-Tawi track with little interruption – about 150 miles long and in some places half that in breadth. However, these banks are in many parts too deep for diving, although the panglooloorook are excellent in their profession. The teepye are also found at Maratua, above 200 miles to the southward of Tawi-tawi, at Balabac, about 200 miles to the westward and in many of the intermediate places. Indeed, it is imagined that there are pearl banks in Palawan, but are unexploited for want of divers. No place in Sooloo equals the Peelas and the islands adjoining Sangboy; the water is not deep – generally 7-8 fathoms – and the shells so large that the white part of some is a foot in diameter. Tacoot Pabanoowas has plenty of fine teepye, but there they find many sharks. The Peelas is inconvenient because of its distance and lack of water" (Dalrymple in Pires 1971).

In 1843, Keppel described "All that extensive range, from Cape Unsing, passing by the Tawi-Tawi islands and Sulo (Sulu), as far as Baselan, is one vast continued bed of pearl-oysters, principally of the Behoren or mother-of-pearl shell species; these are called by the natives tipi. There is likewise an extensive bed of the Ceylon oyster, called by the Malays kapis; the principal banks of the latter are found in Maludu Bay. The Sulo pearls have, from time immemorial, been the most celebrated, and praised as the most valuable of any in the known world. Pigofetta, the companion of Magalhaens, mentions having seen in 1520 two Sulu pearls in the possession of the Raja of Borneo as large as pullet eggs. The quantity of mother of pearl shell, communibus annis, sold there is two thousand piculs (266,000 pounds), at six dollars a picul" (Keppel 1968).

He goes onto to describe the the Bay of Maludu, on the north end of Borneo "is thirty miles in length, and from four to six in breadth, with numberless rivers flowing into it. There is no danger on the right going up, but what is seen; on the larboard shore considerable reefs are met with. Laurie and Whittle's chart of it is tolerably correct.....The rich and valuable fishery of capis or Ceylon oyster in this bay has been mentioned; it might be rendered of considerable value. There is no quarter of the world which abounds more in that species of the sea turtle (called by the Malays pakayan) which yields the shell; any quantity may be had on all shores and islands of this bay" (Keppel, 1968).

Currently, pearls are mostly cultured, rather than harvested, tracking the overall trend towards aquaculture. The South Sea pearl is a commercial term used to describe pearls produced by two species of pearl oyster which belong to two genera of the family *Pteridae*: *Pteria* and *Pinctada*. *Pinctada maxima* is the white lip pearl oyster, which includes the gold-lip and silver-lip, and *Pinctada margaritifera* is the black-lip pearl oyster. These are the oysters which are cultured today. *P. margaritifera's* distribution is tied with the coral reefs around scattered tropical islands in the Indian Ocean, Western and Easter Pacific and Caribbean. *P. maxima* are restricted to the Indo-Malaysian region. It has its greatest concentration in Malaysia, Indonesia and the Philippines (Doumenge 1991).

Sea currents are intensified between the islands. They cut channels where the coarse coral sand (.5 – 3 mm) is scattered with blocks of dead coral. This is where the gold and silver lip *Pinctadas* are found. But divers now have to go deeper. Due to over-exploitation, oysters have become readapted to the fine foraminiferal sands (.05 - .20mm) down to 120 M. The oysters that live on gravel are thicker and rounder than those on muddy sand. Today, skin divers are equipped with SCUBA, which has resulted in the exhaustion of a greater number of oyster beds. In the 1930's the ports of Jolo and Zamboanga were exporting 250 tons of mother of pearl from *Pinctadas* annually. *Pinctada* is much sought after, mainly for pearl farms. Skin divers can bring oysters to the surface without much stress, but the depths at which the beds are now scattered make it very dangerous. The craze for natural pearls brought about the exploitation of millions – *more likely billions* - of oysters. This practice eventually brought about the destruction of most of the natural pearl oyster beds (Doumenge 1991).

The Bajau sea people were the predominant pearl divers. Starting in the 1880's a pearl fishing fleet was organized which included 30-60 American, Arab, Chinese and Japanese boats. At first, they were under sail, but later became mechanized. Each crew included 1-2 armored divers. The daily catch was seldom as much as a dozen Pinctada maxima from a depth of 25-30 meters (Doumenge 1991). This is in contrast to the 50 oysters per day described by Dalrymple in 7-8 meters (Dalrymple in Pires 1971). Other Bajaus worked by trawling, bringing up about 100,000 pearl oysters/year until 1940. This provided about 150-250 tons of shell and plenty of pearls. Then, fishing by heavily equipped divers came to an end when the pearl banks became exhausted (Doumenge 1991).

It has been estimated from trade statistics that around 68,000 fishermen must have been engaged in diving for mother-of-pearl and fishing for trepang in Sulu and Sabah during the 1830's. (Warren 1981). Dalrymple reported in the 1770's that pearl divers averaged about 50 pearl oysters per day (Dalrymple in Pires 1971). If half of the divers (34,000) were diving for pearls, and they averaged half that described by Dalrymple (25/day) then they would have brought up approximately 850,000 oysters per day, or over 300,000,000 per year, at the height of the trade. The standing population of oysters within diving limits must have been in the order of billions with this magnitude of harvest. One pearl oyster can filter 400 liters of water per day (Doumenge 1991), which means that the pearl oysters would have been filtering hundreds of billions of liters of sea water per day.

In Jackson 2001, the degradation of the Chesapeake Bay is attributed, in part, to reduced top-down control resulting from the loss of suspension feeders which predated eutrophication. Similar in trajectory to the Sulu and Sulawesi pearl oyster beds, the vast oyster reefs were once prominent in the Chesapeake, and they were intensely harvested by the aboriginal people, but suffered the greatest reduction with the advent of mechanical dredges. In the Chesapeake, the oysters may have filtered the equivalent of the entire water column every 3 days. The symptoms of eutrophication appeared after the collapse of the oyster fishery (Jackson 2001). While one system is an estuary and the other coral reef, the loss of a "hundreds of billions" liter per day filter should not be ignored, especially when we are considering conservation of increasingly fragile and overwhelmingly valuable coral reefs.

Another analogy to the Southeast Asian pearl fishery is found in the Central American pearl fishery, where historic overfishing resulted in the collapse of the pearl oyster *Pinctada mazatlantica.* The population was determined to be 1% of its historical population. The rapid decline of the fishery, low modern densities, and slow recovery suggests an Allee effect, which occurs when low density inhibits reproduction. The population structure and life history characteristics of *P.*

mazatlantica suggest that exploitation has the potential to reduce densities below a critical threshold. Nearly all of the populations have been exploited, so it is impossible to observe natural densities. Typical densities of *P. mazatlantica* are <.5 / m^2 and the maximum reported density is 2.4 individuals/ m^2. In the British mother-of-pearl fishery, it was estimated that between 1802 and 1837, 610 million oysters were exported from Panama (McClenachan, unpublished data).

Present day density analyses of *P. margaritifera* and *P. maxima* were not available for the Sulu and Sulawesi seas. A survey of *P. margaritifera* in the lagoon of Takapoto Atoll in French Indonesia indicated that the density of oysters increased with depth. Density ranged from a mean of 1 individual / 100 m^2 at 0-10 m to 8 individuals/100 m^2 at 30-40 m. More than half the stock occurred at depths greater than 30 m. The total stock was estimated to be 4.3 $\pm$ .67 million oysters (Zanini, 1999). Eight individuals per 100 m^2 is only 3% of the maximum reported density of the pearl oyster *P. Mazatlantica.*

The magnitude at which oysters were estimated to be harvested from the Sulu Archipelago at the height of trade (300,000,000 individuals/year) is quite astounding when compared to the estimates of oysters harvested from a Caribbean fishery (610,000,000/35 years.) This suggests high population density and productivity in the region. In addition, the densities of *P. margaritifera* in Takapoto Atoll indicate a severely depleted population. Future research should include an in-depth survey of the density of pearl oysters throughout the Sulu Archipelago, the calculation of the area from which oysters were harvested in comparison to other fisheries, analysis of pre-fishing abundance and density, estimates of area productivity, life history analyses, (McClenachan, unpublished data) and research into the community role of oysters (or the loss of them) in an open system.

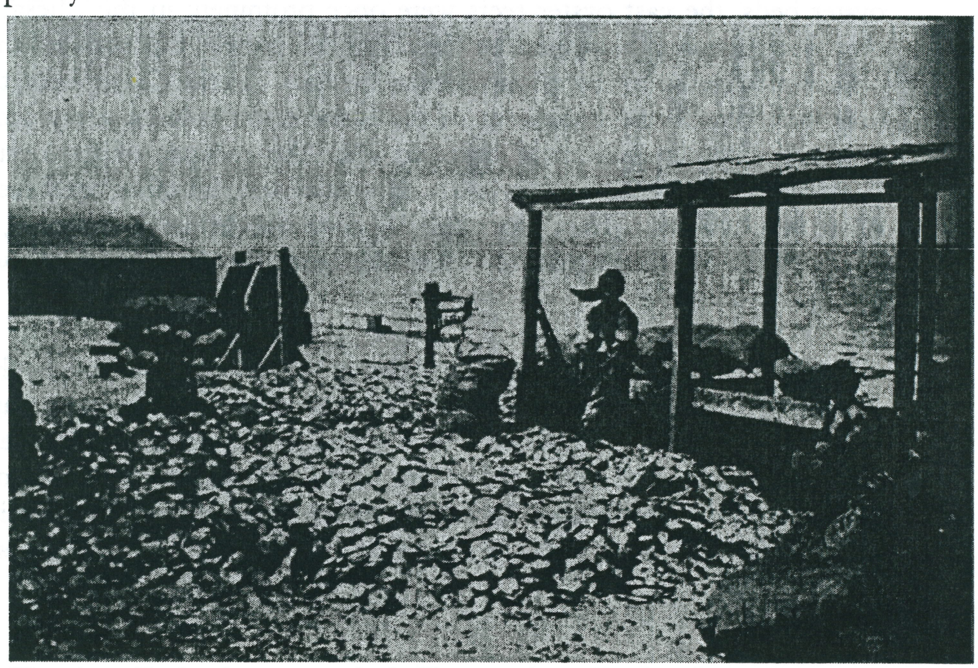

Fig. 6. Early days: pearl shelling station, Shark's Bay, Western Australia, 1890. Norman Bartlett, The Pearl Seekers (London: Andrew Melrose Ltd., 1954).

Section 4

SHARKS

The history of sharks, in some ways, is found through reading the history of pearls. Pearl diving, according to Dalrymple in 1770, was dangerous. "Many [pearl divers] are destroyed, particularly by the sharks and poggyes, or sea-devils (rays), which are common here in calm weather. It is difficult to describe these monsters, some of which equal a small boat in size and are often seen in most parts of the Sooloo seas" (Dalrymple in Pires 1971).

This account was published in 1770 and illustrates that the region had an abundance of large carnivores. They were harvested for their fins and there were still enough big ones to terrorize the pearl divers. This would be indicative of the inverted trophic pyramid with high biomass at the top of the food chain and a predator biomass more closely resembling Palmyra Atoll. Dampier experienced a scene in 1699 on the West Coast of Australia, which he called "Shark Bay" which was "swarming with sharks, skates, and turtle" (Dampier in Pires 1971).

Sharks were and are harvested for their fins to supply the Chinese demand which began around 2000 years ago (www.sharkinfo.ch). Chinese demand has expanded greatly in the past 10 years, and the high price paid for shark fins is putting pressure on the stocks (Fowler 2002). In recent times, the Sabah elasmobranch fisheries were steady at about .5 – 2000 tons until 1990 when it increased by 50% and then 180%. Commercial gears form the backbone of the industry. The shark fin trade has ranged from between 3 and 6 ½ metric tons from 1991- 1995 (Fowler 2002). Below are the calculated metric tons of shark fins traded from Jolo in 1835 in order to compare with the 1993 statistics from Sabah.

Produce	1835 mt - Jolo	1993 mt - Sabah
Sharks fin	~36 mt	~ 5 mt

Table 2. Comparison of shark fins exported from Jolo in 1835 and Sabah in 1993. (Fowler 2002 and Warren 1981).

In Jolo 1835, they exported 36mt but only 5 mt from Sabah in 1993. With advanced fishing technology, high population, and increasing demand, the answer must be that today there are just a small fraction of the sharks as in the past and the population of sharks was already diminished in 1835. This is quite alarming as the selective removal of species has been shown to have the potential to be significant in coral reef ecosystems. Bascompte et. al. showed that in Caribbean coral reefs, selectively removing predators which are overrepresented in strongly interacting food chain links creates the potential for community-wide effects (Bascompte 2005). A successful conservation plan should include fisheries regulations for sharks, as the fishery may already be in collapse.

Section 5

GIANT CLAM

Another bivalve that was collected was the giant clam. Dalrymple in 1770 refers to very large examples of the manangcy, or the cockle. "It is said that they have been found so large as to contain 50 gallons in 2 shells. There is something else that resembles the manangcy – pearl divers insist that it is one – is extraordinarily large – up to 4 feet long. These are much esteemed by the Chinese for their flesh and keep a long time when dried – longer than trepang. They make big pearls" (Dalrymple 1996).

Figure 7. "A giant clam can be seen – they reach the length of 4 ft. and a breadth of 2 ft." Norman Bartlett, The Pearl Seekers (London: Andrew Melrose Ltd., 1954).

Traveling at about the same time was Thomas Forrest who "reflected how well Dampier, Funnel, Roggewein, and many other circumnavigators might have fared when passing this way in distress for provisions, had they known where to find the groves of sago trees with which most islands here in low latitudes abound. Fresh bread made of sago flour and the kima (a large shellfish like a cockle) would have been no bad support among the Moluccas. The kima is found in abundance, of all sizes, at low water during spring tides, on the reefs of coral rocks. From experience, I equal the fresh baked sago bread to our wheat bread; and the kima stewed is as good as most fish; nor does one tire of it, but it must be stewed some time or it will not be tender. Its roe will sometimes weigh six pounds; the fish altogether, when cleared of the shell, weighing 20 or 30 pounds. Neither is the kima cockle the worse for being large. Sometimes the kima, in the shell, may endanger staving a small canoe when getting it in. The best way is to put a stick under the water into the gaping shell, which then closes and holds fast; then drag or lift it toward the shore and stab it with a cutlass; it dies immediately and can be taken out. Small kimas, about the size of a man's head are very good; they will keep long alive if wetted frequently with salt water" (Forrest 1969).

21. Douglas Pitt, one of the best native "skin" divers in the Torres Strait

Fig. 8. "Douglas Pitt, one of the best native skin divers in the Torres Strait." Norman Bartlett, The Pearl Seekers (London: Andrew Melrose Ltd., 1954). Note the giant clams at low tide.

Giant clams were once so abundant that their shells were used as construction material. Now, *Tridacnae gigas* is rarely seen and is extinct in Peninsular Malaysia. Of the other 5 species of Tridacnae, only one is considered a stable population. They are listed as a protected species, but are spread very far apart and there may be poaching (Shau-Hwai 2003).

Future research should involve documentation of giant clams in the intertidal as seen in the image above and the magnitude at which they were harvested.

Section 6

SEA CUCUMBER

In 1792, when Bligh and Flinders were charting the Torres Straits, the scene that Barlett painted for their first impressions included "everywhere, on the clear sandy bottom, lay round, elongated, obscene-looking sea slugs, or beche-de-mer, trepang to the sea-going Malays who fished the Arafura Sea long before the white men sailed there" (Macknight 1976).

To meet the demand of the Chinese for the aphrodisiac soup created from trepang, the Malay praus searched farther east from the Indies into the Arafura Sea. Later, the brigs and barques of colonial Sydney moved into the dangerous Barrier Reef to access the unexploited coast. In 1802, there were 60 praus and 1000 men scattered along the northern coast of Australia, under Salu (the Raja of Boni in the Celebes) fishing for trepang. Nakhodo Pobassoo, commodore of the Malay fishing fleet, told Flinders (captain of the Investigator) that fleets such as this had made annual expeditions as long as he could remember (Bartlett 1954).

The use of trepang is almost exclusively limited to the Chinese. The use of trepang is not very old, however, and followed the shark fin fishery. The first recorded use is medicinal and came from the sixteenth century. In the seventeenth century, trepang becomes very common in Chinese literature and the use had spread to northern China. Makassar was especially known for trepanging and made annual trips to the north coast of Australia. By 1903 the trepang fishery was considered over-fished in many areas and there were suggestions for closing the fishery to allow time to recuperate (Macknight 1976). Whether or not the trepang fishery suffered the similar fate in the Sulu Zone or Sabah is yet to be determined.

From Sulu, it was not unusual for vessels to freight as many as fifteen different types of sea cucumber in varying amounts up to fifty tons. The Spanish pontin, Nuestra Senora del Rosario and the brigantine San Jose alone imported a total of 100 tons of tripang to Manila in 1821 (Warren 1981).

More than 60 spp of tripang (principally holothuria) are found in the Sulu and Celebes Seas. At the beginning of the 19th century, tripang fisheries were found throughout the Sulu archipelago, especially near the islands of Pangutaran, Panducan, Siassi, Tawi-Tawi, and Sitangkai. The Samal built wells in Maratua island (Tirun district) to encourage the Samal Bajau Laut to "go thither and collect sea slug which is in great plenty on the banks near it" (Warren 1981).

The Bajau Laut would spear tripang in shallow water or dive for them. There were different ways of processing tripang: washing, eviscerating by squeezing the animal if this has not already been done by spearing, boiling, rubbing off the hard shell-like outer skin with some abrasive substance like coral flowers, and drying either in the sun or over a smoke fire (Warren 1981).

There are few papers regarding the role of the sea cucumber in coral reef systems and whether they would play any significant role if over-fished. Dr. Sven Uthicke wrote that commercially fished holothurians have important functions in nutrient recycling, which increases the benthic productivity of coral reef ecosystems. Thus, removal of these animals through fishing may reduce the overall productivity of affected coral reefs. Recovery of holothurian stocks may take several decades due to slow growth rate and low recruitment (Uthicke 2004).

11. Macassans at Victoria, Port Essington, 1845, by H. S. Melville. 'Our illustration is made from a sketch drawn on the spot; the only departure from the original being the introduction of two of the aborigines, with whom the captain of the prahus is parleying.'

Fig. 9. Macassans at Victoria, Port Essington, 1845, by H.S. Melville. Rpt. In C.C. Macknight, <u>The Voyage to Marege, Macassan Trepangers in Northern Australia</u> (Victoria: Melbourne Univ. Press, 1976).

Section 7

TURTLES

Sea turtles and eggs were harvested by almost all people living or trading in Southeast Asia. The native people harvested them for meat. Europeans harvested for meat and shell. Eggs were harvested and consumed or shipped. Tortoiseshell (from the sea turtles) was collected and traded to the Chinese. The species that were recorded with the greatest amount of trade with the Chinese were: *Caretta caretta* (loggerhead), *Chelonia mydas* (green), *Eretmochelys imbricata* (hawksbill) and *Dermochelys coriacea* (leatherback.) The turtles with the highest commercial value were the hawksbill and green. The green is considered the tastiest, while the hawksbill is valued for its beautiful carapace. The other marine turtles were considered of less commercial value. Mindanao, Brunei, and Borneo and Sulu were probably important sources, based on Chinese records. Information on the occurrences of sea turtles and tortoise shell in eastern Indonesia is mainly to be obtained from the late 16th century onward. Manado, on the north coast of Celebes, was an important trading center for this commodity and the Bay of Tomini (near the city of Gorontalo in Celebes) and its adjacent areas were rich in sea turtle as well. In the 1600's the Dutch and English became involved in the tortoise shell trade and demand in India increased. Chinese demand may have dropped off a bit at this point (Ptak 1999).

"When the blessed Odorico de Pordenone came traveling to the East (14th century), resigned to the will of God and prepared to baptize some 20,000 heathen within sixteen years, he is said to have seen among other things, 'a tortoise bigger in compass than the dome of St. Antony's in Padua. Stories of giant turtles, it will be remembered, were widely spread in Asia and Europe. In Chinese lore an enormous tortoise supported the isles of the immortals on its massive back and, according to Pliny and others, there existed tortoiseshells large enough to cover a house or be used as a boat" (Ptak 1999). While there may be some exaggeration, the point is that there were giant sea turtles which inspired such descriptions in the early 14th century.

In 1921, an adventurer named Alexander Powell reported, "Two hours steam off the towering promontory which guards the entrance to Sandakan harbor lies Baguian, a sandy islet covered with cocoanut palms, which is so small that it is not shown on ordinary maps. Though the island is, for some unexplained reason, under the jurisdiction of the British North Borneo Company, it is part of the Sulu Archipelago and belongs to the United States. Baguian is famed throughout those seas as a rookery for the giant tortoise – Testudo elephantopus. (He is mistaken. Testudo elephantopus is the Galapagos Tortoise.) Toward nightfall the mammoth chelonians – some of them weigh upward to half a ton – come ashore in great numbers to lay their eggs in nests made at the edge of the jungle which fringes the beach, the old Chinaman and his two assistants, who are the only inhabitants of the island, frequently collecting as many as four thousand eggs in a single morning. The eggs, which in size and color exactly resemble ping-pong balls and are almost as unbreakable, are collected once a fortnight by a junk which takes them to China, where they are considered great delicacies and command high prices. As we brought with us a supply of magnesium flares for night photography, we decided to take the camera ashore and attempt to obtain pictures of the turtles on their nests.

"As we were going ashore in the gig we caught sight of a huge bull, as large as a hoghead, which was floating on the surface. Ordering the sailors to row quietly, we succeeded in getting within a hundred yards before I let go with my .405, the soft-nosed bullet tearing a great hole in the turtle's neck and dyeing the water scarlet. Almost before the sound of the shot had died away one of the Filipino boat's crew went overboard with a rope, which he attempted to attach to the monster before it could sink to the bottom, but the turtle, though desperately wounded, was still very much alive, giving the sailor a blow on his head with its flapper which all but knocked him senseless. By the time we had hauled the man into the boat the turtle had disappeared into the depths.

"Waiting until darkness had fallen, we sent parties of sailors, armed with electric torches, along the beach in both directions with orders to follow the tracks made by turtles in crossing the sand, and to notify us by firing a revolver when they located one. We did not have long to wait before we heard the signal agreed upon, and, picking up the heavy camera, we plunged across the sands to where the sailors were awaiting us in the edge of the bush. While the blue-jackets cut off the retreat of the hissing, snapping monster, Hawkinson set up his camera and, when all was ready, someone touched off a flare, illuminating the beach and jungle as though the search-light of a warship had been turned upon them. In this manner we obtained a series of motion-pictures which are, I believe, from the zoological standpoint, unique. Before leaving the island we killed two tortoises for food for the crew – enough to keep them in turtle soup for a month. The larger, which I shot with a revolver, weighed slightly over 500 pounds and lived for several days with three .45 caliber bullets in its brain-pan. Everything considered, it was a very interesting expedition. The only person who did not enjoy it was the old Chinese who held the concession for collecting turtle eggs. Instead of recognizing the great value of the service we were rendering to science, he acted as though we were robbing his hen-roost. He had a sordid mind" (Powell, 1921).

The island of Baguan to which he is referring is in the Turtle Islands, Tawi-Tawi, and is located at the southwestern tip of the Philippines. The group of islands, namely, Boan, Lihiman, Langaan, Great Bakkungan, Taganak, and Baguan, is situated south of Palawan, northwest of the Tawi-Tawi mainland and northeast of Sabah, Malaysia. Baguan is a 29.1-hectare, bell-shaped island with a coastline of 1.7 km (www.oneocean.org). This is a coastline about the same length as the beach by Scripps.

Turtles nest 3-4 times per season. The season and frequency of nesting among females depends on individual populations and the species. At the Baguan Island Marine Turtle Sanctuary, Turtle Islands, Tawi-Tawi, the renesting interval has been determined to be 11.08 days and remigration interval (period between two nesting seasons) is 3 years (www.oneocean.org).

Turtles average about 100 eggs per laying. In the 1950's, there were relatively few turtles nesting on the islands of Great Bakkungan and Lihiman. At Taganak, however, fisheries found that nesting occurred year round, with as many as 60 or more nestings per night, especially in the months of July and August. It was calculated by Jose Domantay of the Bureau of Fisheries in 1951, that about 3,000 turtles nested every month on the islands. Now they report that it is rare in recent years to observe more than 30 turtles nesting in a single night on any of the islands, except at Baguan Island Marine Turtle Sanctuary (BIMTS), where about 100 clutches of eggs can be laid in a single night during the peak of the nesting season - from July to September. Since 1951, egg production on Taganak has declined by approximately 80% (www.oneocean.org).

If, in 1921, the Chinese turtle egg collector was gathering about 4000 eggs per day on just the island of Baguan, this means that approximately 400 turtles were visiting each day just to supply the demand for turtle eggs. The peak of the season is July – September and on the island of Taganak, the turtles nest year round (www.oneocean.org).

If our collector collected just July-September, then he would have collected ~ 360,000 eggs in those months. Using the information about the number of times turtles returned to lay eggs per season (3-4) and the eleven day period between nestings, it is estimated that the number of turtles that supplied our collector on Baguan Island alone was about 10,000 in the months of July-September. This is data from the number of eggs collected, so it does not include nestings from which there was no collection or males. This is about 3000 turtles per month as described by Jose Domantay of the Bureau of Fisheries in 1951 but only for the island of Baguan not all of the Turtle Islands.

In 1843, Keppel logged another account of turtle egg collection in his journal. "August 7th – morning calm. In the afternoon got underweigh, and anchored again near the island of Talang-talang; the smaller one a conical hill bearing south.

The Bandar (bendahara) of the place came off in his canoe to make us welcome. He is a young man sent by Rajah Muda Hassim to collect turtles' eggs, which abound in this vicinity, especially on the larger island. The turtles are never molested, for fear of their deserting the spot; and their eggs, *to the amount of five or six thousand*, are collected every morning, and forwarded at intervals to Sarawak as articles of food' (Keppel, 1968).

Sea turtles probably evolved under conditions of high environmental uncertainty and heavy predation on the nesting beaches. High fecundity rates may have offset the high egg and hatchling mortality, with relatively low mortality in the larger stages allowing delayed maturity and iteroparity. It is very difficult to estimate survivorship in long-lived, mobile organisms. In a 20 year study on Little Cumberland Island, Georgia, the best estimates of Loggerhead turtle survivorship have been generated (Crouse 1987).

Crouse (1987) reports turtle survivorship of the first year as 67%, which seems high to me. The estimates are not certain by any means – with some estimates ranging from 3% - 90%. Nevertheless, if we assume a very low survivorship of 5%, then there would have been 18,000 turtles which would have survived had it not been for collection from the island of Baguan in the breeding period of July – September, 1921.

Among the major forage items of adult green turtles are the seagrasses *Zoostera*, *Thallasia*, *Cymodocea*, *Syringodium*, *Diplantera*, *Halodule* and *Halophila*, and the algae *Gelidium*, *Gracillaria*, *Gracilliaropsis*, *Hypnea*, *Caulerpa*, *Vidalia*, *Bryothamnion*, *Cryptonemia*, *Agardiella*, etc. (www.fao.org). In the Florida Keys, the loss of sea grass beds is attributed in large part to the functional loss of sea grass grazers, such as sea turtles. The abundant green turtles crop turtlegrass and greatly reduce the flux of organic matter and nutrients to sediment. In the absence of grazers, the seagrass ecology is altered in ways which make the seagrass beds susceptible to disease, such as turtlegrass wasting disease. The deposition of organic material in the seagrass detritus increases microbial activity which promotes hypoxia (Jackson 2001). In addition, according to the Intermediate Disturbance Hypothesis (Connell, 1978), grazing would promote diversity within the system, allowing less dominant species an opportunity to reproduce and an ongoing pattern of patchy succession within the plant communities.

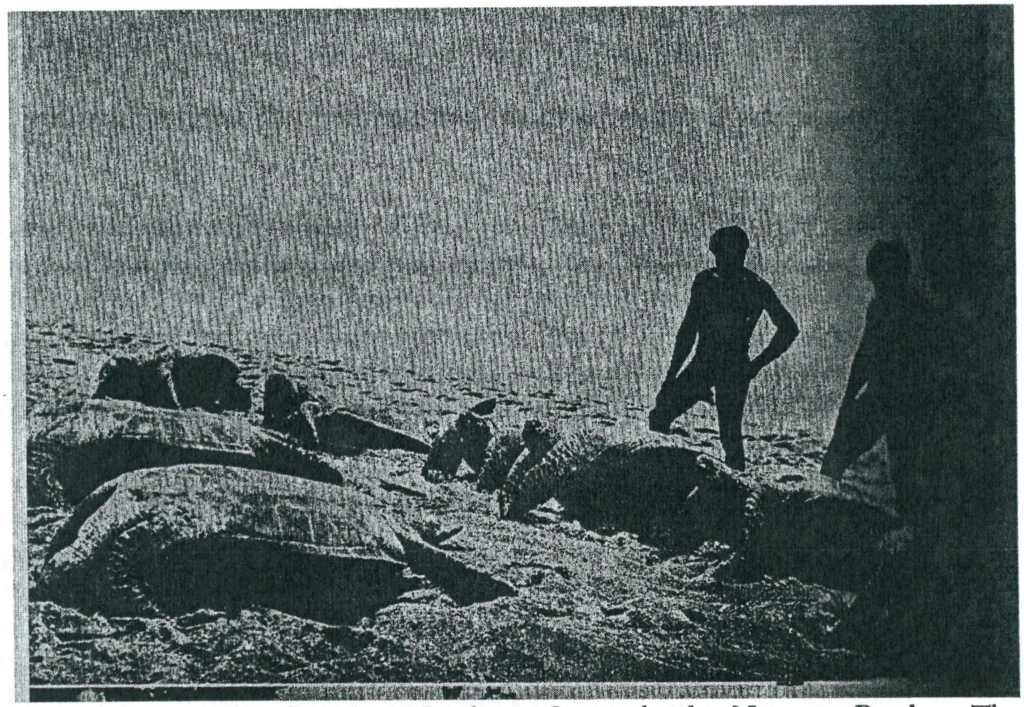

Fig. 10. A catch of turtles, Northern Queensland. Norman Bartlett, The Pearl Seekers (London: Andrew Melrose Ltd., 1954).

Section 8

CORALS

Corals were used for jewelry and other ornamentation and in powders for medicinal purposes in China. Records are sketchy and we do not know when the Chinese began to introduce the various usages of coral, but it was perhaps as early as 1178. A 1345 Chinese reference specifically describes coral from the Philippines and its fishing. The Chinese word for coral, shanhu, probably refers to the black coral Antipatharia. The prevalent species of *Antipatharia* in Malaysia is *A. ternatensis* and *A. cirripathes* (Ptak 1999).

When Dalrymple was traveling in Sulu, he described stalks of black coral over 12 feet long. He reported that the Sulus mention others of very great magnitude. "A tree at Basilan, one at Pooloo Gaya on the northwest side of Borneo and another at Tambaloolan near the north end, if consonant to the description, must be singular curiosities; they pretend the last is 20 or 30 feet high, with many branches. I have the handle of a kris made of black coral, which is a full 1 ½ inch broad' (Dalrymple 1996).

The Dutch built buildings and forts from coral rock. In Batavia, or modern day Jakarta, Rumphius encountered dazzling white walls of a fort, known as the Castle of Batavia (Fig. 10.) The Dutch used coral because it was cheap and it would absorb 17th century bullets. In addition, the streets of Batavia were paved with coral (Beekman 1999). While no references were encountered describing construction using coral rock in Sulu and Sulawesi, this process was universal and would warrant additional research. Portobello, Panama, the most important city of the new world, was built almost entirely of coral rock (Jackson personal correspondence). It is important to imagine and if possible quantify the amount of coral stone that would need to be harvested in order to build a city or a fort.


Fig. 11. Castle of Batavia. Painted by A.M. Beekman. (http://www.wga.hu/support/viewer/z.html)

Section 8

DUGONGS

The peak of Sirenian diversity occurred in the Miocene (5 to 25 million years ago.) No one knows for certain why sirenians declined to four species but it is hypothesized that climate change, habitat alteration and the arrival of human hunters may have been responsible. There has not been a documented case of primitive hunting causing a complete extinction; however certain local populations were driven extinct through hunting. The Steller's sea cow went extinct just 27 years after they were discovered by Russian hunters (Reynolds 1991). The population was already diminished by indigenous hunting when encountered by the Russians (Jackson personal correspondence).

Dampier's encounters with dugongs took place in Mindanao and Cebu. In Mindanao he reported "There are a great many harbors, creeks, and good bays for ships to ride in; and rivers navigable for canoes, pores, or barks, which are all plentifully stored with fish of divers sorts, so is the adjacent sea. The chiefest fish are bonetas, snooks, cavally's, bremes, mullets, 10 pounders, etc. Here are also plenty of sea turtle, and small manatee, which are not near so big as those in the West Indies. The biggest I saw would not weigh above 600 lbs, but the flesh of both the turtle and the manatee are very sweet." In Cebu: "In the middle of the bay, about a mile from shore, there is a small low woody island, not above a mile in circumference; our ship rode about a mile from it. The island had large numbers of bats (big ones.) At this isle also we found plenty of turtle and manatee, but no fish" (Dampier in Pires 1971).

Most of the information that is available about dugong hunting is about Australian waters and the Torres Strait. The Torres Strait Islanders of NE Australia are skilled dugong hunters and have inhabited the area for 2500 years – although no date has been found in which dugong hunting is believed to have started. In 1935, it was reported that the "two most important food animals of the Torres Strait Islanders were the dugong and turtle" (Haddon qtd. in McNiven 2003.) Senior Kiwai people "believed that the bounty of the sea was inexhaustible and the dugong could never disappear" (Parer qtd in McNiven, 2003). Other areas south of the Torres Strait did not have the abundance of dugongs and this was correlated with religious rituals meant to enhance the number of dugongs (McNiven, 2003).

On Tudu Island in 1840, the French explorer Dumont d'Urville described this scene (Fig. 12.) "At the north point of the island is a great quantity of the bones of dugong destined to decorate graves. Walls 1M to 1 ½ M in height and nearly 2M thick are built of the ribs of these animals. The skulls were sometimes raised into a pyramid, sometimes they were hung onto neighboring trees, with large shells" (paraphrased in Haddon qtd. in McNiven, 2003). In 1845, a similar site was observed on Dalrymple Island which consisted of great piles of rotting dugong and turtle skulls. He estimated that there were hundreds of each type of animal, which were probably the numbers of animals caught in one season. Gill, in *Life in the Southern Isles,* in 1876 mentions "a huge pile of bones of the dugong….and rows of pig's jaw bones" at Matawa village on the adjacent Papuan coast. Middens throughout the Torres Strait are filled with dugong bones (McNiven 2003). Today, the dugong fishery in the Torres Straits is viewed as most likely unsustainable at 1,226 animals per year (Marsh 1997).

In Sabah, however, it seems that dugongs are so rare that they are functionally extinct. Dugongs are hunted and have been hunted in a traditional artisanal fishery of the Orang Laut in Sabah. Dugong meat is said to be tastier than beef and is a traditional ceremonial meal. In Kudat, Sandakan and Semporna, there are reports of the meat being sold secretly, despite its endangered and protected status. Surveys for dugongs in Sabah and Sarawak resulted in few sightings. Between 1996-2001, they conducted boat and aerial surveys, interviews, and site investigations. There were only 18 animals sighted during the surveys. During the survey period, they investigated 9 strandings and 4 incidental catches (Jaaman 2000).

Many older fishermen and villagers interviewed in Sabah, Labuan, and Lawas, Sarawak reported that they had seen live dugongs. They indicated that dugong populations had declined significantly in the past few decades. Several of the indigenous medicine men, when interviewed, recalled historical dugong hunting grounds in Rancha-Rancha, Pemukat in Labuan Island, Lung Bay and Malawali Island in Kudat, Kaniogan, Cape Semangat, and Nunuyan Islands in Sandakan, Tambisan, Timbun mata, Gaya Islands, and Tungu in Tawau Division. A medicine man from Seporna claimed that before the 1980's he would return with approximately 10-50 dugongs per year, out of 10 trips. In Sandakan, older respondents claimed that an average of one dugong per month was caught before 1955. Dynamite fishing was cited as a factor in dugong mortality. In Kudat division, 2 groups of respondents admitted that they used dynamite instead of harpoons for hunting dugongs (Jaaman et. al 2000).

Jackson et al. (2001) estimated the historical baseline of dugongs at 1.0×10^6 and a current baseline of 14,000 in Eastern Australia. In Wide Bay, Australia, three or four-mile-long herds of dugongs were described by E. Thorne around 1870 (Jackson 2001). The amount of bioturbation which could be accomplished by a 3 mile herd of dugongs would be quite significant in the functionality of the system, as the seagrasses would have evolved in the presence of dugongs. There are some reports which indicate that seagrasses flower as a response to grazing (Jackson, personal correspondence). In addition to recycling nutrients (Jackson 2001), the dugongs created a disturbance regime, which when disrupted would result in a cessation of important processes associated with disturbance. Moderate sized herds of dugongs remove up to 96% of above-ground biomass and 71% of below-ground biomass of seagrasses (Jackson 2001). Future work should include the role of a grazing disturbance regime to the health of seagrass beds.

Fig. 12. Lithograph of a dugong bone mound on Tudu Island, Dumont d'Urville expedition 1840. Dumont d'Urville 1846 rpt in Ian McNiven, "Ritually Orchestrated Seascapes: Hunting Magic and Dugong Bone Mounds in Torres Strait, NE Australia" (Cambridge Archaeological Journal 13:2, 2003).

Section 9

FISHES

As in the case of many other ocean resources, there is a long history of reef fish exploitation in Sabah and Sulu, however the most intense exploitation appears to have occurred after World War 2 (Tregonning 1965). Currently, Sabah is well known within the region for its fishery products. Since Sabah became a state in the Federation of Malaysia in 1963, its fishery industry has grown rapidly. Fisheries in Sabah provide employment to approximately 20,000 people, and involve 8500 boats of various kinds and sizes. Recently, tuna has become a major capture fishery (Kong, 1998).

Products that were historically traded were dried reef fish and fish maws (gas bladders) which were in demand in China. Fish were collected from surrounding islands and traded in central entrepôts. Fish maws, or isinglass, appear to have become an article of exportation from the Indian archipelago as early as they came to be visited by the Chinese (Cantor, 1849). No references were found of the amount of reef fish or isinglass which came out of Sulu or Sabah but the Catalog of Malayan Fishes describes trade that went out of a Peninsular Malayan settlement. The products were collected throughout the islands, however.

The fish from which isinglass was obtained at Pinang in Peninsular Malaysia are *Lates heptadactylus* (Asian seabass, which averaged size 5 feet and was described as scarce in 1849), *Polynemus indicus* (a threadfin, up to 3 feet), *Otolithus biauritus* (a sciaenid, 3 feet), *Othlithus rubber* (a sciaenid, 2 ½ feet), *Otolithus argenteus* (a sciaenid, 2 ½ feet), *Otolithus maculates* (a sciaenid, 2'9"), *Johnius diacanthus* (a lutjanid), *Lobotes erate* (a tripletail), *Arius truncatus, Arius arius*, and *Arius militariesed* (catfish) (Cantor, 1849). *Lates heptadactylus* may be *Lates calcarifer*, or the Giant Seaperch (www.fishbase.org).

The table below gives us an idea how much isinglass was traded from a Prince of Wales Island in 1832-1842. The number of fish that would be required to produce these amounts of isinglass is calculated. It takes 30-40 gas bladders to make a pound of isinglass (Lin n.d.).

	Import - piculs	Import - pounds	Export-piculs	Export - pounds	Number of fish (if 30fish/lb)
1832-33	163	21679	182	24206	726180
1833-34	103	13699	170	22610	678300
1834-35	126	16758	224	29792	893760
1835-36	76	10108	172	22876	686280
1836-37	135	17955	184	24472	734160
1837-38	120	15960	202	26866	805980
1838-39	103	13699	204	27132	813960
1839-40	71	9443	192	25536	766080
1840-41	309	41097	144	19152	574560
1841-42	117	15561	265	35245	1057350
Totals	1323	175959	1939	257887	7736610

Table 3. Quantity of Fish Maws Imports and Exports - Prince of Wales Island, 1832-184. (Cantor 1849 and Lin n.d.).

The Chinese were harvesting reef fish in Sulu and Sabah until the first half of the 20th Century. Keppel, in 1843, describes the fish that the Chinese were harvesting from the waters off of the Bornean coast along the Sulu Sea: "The coasts and rivers abound with excellent and wholesome fish in the greatest variety, and of the most delicious flavours: but such is the miserable state of society, that few Malays have either the inclination or the inducement to venture beyond the mouths of their rivers in quest of them; and even there they are more indebted to the industry of the Chinese with their fishing stakes than to their own labor for the supply of their markets. The names of their fish are, the kabab, klabaw, jilawat, lai-is, pattain, udang or prawn, shrimp, talang, sinangan, bawan, rowan, taylaon, duri, bleda, tingairy, alu-alu, pako, jumpul, pari or skait, boli ayam, tamban or shad, belut or eel, iyu or shark, lida or sole, batu batu, tipy and lapis pearl oysters, cupang or muscle, all the varieties of turtle, with several other sorts" (Keppel, 1968).

Malay Common name	English Common Name	Family / Genus	Species occurring in Malaysia
Kabab	TBD	TBD	TBD
Klabaw	TBD	TBD	TBD
Jilawat	TBD	TBD	TBD
Lai-is	TBD	TBD	TBD
Pattain	TBD	TBD	TBD
Talang	Queenfish	Family Carangidae Genus Scomberoides	*S. Commersonnianus* *S. Lysan* *S. Tala* *S. Tol*
Sinangan	TBD	TBD	TBD
Bawan	TBD	TBD	TBD
Rowan	TBD	TBD	TBD
Taylaon	TBD	TBD	TBD

Duri	TBD	TBD	TBD
Bleda	TBD	TBD	TBD
Tingairy	TBD	TBD	TBD
Alu-alu	Barracuda	Family Sphyraenidae	Sphyraena spp.
Pako	Cobia	Family Rachycentridae	*Rachycentron canadum*
Jumpul	Mullet	Family Mugilidae	*Mugil cephalus*
Pari	Rays, skates, and shovelnose guitarfish	Family Dasyatidae Family Rhinobatidae Family Narcinidae Family Myliobatidae Family Rajidae Family Gymnuridae	Many species
Boli ayam	TBD	TBD	TBD
Tamban	Herrings, shad, menhaden, sardines	Family Clupeidae	Many species
Belut	Moray eels	Family Muraenidae	Many species
Iyu	TBD	TBD	TBD
Lida	Tonguefish	Family Cynoglassidae	Many species
Batu-batu	Threadfin breams Wrasses	Family Nemipteridae Labridae	Could refer to many different species of threadfin bream and wrasses, including *Cheilinus undulatus*

Table 4. Common name translations (www.fishbase.org).

Pearl divers were also terrorized by certain giant fish, such as the giant groper (grouper) (Fig.13.) "Divers fear these fish more than any other underwater creature. This specimen is about 400 pounds, but they often reach 700 lbs in weight. The mouth contains many rows of serrated teeth, and the gullet is large enough to swallow a man whole" (Bartlett 1954).

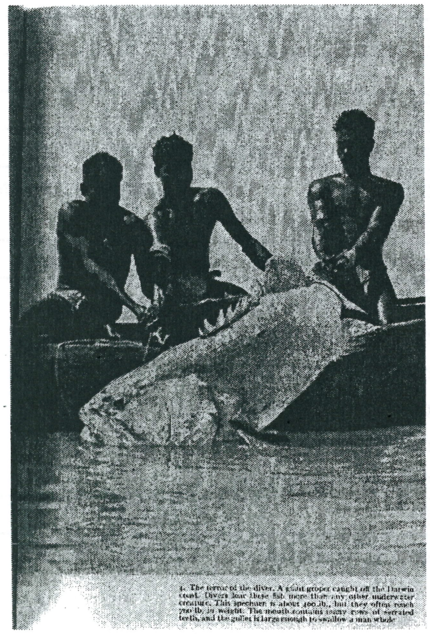

Fig. 13. Giant groper caught off of the Darwin Coast. Norman Bartlett, The Pearl Seekers (London: Andrew Melrose Ltd., 1954).

After WW2, the Malaysian fisheries were organized and mechanized. While traditional fishing methods are still used, recent times are marked by a shift to aquaculture, industrialization and the live fish trade. Dr. Ishak Omar, an economist at the Universiti Putra Malaysia, states that the fisheries off Sabah have yet to be exploited to maximum sustainable yield (Omar, personal correspondence).

Myers and Worm showed amazingly similar trajectories of fisheries worldwide following industrialization. Industrialized fisheries reduced biomass by 80% within 15 years. They estimated that large predatory fish biomass is only 10% of pre-industrial levels (Myers 2003). In Pauly's 1988 study of the Gulf of Thailand fishery which was rebuilt after WW2, there was a profound change in species composition after the fishery had advanced technologically to include bottom trawling. Historically, resources had been exploited in this area for a long time, yet the marine resource extraction was kept relatively light compared to today's standard by several limiting factors: populations and markets were smaller than at present, abundant freshwater fish resources, and lack of gear capable of catching demersal species. After trawling, squid populations were much higher due to the fact that their eggs had been released from demersal predators. One would expect to find a decrease in the desired species – usually the large and long-lived and an increase in the species below them – such as mollusks and crustaceans (Pauly 1988).

The data obtained from Sabah Fisheries is very superficial with categories such as live "fish," "crustaceans," and "mollusks" (www.agrolink.moa.my). In the years 1990-1995, crustaceans and squid were the dominant fishery. Without more detailed data over a long time period it can only be hypothesized based on circumstantial evidence that the fisheries in Malaysia and perhaps Sabah are following a trajectory similar to that described by Myers and Worm and Pauly.

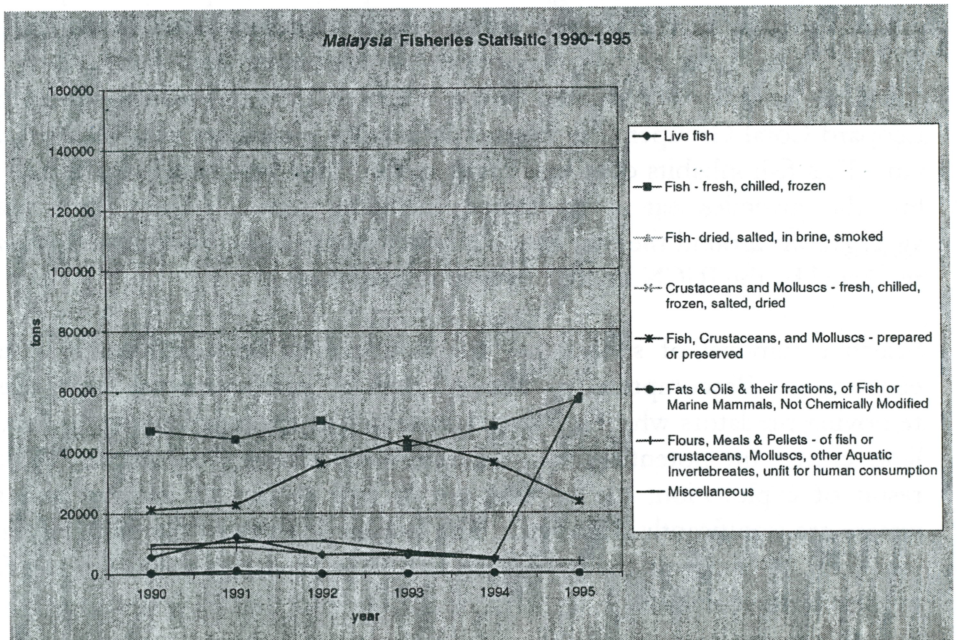

Fig. 13. Graph of Fisheries Statistics 1990-1995. Raw data taken from www.agrolink.moa.my.

Correspondence with University of British Columbia graduate student, Louise Teh, who works with traditional fishermen of Banggi has revealed that the fishermen are witnessing changes themselves. From speaking with the fishermen in her study area, she concluded that there "has definitely been a temporal change in target fish species, most notably humphead wrasse and humpback grouper, which are now very rare due to the intensive targeting for the live-fish trade. Leopard coral grouper is now becoming harder to find too, and might follow the same trend if no conservation measures are put in. Sharks were once abundant, but are no longer caught frequently. Dugongs are also rarely caught as well, although there used to be many of them around certain areas on the island. Trepang (called balat in Sabah) is still harvested regularly by fishermen." As far as she knew pearls weren't harvested around southern Banggi, although there used to be a Japanese run pearl farm on a nearby island during the 1990's (Teh personal correspondence).

The Humphead or Maori Wrasse (*Cheilinus undulates*) grows to an enormous size of over 2000 cm in length and 150 kg and is very slow growing. It inhabits coral reef areas and feeds on mollusks, fish, urchins, crustaceans and other invertebrates (Kong 1998). It is one of the few predators of animals such as sea hares, boxfishes and crown-of-thorns starfish (fishbase.org.) *Cheilinus undulates* was red-listed by the IUCN (International Union for the Conservation of Nature) in 2001 (www.iucnredlist.org). The Humpback Grouper (*Cromileptes altivelis*) inhabits shallow coral and rocky reefs. This is a medium-sized, slow-growing fish (200-300 cm) and feeds on bottom invertebrates and fish (Kong 1998). *Cromileptes altivelis* was red-listed by the IUCN in 1994 (www.iucnredlist.org). The Leopard Coral Grouper (*Plectropomus leopardus*) is a medium sized fish of 250-300 cm. This fish inhabits coral and rocky reefs. They feed mainly on fish as adults, but the juveniles eat invertebrates, including squid. They form spawning aggregations around the new moon (www.fishbase.org). *Plectropomus leopardus* was red-listed by the IUCN in 2001 (www.iucnredlist.org).

Selective removal of species has the potential to be significant in coral reef ecosystems. Bascompte et. al. showed that in Caribbean coral reefs, selectively removing predators which are overrepresented in strongly interacting food chain links creates the potential for community wide effects (Bascompte 2005). As a result of exploitation, the populations of two species of grouper and a large wrasse are significantly decreased. The trophic analysis of the Sulu and Sulawesi seas (Fig. 14) supports the hypothesis that large predatory fishes are at a fraction of their historic levels.

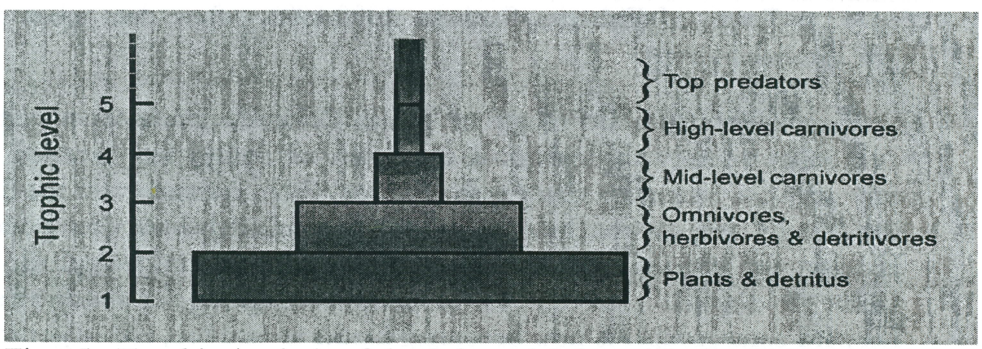

Fig. 15. Trophic Analysis of the Sulu and Sulawesi Seas. (Fishbase.org).

Section 10

CONCLUSION

Conservation is both a biological and social activity requiring understanding of an area on many levels. Historical ecology is a discipline which addresses biological change due to human interactions with nature and can be used as a tool to gain insight for conservation decisions. In most cases, our concern is fishing as this is the most direct way in which we influence marine systems; however climate change and pollution cannot be ignored. In addition, historical ecology provides a context for present day politics, social structure, labor, behavior, etc. This perspective is highly valuable in conservation which is so related to interactions of people and nature.

This project was done over a three month period and should serve as a broad overview to the history of the human-marine relationship in the Sulu and Sulawesi Marine Ecoregion. Historical ecology should have an active purpose in conservation rather than solely being an intellectual construct of those in academia. Historical ecology serves to inform those whose decisions are critical to saving ecosystems and species which are teetering on the edge of collapse or extinction. Returning to an exact historical baseline is an unrealistic goal. There are few, if any, places which are not severely impacted by which to measure conservation success. Therefore, conservation must turn to historical ecology to provide this benchmark or risk having an inadequate way to measure success.

While this study was broad in scope, conclusions can still be drawn about anthropogenic change in the Sulu and Sulawesi Seas due to fishing. There have been serious decreases, most likely collapses, in major fisheries such as the pearl oysters, sharks, dugongs, turtles, and some reef fishes. The magnitude at which these existed in the past is greater than what may have been imagined previously. Many targeted species have important functional roles in the ecosystem. As in any research project, the deeper you look, the more questions you have, and this project is no exception. The Sulu and Sulawesi Marine Ecoregion Program is of such importance that it deserves a multi-year, in-depth analysis of historical baselines. By elucidating the past we will better know the present in order to conserve the future.

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