

## Historical Ecology of the Raja Ampat Archipelago, Papua Province, Indonesia

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**ABSTRACT** – This work presents a review of the status of marine resources of the Raja Ampat Archipelago, Papua Province, Indonesia, based on narratives of early European expeditions in various museums and libraries in Europe, Canada, and local archives in Papua. More than 500 pertinent documents on the study area were identified and located in various European museums and at the University of British Columbia library. About half of these were scanned (25.000 pages), which yielded the equivalent of 900 pages of text (or 4% of the total number of pages scanned) with observations on abundance and impact of the human population on the marine ecosystem within 2° North and 2° South between 127° and 132° East. In general, these observations, which spanned the period from 1810 to the present, suggest a decrease in the perceived occurrences of turtles, fish, and invertebrates; perceived abundance of turtles, fish, and algae; perceived subsistence exploitation of marine resources; and an increase in perceived commercial exploitation of marine resources. We conclude with a discussion of the problems and potential of contents analysis, and its use in the historical reconstruction of broad biodiversity trends.

**KEYWORDS** – Contents analysis; Database; Biodiversity; Abundance; Indonesia

### **Introduction**

Southeast Asia, more precisely the triangle made up by the southern Philippines, central Indonesia, and Papua New Guinea, appears to be at the very center of the world marine biodiversity (Carpenter and Springer 2005). This biodiversity is still not fully described but progress on this is being made, notably by the Conservation International's Papuan Bird's Head Seascape Program, which includes the Raja Ampat region (Erdmann and Pet 2002; Kranz 2006). This contribution emanated as a part of that project in an attempt to recover early descriptions and first hints of change in that biodiversity, as can be recovered through historic narratives.

The method used here is a form of content analysis (Krippendorff

2004), modified to be applicable to the narratives of historic expeditions. This methodology was previously applied to the Falkland Islands (Palomares *et al.* 2006a). Here, it is applied to the Raja Ampat area (Palomares *et al.* 2006b, Figure 1) to provide a historical context for the present attempt at documenting the biodiversity of the region and as a contribution to current issues of biodiversity.

The Raja Ampat Islands, occurring between 0°20' N and 2°15' S and 129°35' E and 131°20' E (McKenna *et al.* 2002), encompass over 4 million hectares (Erdmann and Pet 2002) or 43,000 km<sup>2</sup> (McKenna *et al.* 2002) of land and sea off the far northwestern tip of the Papua Province of Indonesia. This area includes the four large islands of Waigeo, Batanta, Salawati, Misool, and hundreds of smaller islands scattered amongst them and the peripheral islands of Sayang in the north and Gag, Kofiau, and the Bambu Islands to the west. However, this specifically excludes the Ayu and Asia Islands to the north and the Boo Islands to the west (Erdmann and Pet 2002). The area so defined is entirely within the administrative boundaries of Sorong Regency (*kabupateng*), with Sorong city as capital. Included within this regency are the five districts (*kecamatan*) of Salawati, Samate, Misool, South Waigeo, and North Waigeo, with a combined population of approximately 50,000 persons occupying 89 villages (McKenna *et al.* 2002).

For this study, we included data from areas surrounding the Raja Ampat Islands (bounded roughly at 2°N to 2°S and 127° to 132°E; Figure 1), including the Bird's Head peninsula and expanding to the Halmahera Islands and the Moluccas.

The materials used here were historical documents of voyages and expeditions of European powers, notably Dutch, French, and English, to the East Indies.<sup>1</sup> The materials processed first were those with species lists and descriptions containing abundance observations and inferences on the human population and their impact on the marine environment (see Palomares *et al.*, 2006b, Appendix B). Studies focusing solely on the Raja Ampat islands proper are few, thus necessitating an expanded search for documents covering neighbouring areas, e.g., the Halmahera Sea (see Figure 1).

<sup>1</sup> See Palomares *et al.* (2006b, Appendix B and C) for narratives of voyages and expeditions, and the other historical documents obtained for this study.

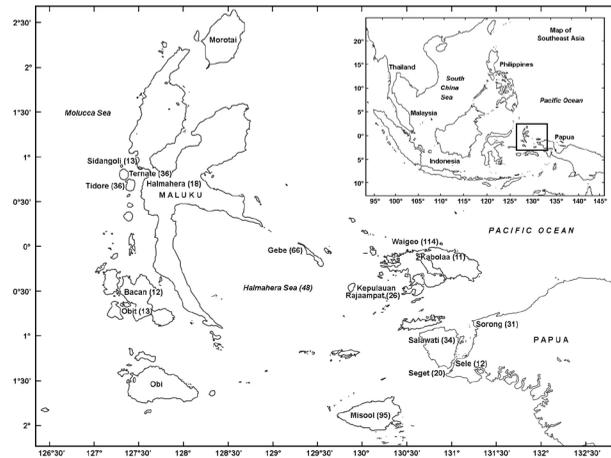


Fig. 1 - The Raja Ampat region, showing some of the place names (and number of observations in brackets) used in this analysis; the complete list of place names and number of observations available for the region is presented in Palomares *et al.* (2006b, Appendix A).

## Abundance of Marine Organisms

The study of biodiversity is not only limited to knowing what species occur in the area, but also how much of it was (and is) there. However, it appears that at least in Southeast Asia

we have no way of estimating the abundance of fish, shrimps, oysters, and other marine animals in the middle of the nineteenth century, as the first systematic surveys did not take place until after World War II. We therefore have to rely entirely on anecdotal evidence to gain an impression of the abundance of marine life at this time, but this at least gives us a base from which we can judge the great changes that began to take place in the middle of the twentieth century. (Butcher 2004, 28)

Granting that abundance data are not easily accessible, we can “reacquire” such data from records of specimens and descriptions of organisms from the narratives of historic expeditions and from survey reports.

Following the methodology of Palomares *et al.* (2006a), we extracted accounts of marine organisms and encoded these into the Historic Expeditions and Surveys Database, a relational MS Access database hosted within the *Sea Around Us* Project website (see [www.seararoundus.org](http://www.seararoundus.org)). Each observation or “anecdote”, *sensu* Pauly (1995), comprising one or several sentences or paragraphs, was ranked according to the perceived abundance it expressed about a group of species, using the multi-level system in Palomares *et al.* (2006a), viz: extremely abundant; abundant; very common; common; rare; absent; and “occurrence” when no inference on abundance was possible.

**Table 1.** Definition for and example of the coding system used in this study.

Code	Example
Very abundant	<u>Enormous quantities</u> of small fish swarmed under the drift-wood, and troops of Dolphins (“Coryphaena”) and small Sharks (“Carcharias”), three or four feet long, were seen feeding on them, dashing in amongst the logs, splashing the water, and showing above the surface, as they darted on their prey. The older wood was bored by a “Pholas” (Moseley 1892, 374-375).
Abundant	The coral banks, though <u>abundant</u> , were not so easily accessible at Amboina as at Banda, being in deeper water, and specimens of most of the species could only be procured by deep wading and diving (Moseley 1892, 335).
Very common	The cliffs appear as if formed of a stratified ferruginous red rock. Here and there were conspicuous white patches on the cliffs, the nesting-places of Boobies, of which <u>large flocks</u> were seen flying to roost as evening came on (Moseley 1892, 316).
Common	It is evident that a wide area of the sea off the mouth of the Ambernoh River is thus constantly covered with drift-wood, for the floating wood is inhabited by various animals, which seem to belong to it, as it were. [...] A “Lepas” was <u>common</u> on the logs (Moseley 1892, 374-375).
Rare	Les îles que j’ai citées se trouvent sur un banc étendu, qui unit la Nouvelle-Guinée à Misool et devient progressivement plus profond en se rapprochant de cette dernière île, [...]. On n’y rencontre <u>presque pas</u> de “Lithothamnion”, en dépit de la faible profondeur (18 mètres), à laquelle il se trouve placé (Weber 1902, 72).
Absent	Entre Sulu et Kapul, nous avons rencontré, à 275 m. (Station 105), [...] Un second coup de filet (Station 95), exécuté plus au Nord, ne nous fournit <u>aucun</u> autre exemplaire de cet Ascidien; [...] (Weber 1902, 53).
Occurs	Entre Sulu et Kapul, nous avons rencontré, à 275 m. (Station 105), [...] parmi lesquels il faut aussi signaler quatre exemplaires du remarquable “Chelyosoma”, connu surtout dans les mers arctiques. La <u>présence</u> de ce Tunicier dans cette région torride du globe fit sur nous une impression profonde (Weber 1902, 53).

Coding was based on words used in the descriptions indicating relative amounts of observed marine organisms. For example, “fish abound along the coast” was coded as “abundant”, while “enormous quantities of” was coded “extremely abundant” (Table 1).

Note that coding can be repeated independently by one or more researcher(s) in order to reduce the subjectivity added by the coding to that of the narratives. In this study, there was an extremely high correlation (results not shown) between the codes attributed by the first and second authors.

Each observation was assigned to the functional group being described (marine mammals, seabirds, turtles, fish, invertebrates, seaweed, al-

gae, others). Scientific names of the species when mentioned or footnoted were encoded in the remarks field and the phylum, class, and order were obtained from the Catalogue of Life (2006 annual checklist; [www.catalogueoflife.org](http://www.catalogueoflife.org)). Biological information (e.g., size, feeding, and spawning behaviour) were also encoded in the remarks field of the historic expeditions and surveys database of the *Sea Around Us* Project ([www.seaaroundus.org](http://www.seaaroundus.org)) as well as in SeaLifeBase ([www.sealifebase.org](http://www.sealifebase.org)) for non-fish marine organisms and in FishBase ([www.fishbase.org](http://www.fishbase.org)) for marine fishes. If the description includes several groups of species in one sentence, separate records were created to account for each functional group (including the name of species when specified). Each observation was linked to the following information:

- The “sampling station”, i.e., the spatial coordinates (most of the time from details of stations but sometimes estimated using MSN Encarta® or Google Earth®), time of arrival and departure, the country, and locality names of the “station”;
- The expedition details;
- The source and online links to the entire text, if available;
- The specimen accession number, if identified and online links to the website of the museum that holds the specimen, if available.

The observations were separated by functional groups and arranged chronologically. Observations for each functional group were further subdivided into time periods with similar number of observations and plotted on the chronological axis at the value corresponding to the mean of the years with observations. The total number of observations per coded abundance level was obtained for each time period (represented by its mean year). This permitted the plotting of the “perceived” abundance (in %) of each functional group over time.

### **Exogenous Impacts to the Ecosystem**

A methodology similar to that described above was employed for exploitation or appropriation of natural resources, e.g., fishing and trade, and human population accounts. Observations describing intensity of fishing and fishing practices, amount extracted, trading, etc., were ranked according to the level of intensity of the activity using four qualitative levels, viz.: low, medium, and high for commercially important activities and “subsistence” for non-commercial activities. Thus, for example, de Clercq’s (1999) description of the Bajorese at Ngaai ma-Dodera, which “has a small beach where a few Bajorese from Kayoa Islands have temporarily settled and whose main occupation is collecting *tripang* (sea cu-

cumbers) and turtles; both are harpooned with a pointed instrument” is ranked as “high” since this was probably a “boom and bust” operation; the Bajorese traded seasonally with the Chinese.

These observations on exogenous impacts to the marine ecosystem were grouped according to the type of activity, sorted in increasing chronological order and expressed as percent of the total for each period. They were then plotted in a line graph to infer trends of population level, extraction and trade of natural resources in the area.

### **From the Spice Trade to the Study of Natural History**

The first European account of the East Indies can probably be attributed to Marco Polo, heir to a rich Mediterranean tradition of international trade, who stayed in Sumatra in 1292 (Robequain 1958, 1). This was followed by various accounts of the spice trade, i.e., nutmeg, cloves, and cinnamon from the East Indies (India, the Malay Archipelago, and the Moluccas) to Europe. As the demand increased, “based on the intense need for pepper and other spices to preserve meat in Europe” (Findlay 1992, 158), merchants established agencies and correspondents, mostly Indians, Chinese, and Arabs in the East Indies, which encouraged active trade and the growth of “middlemen” trading between Europe and the East Indies. The resulting increase in the cost of spices made European powers, notably the Portuguese, establish monopolies (see Hamilton 1948, 34-40) on the production of spices itself, thus making, for about 100 years, the Moluccas “the centre of European activity in the East Indies” (Robequain 1958, 2). Because of this and similar monopolies by other colonial powers, information on the occurrence of natural resources was suppressed and in spite of the long presence of European powers in the area, cartographical, hydrographical, geographical, and biological studies became openly available only much later.

Because the islands “can never be expected to yield any advantage, besides that derived from the spice-trade” (Stavorinus 1798, 335), European officials in the region, some of whom were learned individuals, occasionally noted descriptions of the exotic and lush nature of the region as a respite from writing reports on the commodities of trade and politics of the colonies.

As they were first and foremost, civil servants – colonial bureaucrats [...] not highly paid, but the cost of colonial living was low, and they had solid pensions [...] many of their studies were financed out of the colonial budget and moreover, it was not of great matter to their employers whether or not they published a great deal [...]. (Anderson 1992, 26)

They made time to undertake studies of natural history as a hobby ra-

ther than as an obligation to their employers. In such manner, excellent botanical and zoological collections enriched the *cabinet de curiosité* of the colonial powers and eventually contributed to the natural history studies of the area.

One such “employee” was Georg Eberhard Rumphius. Born to a wealthy family in Hanau, Germany in the late 1620s, he was enlisted by the count Ludwig von Solms-Greifenstein (Braunfels) into the Venetian army (then a cover for the Dutch East India Company) in the 1640s and as “warrant officer” in 1652, sailed on the *Muyden* and took his post at Ambon in 1653 where, due to his lack of military prowess, he was appointed “under-merchant” in 1657 and merchant in 1662 (Sarton 1937, 244-246).

Whatever his training may have been, he was a born naturalist and one can easily imagine the impact of tropical nature – fantastic and equally alluring in its luxuriance and diversity - upon a young mind thus oriented. No sooner was he settled in Amboina that he began making a systematic survey of the flora and fauna of the Moluccas, describing carefully everything that lived and grew in his island and the neighbouring ones, collecting as well geographical and mineralogical information, in short preparing, with increasing consciousness, what might be called the Natural History of that region. It is much to the credit of the Dutch authorities that they favored his efforts outside of the commercial field, and allowed him to devote to his hobby more and more time. The governor-general Joan Maetsuyker (1608-1678, gov. 1673-78) in Batavia, a man of considerable influence who could have harmed as well as helped him, chose the latter course and deserves our gratitude. (Sarton 1937, 246)

His studies resulted to the now famous catalogue, entitled *Herbarium Amboinensis* published in 1741, nearly 40 years after his death (Rumphius 1999, [www.museumboerhaave.nl](http://www.museumboerhaave.nl)). This delay, due to a series of unfortunate events including his blindness, was prolonged by the Dutch East India Company which refused to publish the catalogue because it contained “sensitive information”, i.e., biogeographical notes pointing to localities where the coveted spice plants occurred.

The colonial policy of monopolies triggered the 16th-century spice wars and led to the deployment of Royal Navy vessels tasked not only with political agendas, i.e., capture of cargo ships, but also with the exploration of surrounding regions, preferably not controlled by the current monopoly, for new sources of spice plants. Such explorations required fast sleek warships (Lane 1933, 219) equipped for fighting at sea and thus a suite of officers issuing from the aristocratic families of Europe and a crew of seamen, totaling on the average 200 men (Lane 1933, 221). Most of the time the accompanying navy surgeon, physician, or chemist acted as the naturalist tasked with assembling collections of

natural history and ethnography. Though sporadic and often delayed in publication, accounts of hydrographic, botanical, and zoological atlases describing in detail the discovered and explored lands as well as the marine and terrestrial organisms observed and collected, became available.

Colonial explorations evolved into scientific expeditions, which expressed more diffused commercial interests. The period of European Enlightenment, closely linked to the growth of eighteenth-century science, provided many scientific reports of oceanographic expeditions by leading European countries, notably France and Britain, whose monarchies and merchant guilds were able to finance the rather expensive voyages. The format and extent of the scientific reports issuing from these voyages improved over time from descriptive accounts of what was seen to quantitative accounts of what was measured, sampled, and catalogued. This period also marks the rapid increase in museum collections of natural history and the birth of the Linnaean system of biological naming and classification of species. The following paragraphs illustrate some of the work of naturalists who visited the Raja Ampat region during this period and beyond.

The French naturalist and explorer, Pierre Sonnerat published an account of his voyages to Southeast Asia and the Moluccas (Sonnerat 1776; 1782). In the 1776 account of his voyage to New Guinea, he described many terrestrial plants, trees, and birds. Joseph Banks joined the first joint scientific expedition of the British Royal Navy and the Royal Society to the South Pacific Ocean on the H.M.S. *Endeavour* in 1768-1771, the first of James Cook's voyages to the region. Banks is credited with several species of plants, now bearing his name (see Banks's *Endeavour* journal at [www.southseas.nla.gov.au](http://www.southseas.nla.gov.au)). Studies of the terrestrial fauna, flora, and paleontology of the region continued until the late 1800s and included the Dutch expedition to the center of Sumatra in 1877-1879 and Vorderman's ornithological studies in Jakarta (Weber 1902, 2-3).

The first real oceanographic expedition, however, can probably be attributed to the circumnavigation of the *Géographe* and the *Naturaliste*, commanded by Nicolas Baudin with François Péron and Jean Baptiste Louis Claude Théodore Leschaunault de la Tour as naturalists and Charles Alexandre Lesueur as artist (Péron, Lesueur, Petit 1807; Freycinet, Péron 1811). This expedition was the first to carry scientists and private citizens among its crew. Baudin and his crew sailed through the Timor Sea and on their way to Australia in 1801 anchored at Kupang (Timor Leste), where about 200 species of fish were obtained.

Louis Claude de Freycinet, who sailed with Baudin as commander of the *Naturaliste*, undertook his own circumnavigation in the *Uranie* (and

later in the *Physicienne*, under the command of Dumont D'Urville) in 1817-1820 with Jean René Constant Quoy and Joseph Paul Gaimard as naturalists (Freycinet 1825-1829). Freycinet and his crew (which included his wife, Rose de Freycinet) anchored at Kupang and later set up an "observatory" on the island of Rawak (probably Balabalak) to observe the marine life of the islands Vaigiou, Boni, and Manouaran (all in Waigeo, Papua Province). A total of 164 fish species were brought back, 137 described, 62 illustrated in the atlas of the expedition, drawn either by Jacques Étienne Victor Arago or by Quoy himself. The infinite patience and determination of Charles Gaudichard-Beaupré in retrieving his herbarium from the shipwrecked *Uranie* (he washed the plants in freshwater and dried them again), thus saving two-thirds of the shipwrecked botanical collection, is representative of the dedication of voyageur-naturalists of the time (Bauchot *et al.* 1990).

Louis Isidore Duperrey commanded the *Coquille* in 1822-1825 with Prosper Garnot (another navy surgeon) and René Primevère Lesson (pharmacist) as naturalists (Duperrey 1825; 1826; 1830; Lesson *et al.* 1826-1830, t. 1; 1826-1830 t. 2). This expedition on board the *Coquille* sailed through the Torres Strait to New Ireland (Schouten Island), Waigiou (Waigeo), and the Moluccas, but later the *Coquille* sank near the Cape of Good Hope in South Africa. The expedition, noted by the Baron Cuvier as "scientifically exemplary", brought back specimens representing 288 fish species preserved in spirits of wine, 70 of which were illustrated by Lesson. More than 100 of them were to be described in the report of these travels (Bauchot *et al.* 1990).

The zoologists of the *Uranie*, Quoy and Gaimard, went on another circumnavigation passing through the "southern seas" with the *Astrolabe* commanded by Dumont D'Urville in 1826-1829 (D'Urville 1843; 1844). In the region they visited New Ireland (Schouten Island), Ambon, Celebes, and Batavia (Jakarta). The considerable collection was brought back to France, along with 6,000 drawings, and 49 fish species (8 of which were new) were described in 1834 (Bauchot *et al.* 1990).

Other scientific ventures that published reports of studies in the region include efforts aboard the British vessel H.M.S. *Samarang* under the command of Captain E. Belcher, which visited the area between 1843 and 1846 with the zoologist Arthur Adams (Adams 1848). This expedition resulted in important documents furthering the understanding of the marine fauna of the Celebes Sea and the coast of Borneo (see online collection of historic narratives at [www.dlxs.library.cornell.edu](http://www.dlxs.library.cornell.edu)). From 1854 to 1862, Alfred Wallace traveled through the Malay Archipelago to collect specimens and stayed for some time in the Raja Ampat area (Wallace 1869). The H.M.S. *Challenger* undertook its major study of the

area between 1874 and 1875 (Tizard *et al.* 1885), the *Siboga* visited the area between 1899 and 1900 (Weber 1902), while the H.M.S. *Snellius* visited the area in 1929-1930 (Kuenen 1941).

Pieter Bleeker, born near Amsterdam in 1819 and certified as a pharmacist in 1841, joined the East Indian Army as a medical officer after several unsuccessful attempts to join the Rijksmuseum van Natuurlijke Historie in Leiden (Carpenter 2007, 5). He arrived in Jakarta (then Batavia) in 1842 as third class military surgeon. As he was more inclined to be a naturalist than a physician, he conducted independent research and “field trips” in the area. Between 1843 and 1861, he collected about 18,000 specimens.<sup>2</sup> From this collection, he described more than 500 fish genera and about 2,000 species in more than 500 papers, many from the Dutch East Indies and specifically from the Raja Ampat area and some from his voyage to the Moluccas in the Minahassa (Bleeker 1856; 1879). His interests in ichthyology did not stop with his field trips. Having felt that medicine and natural history studies were lacking (due to neglect) in the Dutch East Indies, he founded a journal to incite research in these fields. His *Atlas Ichtyologique*, published in 36 volumes between 1862 and 1878, remains a valued resource for today’s ichthyologists.

### Perceived Abundance of Marine Organisms

The more than 350 documents obtained for this study (Palomares *et al.* 2006b, Appendix B and C), of which more than 250 were processed (slightly over 25,000 pages of text read in a span of 6 months), furnished a total of 1,950 observations of natural history of marine organisms observed to be present in Indonesia. Of these, 1,243 (64%) pertained to the Papuan region, 586 (30%) to the Maluku region, and 121 (10%) to other areas in Indonesia. Table 2 summarizes the observations obtained for Papua and Maluku by functional group. It also indicates the percentage of these groups used in the analyses. Only observations for which geographic coordinates were available from station details and/or reasonable estimates (from plausible descriptions of localities) that fall in the bounding box for the study site (see Figure 1) were used.

The materials gathered exist either in electronic (pdf) format, as paper photocopies, or reproduced from digital pictures. A large percentage of these documents were obtained from various libraries in the Netherlands, UK, and France. The rest were obtained from the special and rare books collection of the University of British Columbia (Vancou-

<sup>2</sup> Many are held at the museum in Leiden, some at the Muséum national d’histoire naturelle in Paris, and duplicates sold by Bleeker to the British natural history museum; Carpenter 2007, 6.

ver, Canada). Most of the electronic and digitally reproduced copies are currently protected by copyright from the holding libraries, which thus ironically reproduce the information embargo of colonial times. However, some of this material can be accessed via the Internet, notably from the online library of the Bibliothèque Nationale de France ([www.gallica.bnf.fr](http://www.gallica.bnf.fr)).

One of the earliest statements indicating the wealth of natural resources in Indonesia is that made in a report by Stavorinus (1798, 331), who wrote that the inhabitants of Ambon were “in alliance with the Company, and furnish a considerable quantity of provisions, consisting of wild boars, stags, sea-cows and other articles of food, which they barter at Neira for piece-goods and other necessaries” (this observation is the only one that mentions dugongs, i.e., “sea-cows”). In 1801, François Péron (Péron, Lesueur, Petit 1807, 146) went to the landing area in Kupang and observed the abundance of marine life, then already exploited by the Malays – “fish, mollusks, urchins, crustaceans, and most spectacularly that of Madrépores which the Malays used to line the shore on which they worked and walked”. In 1818, Freycinet (1825-1829, vol. 2, 46) made similar remarks on the abundance and variety of fishes, while setting up his observatory on a sand bank in Waigeo where “all the kinds of fish we obtained occurred in considerable numbers and were excellent; many had unique forms and the most varied of colors”.<sup>3</sup> He also remarked that the sea provided them with many diverse forms of beautiful crustaceans, some shells and almost every day with turtles (Freycinet 1825-1829, vol. 2, 46). However, the earliest statement that identifies the region as a center of marine biodiversity, well before the term “biodiversity hotspot” was coined, is Wallace’s (1869) judgment that “there is perhaps no spot in the world richer in marine productions, corals, shells and fishes than the Ambon harbour”.

Another remarkable point was the generally larger size of marine organisms observed between the 1700s and 1800s. In Lumu-lumu, Weber (1902, 46) observed that fishers of this region were “experts in catching big fish with harpoons”.<sup>4</sup> He further explains that he was able to obtain a specimen of *Urogymnus asperrimus* (Bloch & Schneider 1801; Rajiformes, Elasmobranchii) from a fisher who harpooned it. The photograph (Weber 1902, 46) of the specimen shows that the ray without its tail was about 2/3 as tall as the European holding it in the photograph. If the average European man was 165 cm tall, the ray would have measured 111 cm to its caudal peduncle corresponding to a body

<sup>3</sup> [...] tous les genres de poissons que nous nous procurâmes; ils sont en grand nombre et excellents; plusieurs offrent des formes singulières et les couleurs les plus variées. [...]

<sup>4</sup> [...] très habiles à prendre au harpon de grands poissons [...].

width of 80 cm, not far from the largest size recorded for this species (100 cm body width; Michael 1993). In addition to large rays, Weber (1902, 22) also observed in Lombok several individuals of eagle and manta rays and requiem sharks whose stomachs were full of cuttlefish. He subsequently observed squalid sharks purposely hunting for cuttlefish in the coral reefs. This observation suggests that sharks and cuttlefishes were very common in the area.

**Table 2.** Summary of abundance observations and reference to human impact in the Papua and Maluku provinces of Indonesia obtained from over 250 documents (25,000 scanned pages) processed and encoded in the Historic Expeditions and Scientific Surveys database of the *Sea Around Us* Project ([www.seaaroundus.org](http://www.seaaroundus.org)). Observations in study area are those which had good estimates of geographic coordinates falling in the study area (see Figure 1).

Functional group	Papua	Study area	Maluku	Study area	Total available	Total study area	%
Fishes	253	73	252	61	505	134	26.5
Invertebrates	562	295	200	116	762	411	53.9
Marine mammals	8	0	5	5	13	5	38.5
Other animals (e.g., crocodiles)	18	0	1	0	19	0	0.0
Sea snakes	7	0	0	0	7	0	0.0
Seabirds	18	8	6	2	24	10	41.7
Turtles	68	25	5	0	73	25	34.2
Other plants (incl. mangroves)	54	21	20	12	74	33	44.6
Sea grass	8	3	7	0	15	3	20.0
Seaweed/algae	39	9	16	5	55	14	25.4
Total for marine plants	101	12	43	5	144	17	11.8
Exogenous factors (e.g., fishing)	107	107	31	31	138	138	100.0

Furthermore, observations of marine mammals, though few (5), indicated that marine mammals were not only present, but also provided good hunting. Thomas Forrest (1969, 128) wrote that on the

9th of March [1775], by break of day, Pulo Pisang bore N. E. eight leagues; and Pulo Lyong (an island near Ouby, appearing with an even outline) bore W. N. W. about ten leagues. [...] The water was smooth, and many porpoises blowing near us.

This gives us an indication that dolphins were common or abundant in the area. Weber (1902) wrote that marine mammals, from small species of dolphins and *Kogia* spp to the larger species of Balanopteridae and sperm whales, were harpooned by the inhabitants of Lamakera and Lamararap. Weber (1902, 32) also reported that the locals learned to harpoon cetaceans from the Europeans. It is interesting to note that none except two voyagers' narratives tell of whaling. Baron van Lynden, resident of Timor described whaling by the inhabitants of these two kampongs in 1851 and a short note from an anonymous observer published in 1849 (Weber 1902, 31-33) reported the same observation.

Turtles figured regularly in the daily life of people in the area. Forrest (1969, 86) wrote that Papuans,

in their boats, continued to bring us abundance of excellent fish; also turtles, which my Mahometans would not eat; but they ate the eggs. The natives had a way of stuffing the guts of the turtle, with the yolks of its eggs. So filled, they rolled it up in a spiral form, and roasted it, or rather dried it over a slow fire; it proved then a long sausage.

Not only were turtles used for food, but were also an item with which to barter. De Freycinet (1825-1829, vol. 2, 22) wrote while anchored in the observatory in Waigeo in 1818 that "every morning we had around us a market well stocked; it offered us a great variety of fish, turtles, lobsters, sometimes also wild pigs, pineapples, lemons, etc."<sup>5</sup> In the 1770s, Forrest (1969, 112) observed that tortoise shells can be obtained at "Krudo" and the islands near it, "as indeed every where on this coast; but it requires to me to collect a quantity and the merchant must advance the commodities of barter. This the Chinese do, and are seldom cheated by the Papuas."

Seabirds seemed to be less frequently noticed by the voyagers. We obtained but 10 observations on terns, gulls, sandpipers, kingfishers, and a sea eagle (Van Musschenbroek 1883, 30, 42, 51, 60, 61, 69, 84, 127; Cheeseman 1949, 115; Maurenbrecher 1956, 8; de Clercq 1999, 30). Sonnerat (1776, 178-181) listed three species of "penguins", which seems suspicious as penguins are not known to

<sup>5</sup> [...] nous avons tous les matins autour de nous un marché assez bien approvisionné; il nous offroit une grande variété de poissons, des tortues, des langoustes, quelquefois aussi des cochons sauvages, des ananas, des citrons, &c.

occur in tropical regions. Maurenbrecher (1956, 8) wrote that the best time to go fishing is when the tuna is hunting. "They drive schools of baitfish, silverwhite sardines, towards the surface and there they attract gulls and terns which form a bank of white wings, that can be seen at a distance by the Papuas and draw them to the fishing grounds."

Mollusks and crustaceans were likewise diverse and abundant and generally used for the inhabitants' daily sustenance. Forrest (1969, 124) reported that in 1775 cockles were in quantity in the islands of Bo and Popo, where a "Banguay corocoro went to a smooth landing place, and picked up a great many excellent kimas (cockles) about the bigness of a man's head; nor failed to give us our share". Cockles at present can be described to grow as big as a child's hand, but not a man's head. The kima, which was consumed with fresh bread made of sago flour (Forrest 1969, 43), were "found in abundance, of all sizes, at low water, during spring tides, on the reefs of coral rocks. And the kima stewed, is as good as most fish, nor does one tire of it. Its roe will sometimes weigh six pounds; the fish altogether, when cleared of the shell, weighing twenty or thirty pounds." The kima was probably the giant clam, *Tridacna gigas* (Linnaeus 1758), which though still found in the region (Munro 1989), presumably is not as abundant as it was in the 1770s.

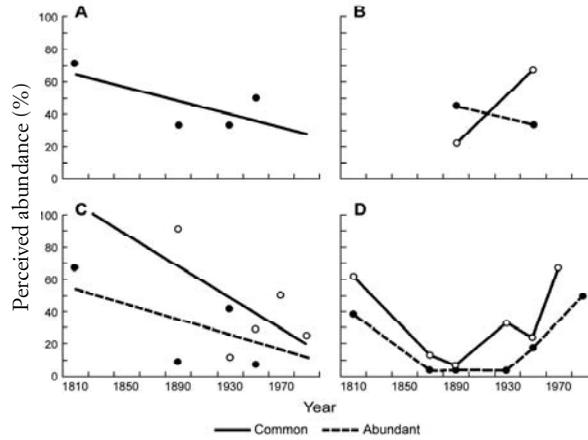
Such a richness and diversity of marine life supported fishing not only as a means of subsistence but also as a means of earning a living. It became, as observed by Resident de Clercq of Ternate in 1890, "as one of the three most important branches of industry in the region", third to weaving of sarongs and tobacco cultivation. He described "rich fishing grounds" which contributed to the decision of some Ternatese locals to move to Sidangoli where they can engage in "calalang (tuna, skipjack) fishing which [p. 46] pays well since that kind of fish is in great demand with the Alfurus from the interior" (de Clercq 1999, 30). Oyster beds became highly exploited "as everybody took whatever he can find from the oyster beds, without giving the pearls time to develop properly, [...] since the divers never [...] receive any pay and are only rarely sufficiently fed, it is natural for the rulers to receive very little remuneration from the activity. They are therefore inclined to hand over the advantages of the exploitation to others, as has happened a few times during the last several years" (De Clercq 1999, 39). De Clercq further noted that this practice was "not conducive to the proper growth of pearl oysters" and this led to fewer profits which

forced the divers to “occupy themselves with collecting nacre”. Thus, in 1890, signs of overexploitation, especially in the shallower coastal zones, began to appear.

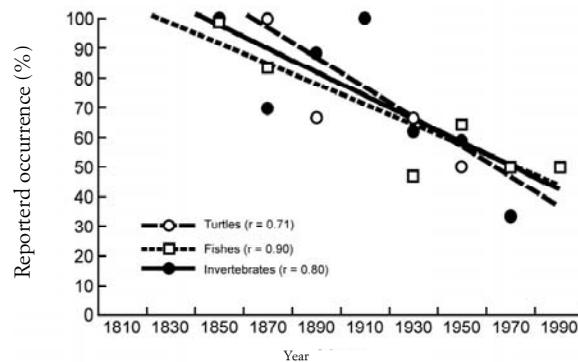
We can infer from such observations that, in the region from the late 1700s up to the mid 1800s, sea life was not only very diverse, but also abundant. There are few descriptions that say otherwise. However, some suggestions of overexploitation, such as de Clercq’s observations in the late 1890s, lead us to believe that such abundance and diversity could not sustain the growing pressures exerted on it by a growing population and an increase in the demand for sea products.

Results of our abundance trends analyses seem to corroborate this. Figures 2a-2c illustrate the trends of perceived abundance of turtles, fish, invertebrates (mostly mollusks, crustaceans and echinoderms), and Figure 2d of aquatic plants (seagrass, seaweeds, algae) in the study area. These plots were based on data summarized in Table 3, which treated all coded observations for the study area, except observations that only mentioned occurrence of a functional group. The perceptions that these organisms abound or are common in the waters of the region appear to generally decline.

The upward trend in Figure 2c of the perception that invertebrates abound and/or are common might be an artifact of scientific surveys conducted in the late 1800s and early 1900s, which sampled the whole range of the ecosystem and included the deep sea flora and fauna with emphasis on invertebrates. Palomares *et al.* (2006a) suggested that before the advent of scientific surveys of the marine environment, observations tended to focus on larger and economically more important organisms such as marine mammals, sharks, large species of bony fishes, birds, turtles, and other remarkable species. Invertebrates, which usually were consumed for subsistence and were smaller, compared to marine mammals and sharks, were often not “seen”, and consequently not described. With the exception of pearl oysters, tripang, and probably giant clams, which were the subject of some of the descriptions we mentioned above, most mollusks and crustaceans gleaned from shallow waters and consumed for subsistence by the Papuans and the Malukans did not “capture the eye” of voyagers. This might explain the discrepancy of the trends for observations in Figure 2c, with the trends extracted from occurrence (not abundance) records (Figure 3).



*Fig. 2* - Perceived abundances of marine organisms in study area (see Figure 1) in % of all observations of each 20-year period (see Table 3). **A.** Turtles: although based on only 4 data points ( $r=0.69$ ), the trend is validated by the fact that the only 2 observations coded 'extremely abundant' fall into the 1810 class and the only observation coded as 'rare' falls into the 1970 class. **B.** Aquatic plants (seagrass and seaweeds): though based only on 4 data points and 2 year classes, this suggests a decrease in the perception of abundance from 'abundant' to 'common'. **C.** Finfishes: although based on few groups of observations ( $r_{\text{abundant}}=0.64$ ;  $r_{\text{common}}=0.60$ ), the two trend lines confirm each other. **D.** Invertebrates (mostly mollusks, crustaceans, scleractinian corals, and sea cucumbers): the seeming increase in abundance of invertebrates may be an artifact due to the improved coverage of benthic and coastal organisms by more recent scientific surveys.



*Fig. 3* - Reported occurrences of turtles, fishes, and invertebrates in Papua and Maluku provinces plotted using the data in Table 3. This shows a continuous decrease in reports of occurrence of these organisms in the study area (see Figure 1).

### Exogenous Impacts to the Ecosystem

In the 19th century, the Kawe people of Raja Ampat frequently went to Gag Island to the west of Waigeo to look for fish and other sea life (Berry and Siswanto 1998, 19), although very little else is known about the subsistence fisheries of “Netherlands New Guinea”. On the Chinese trade, Brunel wrote in his memoirs that the Chinese valued “fish fry, the fins of sharks and sea priapus, crabs, tripam and certain kinds of Molucca beans” (Brunel 1792). Thus, Chinese merchants traded with the Moluccas during the 1700s.

The Bugis, Bajorese, and Makassarese who were expert fishers and boat makers living off the sea and making their business from sea products, were nomadic people who set-up camp in areas where they could fish (Weber 1902, 24). As fish and other sea products (tripang [sea cucumbers], mollusk shells, and pearls) have become trading commodities, the market at Makassar offered a venue for these fishers to sell their goods. The Chinese traded regularly with these fishers. In 1890, there was a “lively trade with Chinese from Makassar and Bugis from Kendari and with other areas which belong to the government of Celebes” (De Clercq 1999, 95). It is, therefore, not difficult to imagine that these people went as far east as Yapen Island on the northern Papuan coast or as far south as the northern coast of Australia to fish. Robequain (1958) observed a change in the groups of people that live almost exclusively by fishing, namely the Orang Laut or “sea gypsies”. Their house boats were usually moored under a sheltering roof and a lighter craft was used for moving about and fishing, selling part of their catch to the Chinese to buy cassava and tapioca (Robequain, 1958, 93).

Whaling was also practiced in the archipelago as Weber (1902, 34-35) deduced from the skulls that were offered to him once the inhabitants understood that scientists considered these valuable. The number of cetaceans harpooned around the villages of Lamararap and Lamakera (Solor, Nusa Tenggara Timur) must have been considerable. He further observed that these animals were captured “to be consumed, in toto”. It also became apparent that the capture of smaller species of whales and dolphins was very important to the local people. He mentioned that in all of the Malay Archipelago, only the inhabitants of these two villages practiced whaling. However, he could not conclude if cetaceans were more abundant in the Solor Strait than in other areas of the archipelago with similar conditions, as the *Siboga* did not capture any specimens of cetaceans outside of the Solor Strait.

Gleaning the shoreline for sea products was also a daily occupation. Weber (1902, 29-30) described how the locals of Savu constructed “dams” of

corals on the reef flats which were totally submerged at high tide, more or less parallel to the reef, their heights decreasing towards the shore. These dams divided the surface of the reef into compartments of different dimensions, which slowly dried up at low tide and served to filter the animals brought in with the high tide (Weber 1902, 29). The locals then captured the animals (fish, mollusks, crustaceans, sea cucumbers, etc.) easily with harpoons and nets or with their hands, in a practice reminiscent of that described for Hawaii (Costa Pierce 1987, 322) and which may have been widespread throughout the Pacific. Note that these artificial parks were used by zoologists of the *Siboga* who joined the locals in hand-picking their specimens from the dams (Weber 1902, 30).

Mollusks were already the object of a fishery, notably of the pearl fishery. Forrest (1969, 144) described that the Sultan (presumably of Misool) claimed Obi for his own but made “no farther use of it, than fishing for pearls on its coasts, where no doubt any stranger may do the same”. In the 1770s, the Dutch East India Company made a profit of “one hundred thousand rixdollars, annually. [...] The fishery, however, does not take, for certain, every year, for this depends upon the condition in which the beds are found. [...] the number of boats and men, to be employed in it, are determined upon: the number of divers is, at present, usually fixed at ninety-six” (Stavorinus 1798, 353).

Robequain (1958) suggested that fishing was profitable on the extensive sand and muddy shallows of the local seas. There was far less fishing off the coasts facing the Indian and Pacific Oceans. However, some villages, much like in the 1770s, “lived entirely by fishing and fishing villages generally consisted of wretched huts or piles where life is often squalid” (Robequain 1958).

In the 1950s, the density of people in the Raja Ampat area was estimated at below 5 individuals per km<sup>2</sup> (Robequain 1958, 91). The least densely populated districts were “not merely those to which nature was unfavorable to humans, but also those that had not had time to be affected by the most intensive type of exploitation” (Robequain 1958, 89). Of the 138 observations collected that indicated the number of inhabitants in the region, 54 fell within our geographic area (Figure 1; see also Table 3). Figure 4 (upper panel) illustrates the results of these observations, suggesting a steady increase in the number of inhabitants in the Papua and Maluku provinces. The 1998 census estimated the population of Raja Ampat at 48,707 inhabitants or 7 individuals per km<sup>2</sup> (McKenna *et al.* 2002). If we accept the increase in the number of inhabitants suggested in Figure 4 (upper panel), the number of inhabitants in the area in the 1700s would have been much lower.

This increase in perceived population abundance in coastal villages

implies an overall increase over the period studied in the impact of the human population on the marine environment and, hence, of fishing effort (Figure 4, upper panel), with a shift from subsistence to commercial fishing (Figure 4, lower panel).

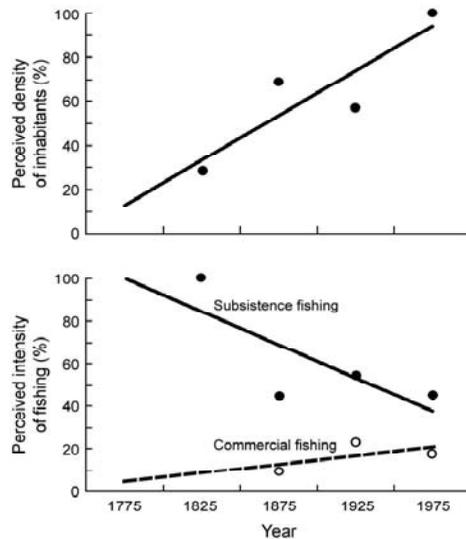


Fig. 4 - Perceived density of inhabitants in Papua and Maluku provinces (upper panel, from data in Palomares *et al.* 2006b, Table 6). Perceived changes in extraction of marine organisms in Papua and Maluku provinces (lower panel). The suggested decrease in subsistence fishing/gleaning ( $r=0.77$ ) and the suggested increase in commercial fishing/gleaning ( $r=0.62$ ) imply a change in the economic importance of marine resources in the study area (based on data in Palomares *et al.* 2006b, Table 7) and thus an increasing impact of the human population on the marine environment

**Table 3.** Perceived density of human inhabitants in Papua and Maluku provinces within the study area (see Figure 1).

Year lower limit	Year upper limit	Un-inhabited	Sparsely inhabited	Inhabited	Populous	Totals
1750	1799					0
1800	1849	2	3		2	7
1850	1899	1	5	5	24	35
1900	1949		3		4	7
1950	1999				5	5

## Conclusions

This study demonstrates that historical information, such as that extracted from narratives of oceanographic expeditions, can be transformed into semi-quantitative data and used for analyses to generate knowledge. Though generating sometimes conflicting conclusions, this study's results support the hypothesis that the Raja Ampat Islands form the eastern base of the triangle of the world's center of marine biodiversity. Abundance observations and fishery records attest to the diversity and abundance of marine organisms in the area. It also appears that the inhabitants of the islands and the surrounding areas, notably of the Maluku Province, have since ancient times practiced fishing for subsistence. In addition, fishing for the export trade has been practiced since the 8th century as encouraged by the profitable business with the Chinese and later on under the control of the Dutch East Indies Company.

There is a lack of quantitative records of extraction during the period when the Dutch East Indies Company ruled; "exact quantities of products were unknown since traders in a free port never disclose true figures" (De Clercq 1999, 14). The impact of these exogenous factors on the marine ecosystem since the 18th century is thus difficult to assess. However, the scientific surveys from the 19th century onwards might help in establishing, at least from the late 1800s, the changes that have occurred in this ecosystem. Our results suggest a 50% decline in sightings of turtles, fishes, and invertebrates, which might be due to increasing pressure exerted by a steadily increasing number of inhabitants.

There are indications of continuing commercial extraction of invertebrates, e.g., mollusk shells and tripang, in spite of signs of overexploitation. However, recent fishery expansion studies suggest that subsistence fisheries can be supported by the current fish, shellfish, and echinoderm stocks, while commercial fisheries seem to be a generally unprofitable enterprise (MacKenzie 1962). The unprofitability of commercial fisheries might be a blessing in disguise for the Raja Ampat ecosystem. As the larger species of fish, crustaceans, mollusks, and echinoderms, though considerably reduced in abundance, have not been extirpated, discouraging commercial trawling in a largely shallow water zone would be beneficial to what is still left of this ecosystem. Thus, emphasis must be placed on the proper management of subsistence and small-scale fisheries.

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