

Marine biodiversity in Ha Long bay and Cat Ba archipelago

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Abstract

Ha Long bay - Cat Ba island located in the Northeast of Vietnam, in the area of Ha Long city (Quang Ninh province) and Cat Hai island district (Hai Phong city) is the largest limestone island in Vietnam. Features of biodiversity include the seven typical ecosystems of tropical limestone islands, namely tropical rainforest ecosystem, cave ecosystem, mangrove ecosystem, tidal ecosystem, coral reef ecosystem, soft-bottom ecosystem. Ha Long - Cat Ba also represents a high level of species diversity with 4,622 species of plants and animals on land and in the sea. In particular, on land there are 2,464 species, accounting for 53.3% and under the sea there are 2158 species, accounting for 46.7%. Up to 16 species and 114 species have been recorded in the Vietnam Red List and in the IUCN List, respectively. Together with hundreds of rare and precious species at national and regional levels, there are species of global conservation value, demonstrating that Ha Long bay - Cat Ba archipelago can possibly be a world heritage site according to the criteria of biodiversity (ix and x criteria).

Keywords: Ha Long - Cat Ba, limestone island, sea, typical ecosystem, high diversity, rare, conservation, heritage.

INTRODUCTION

Ha Long bay - Cat Ba archipelago is situated in the North-Eastern Vietnam and belongs to Ha Long city (Quang Ninh province) and Cat Hai district (Hai Phong city), 165 km from Hanoi.

Total area is about over 1,000 km². Ha Long bay - Cat Ba archipelago is a wonder on karsts generating in tropical moist condition. The distinguished values of Ha Long bay - Cat Ba archipelago are the type of limestone terrains submerged by sea with numberless impressive cones and towers and characteristic features for the eroding process of the foot of islands like watermarks of interesting natural wonder. Ha Long bay - Cat Ba archipelago is also the most distinguished and largest pattern about cone, tower karst terrain eroded by sea and this is one of the most important areas on tower karst terrains.

Ha Long bay - Cat Ba archipelago sufficiently has 7 typical ecosystems of limestone islands on the tropical sea, including: (i) The tropical rainforest ecosystem; (ii) The cave ecosystem (on land); (iii) The mangrove ecosystem; (iv) The tidal ecosystem; (v) The salt-lake ecosystem; (vi) The coral ecosystem; (vii) The soft bottom ecosystem (sea ecosystems). Up to now, there have been 4,622 species of plants and animals both on land and underwater. Living in the area of Ha Long bay - Cat Ba archipelago, 16 species listed in

Vietnam Red Book and 114 species in the World's Red List have been discovered. The high level of biodiversity in Ha Long bay - Cat Ba archipelago with over hundred of rare species and the ones having global conservation values has proved itself able to be the World Heritage Site according to the criterion of biodiversity (criterion ix and x). The article presented below introduces common characters on marine biodiversity of Ha Long bay - Cat Ba archipelago.

RESEARCH METHODOLOGY

Location

Including 3 island groups from Ha Long to Long Chau. Ha Long islands is a World Natural Heritage site, with the sample collection points including Cong Do (Ca Hong lake), Van Ha, Thien Cung, Dau Go, Thien Long, Bo Nau, Luon Cave, Tien Cave, Hang Trai, Dau Be. Cat Ba Island represents the limestone islands of the biosphere reserve where the influence of fresh water from the continental shelf is poured out. There are four key focuses of study including Cat Dua, Van Boi, Van Ha, Hang Toi Cave, Hang Sang Cave, Tra Bau. The Long Chau archipelago, which is located outside the coastal island system and uninhabited, is chosen as a key location in the Cay Bang bay area for comparative study with the coastal islands (fig. 1).

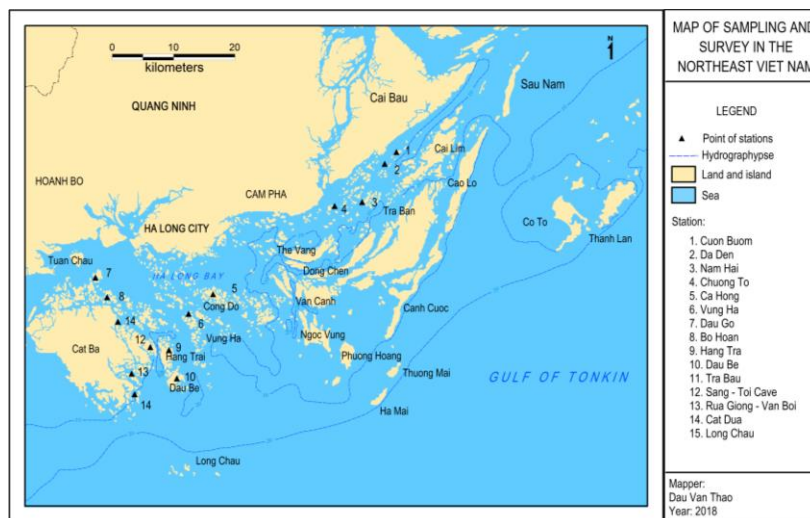


Fig. 1. Sampling location

Method of collecting and analyzing samples of marine organisms around the island

The method basically follows the Provisional Process of the Integrated Marine Survey issued by the State Committee for Scientific and Technological Research in 1981 [1], the process of investigation of marine resources and environment (Institute of Marine Environment and Resources) [2]. There are specific regulations on research groups of marine life. In addition, they are combined with the thematic methodologies of several international organizations and countries which have been widely publicized and published by Reef Check and Seagrass Net [3]. Assessment of organism resources in the study area by quantitative sampling method was described by Winkinson and Baker in the Guide to the Collection of Marine Species, 1998 [3]. Analysis of aquatic organisms is according to specialized methods for different groups of organisms.

THE RESEARCH RESULTS ON MARINE BIODIVERSITY OF HA LONG BAY - CAT BA ARCHIPELAGO

Species diversity

Up to now, 4,622 species of the fauna and the flora including the species living on land and undersea have been discovered in the area nominated as the World Heritage Site.

Among these species, 2,464 ones belonging to land biota hold 53.3% of total species number, aquatic biota comprises 2,158 species (among them 11 species are fresh water fish ones), holding 46.7%. The detail about groups of organisms presented in table 1 shows that the most populous number of species belongs to zoobenthos - 734 species, holding 34.2% of total species number; followed by phytoplankton - 450 species, holding 21%; sea fish - 361 species, holding 16.8%; corals - 247 species, holding 11.5% and the lowest one belongs to sea grass with 4 species, holding only 0.29% of the total species number (table 1).

Table 1. Species diversity of aquatic organisms living in Ha Long bay - Cat Ba archipelago

No.	Name of organism group	Number of families	Number of genera	Number of species	Proportion (%)
1	Mangrove	24	29	31	1.4
2	Seaweeds	35	56	160	7.5
3	Seagrasses			4	0.2
4	Phytoplanktons	38	105	450	21.0
5	Zooplanktons	47	60	154	7.2
6	Zoobenthos	146	345	734	34.2
7	Corals	18	55	247	11.5
8	Sea fish	71	136	361	16.8
9	Sea mammals and turtles			6	0.3
	Total number of aquatic species	2,158 (sea water animals and plants 2,147 + fresh water animals 11)			
	Total number of terrestrial species		2,464		
	Total number of species in Ha Long bay - Cat Ba archipelago		4,622		

The rare and precious species listed in Vietnam Red Book and in the Red List of IUCN

Compared with Vietnam Red Book 2007 and IUCN Red List 2012, it can be seen there are 15 species listed in Vietnam Red Book and 114 species listed in the Red List of IUCN. The highest species number belongs to the coral

group (110 species are in IUCN Red List). The rest numbers are zoobenthos having 6 species (Vietnam Red Book) and turtles having 3 species (IUCN) and 4 species (Vietnam Red Book); sea mammals having only 1 species (*Sousa chinensis*). Especially the only species - sea turtle (*Eremochelys imbricate*) is brought into CR level of IUCN 2012 (table 2).

Table 2. Marine rare and precious species of organisms

No.	Vietnamese name	Vietnam Red Book 2007	IUCN Red List 2012
1	Zoobenthos	6	0
2	Corals	1	110
3	Sea turtles	4	3
4	Sea mammals (<i>Sousa chinensis</i>)	1	1
	Total number of species	16	114

Diversity of the marine ecosystems

Ha Long bay - Cat Ba archipelago is the best model about high concentration of typical tropical - subtropical karst limestone islands such as larger tropical rainforests on limestone islands, mangrove forests, caves, salt water lakes (sea lakes), tidal zone, corals... Here the process of marine transgression to submerge karst depression formed in a larger and intricate setting and with the level of interference between karst islands and sea.

Characteristics are fen-cong depressions of karst Ha Long bay - Cat Ba archipelago from bluff karst depressions with monsoon primary forests to sea lakes which are gradually integrating into the open sea. Nowhere on the world there is the process like that. The process illustrated extremely distinctly the whole periods of repetitively marine transgression over the area of karst Ha Long bay - Cat Ba archipelago and the different environmental changes relating to this marine transgression with the global distinguished value according to the criterion no ix of the World Natural Heritage..

In many patterns here, there is a lively manifestation of processes from beginning to ending which are the process of sea progressing and processes of mountainous formation. The high diversity of ecosystems, especially 1/3 of the number of saltwater lakes in the world concentrated in Ha Long bay - Cat Ba archipelago [4, 5] is global distinguished value and this is also the area of reservation forming new species which immigrate into surrounding sea area. These conditions satisfy the criterion no ix of the World Heritage Site.

There are many typical adjacent ecosystems following one another developing in the Site, such as primary rainforests on islands, cave ecology, mangrove ecosystem,

tidal area, coral reefs, soft bottom, saltwater lakes. The adjacency alternating to develop manifests obviously a continuous ecological succession from limestone mountain sides which are 322 m high to closed coast of islands. There are ecosystems of typical tropical rainforest, cave ecosystem, mangrove forest, then it is the strong development of tidal areas, the part of sea bottom is coral reef. The development of ecosystems following an order of sea-island succession with over 130 saltwater lakes, holding 1/3 of global number [5] of saltwater lakes is considered as a natural laboratory describing an ecological and biological process which is continuing in evolutionary and developing process of the sea-island ecosystems of the Site. The ecological and biological process continuing in the evolutionary and developing process of sea-island is pronounced through high diversity of animal and plant communities on islands and undersea currently continuing to form new species that are manifested with 21 endemic species of plants and animals such as *Trachypithecus poliocephalus* (Cat Ba Langur), *Goniurosaurus catbaensis* (Cat Ba Tiger Gecko), *Tiwariopotamon edostilus* (Cat Ba Cave Crab), *Ficus superba* var. *alongensis* (Ha Long Ficus), *Jasminum alongensis* (Ha Long Jasmin). Experiencing 18,000 years of development, the Site has still remained high natural characteristics. It has not been degraded at all despite human beings' appearance 7,000 years ago.

Tung*, Ang** are officially considered as a symbolized saltwater lake ecosystem of Ha Long bay - Cat Ba archipelago that were proposed by Institute of Environment and Marine Resources in 1997. According to the investigation of scientists, in the area of Bai Tu Long bay, Ha Long bay and Cat Ba

archipelago, there are totally 119 sea lakes (62 ang and 57 tung). As estimated the total area of 62 ang is 289.4 hectares, that of 57 tung is 1,186.2 hectares [6]. By using Google Earth, Jaap Jan Vermeulen, the Netherlander, determined 138 sea lakes for Ha Long - Cat Ba (fig. 2B) [5]. Thus only counting salt-lakes of Ha Long - Cat Ba region, there are 119–138 lakes. Checking on Google Earth, Jaap Jan Vermeulen estimated that there are about 400

saltwater lakes on all the world. Thus Ha Long - Cat Ba holds about 1/3 of the global number of saltwater lakes [5]. They are distributed over the whole study region. The lake Ang Vem, 28.8 ha is the largest one (fig. 2A) and the smallest is Ang Tre Moi (pouling) 0.7 ha.

Note: *Tung, **Ang they are types of saltwater lakes formed on karst limestone islands (Nguyen Chu Hoi, Do Cong Thung, (1997)).

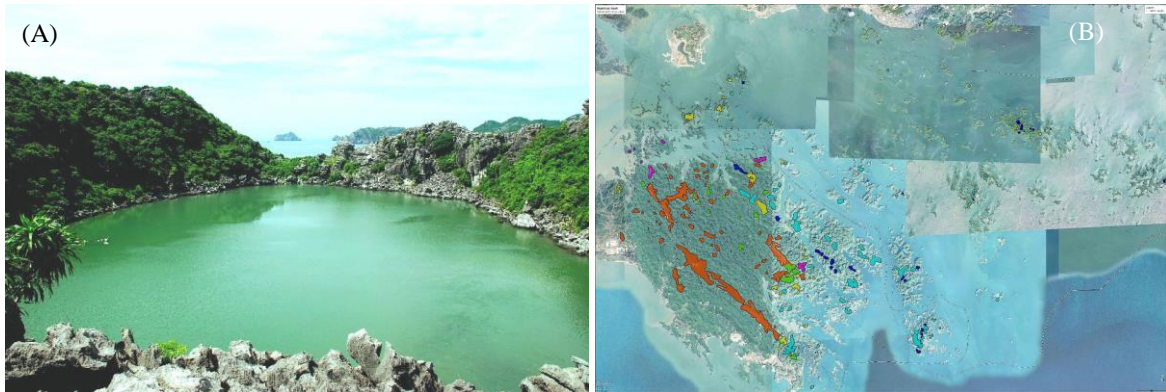


Fig. 2. Saltwater lake ecosystem in Ha Long - Cat Ba

Note: A- Ang Tham saltwater lake seen from above, B- Map of distribution of the saltwater lakes in Ha Long - Cat Ba seen from Google Earth by Jaap Jan Vermeulen (dark and light blue)

During 3 stages of investigating in April 2003, September 2003 and April 2004 (an entire circle), the staff scientists of IMER (VAST) and those of Ancona Institute of Marine Sciences (Italy) explored 8 saltwater lakes in Ha Long - Cat Ba archipelago. They comprise Me Cung, Bu Xam, Ang Du I, Ang Du II, Ba Ham Lake, Ang Vem, Ang Tham, Ang Luon. Among them Ang Du I, Me Cung are worthy of attention, those are entirely enclosed, not adjoining outside, the other lakes more or less have ways to surrounding sea. In 2014, the staff scientists of IMER defined locations and concrete sizes of 30 limestone lakes in Ha Long - Cat Ba area. The research results determining environmental conditions of saltwater lakes manifest quite large difference in comparison with environment of outside sea water. Especially, temperature of water here is often high, varying within 29–30°C, salinity varies within 9–24‰; the contents of nitrate and phosphate are at high level (table 3).

These factors could provoke pressure onto biological populations, forcing them to adapt by forming variants which have ability to endure better or forming new species adapting to changed living environment. Probably this is the process forming new species of the ecosystem of saltwater lakes supplementing aquatic habitats through the ways to the sea.

The species component of biotic community in saltwater lakes is quite diverse. There are often alternate structures among groups of attached organisms and groups of benthos living on sand-gravel group. In the submerged part of saltwater lakes, there are corals and seaweeds growing. In many places, they are pretty dense. Therefore one type of beautiful biotope fascinating tourists is made up. Up to now, 150 species of plants and animals living in saltwater lakes have been discovered. Among them there are 21 species of seaweeds, 37 species of mollusks (19 species belong to the class of Gastropods and 18

species belong to the class of Bivalve), 8 species belonging to crustaceans, 6 species belonging to echinoderms, 31 species belonging to sponges, 41 species belonging to corals and 6 species of fish. Common genera of corals are *Acropora*, *Porites*, *Favia*. Typical mollusk species comprise *Brachidontes* spp., *Anomalodiscus squamosa*, *Paphia malabarica*, *Anadara subcrenata*, *Isoglomum legumen*, *Pinctada martensii*,... Especially species of jellyfish belonging to genus *Mastigias* appears

with large number in 6 investigated lakes. This population of jellyfish existing in 5 saltwater lakes, which belong to Palau archipelago, is considered to be descendants of yellow largely floating *Mastigias papua* and to be a particular subspecies [7]. The situation of species *Mastigias* sp. with two ones among sponge species *Suberites* sp. and *Protosuberites* sp. has never been observed outside environment of these lakes [4].

Table 3. Some environmental factors of limestone lakes in Ha Long bay - Cat Ba archipelago (Ngai, N. D., et al., [8] with modifications)

No.	Parameters	Ang Du	Ang Dau Be	Ang Qua bang	Allowable limits
1	Temperature (°C)	29.0	32.10	30.9	30
2	DO	8.64	9.03	7.63	≥ 5
3	pH	7.62	7.80	7.88	6.5–8.5
4	Concentration for salt (%)	9	24	23	-
5	Nitrite (N-NO ₂)	5.68	5.35	4.94	< 10
6	Nitrate (N-NO ₃)	76.50	108.60	105.6	60
7	Ammonium (N-NH ₄)	32.72	36.57	49.61	70
8	Phosphate (P-PO ₄)	15.84	17.92	18.00	15
9	COD (mg/l)	1.96	2.16	1.83	3

The above data have not manifested all the species diversity of saltwater lake ecosystem because of limited extent of investigation, the groups of echinoderms and sea fish have been little investigated.

The research results of many authors [4–6] defined special values of saltwater lakes expressing scientific and practical values such as:

Expressing the strong evolution of communities that often makes up new species and endemic species.

The saltwater lake ecosystem is the proof for evolutionary adaptation of organisms with the new species formation in the new experimental conditions.

Being specific sea ecosystem but more or less separated from surrounding sea, they express obvious impact of weather, climate on the environment.

The too little existence of saltwater lakes all over the world is one of rare and precious characteristics which should be protected.

From above characteristics, saltwater lake ecosystem has created wonderful chance to watch, to study the relation between the fluctuation of physical climate factors and the evolution of ecology and population.

CONCLUSION

With 2,147 species of sea organisms, among them 114 recorded in IUCN Red List, it is a clear evidence demonstrating that the sea region of Ha Long - Cat Ba is a high diversity centre of marine organisms which have high valuable conservation.

Among 7 typical ecosystems of Ha Long - Cat Ba site, there are 5 sea ecosystems characterizing interferential process among repetitively ecological processes of progressing sea that can be observed nowhere. The information of over 130 limestone saltwater lakes here has expressed global value of marine ecosystem.

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