Vietnam Academy of Science and Technology

Vietnam Journal of Marine Science and Technology

journal homepage: vjs.ac.vn/index.php/jmst

Research results of biological resources and and biodiversity of Vietnam sea: current status, treats, proposed solutions to use lasting

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Received: 7 October 2021; Accepted: 30 December 2021

ABSTRACT

The marine biology investigation and research activities in our country since 1990 have made remarkable changes; especially there have been changes in thinking, scale, content, level, research, skills research, and international relations in research. We have proactively overcome the limitation of general, preliminary, and undirected investigation to shift to new thinking about research gradually. Research on changes in typical ecosystems is extended to the whole sea, to deep water, offshore and remote islands such as Pracel (Hoang Sa) and Spratly (Truong Sa). We have focused on researching issues about the causes of formation, the law of fluctuations, and the mechanism of action of marine processes, studying the basis of the application of technology, and creating new technologies to solve these problems in practice. Therefore, there have been outstanding results compared to the period before 1990. It has been identified that there is a high level of biodiversity in the sea of Vietnam with over 11,000 species, forecast to reach 12,000 marine species, and 134 species are listed in the Red Book of Vietnam, but the structure of biodiversity and marine resources in our country are also susceptible and vulnerable. Also, nearly 20 specific ecological systems and sub-systems have been identified in the sea and coastal areas; Seafood reserves of almost 4 million tons are an essential basis for developing eco-tourism, fishing, and aquaculture. Due to economic and social activities, many threats to marine biodiversity have been caused: narrowing of ecosystem area, decrease in density, number of species and reserves, decrease in ecosystem value, and habitat degradation. The real solutions to conserve and sustainably use biodiversity and marine resources include institutional and policy solutions, strengthening the construction of protected areas, artificial reefs, and areas where exploitation is prohibited over time, sustainable exploitation and cultivation of marine resources, and sustainable marine economic development.

Keywords: Biological research, transformation, initiative, expansion, causes, laws, biodiversity, vulnerability, ecosystem, solutions.

Citation: Do Cong Thung, 2022. Research results of biological resources and biodiversity of Vietnam sea: current status, treats, proposed solutions to use lasting. *Vietnam Journal of Marine Science and Technology*, *22*(1), 1–20. https://doi.org/10.15625/1859-3097/17034

ISSN 1859-3097/

INTRODUCTION

In the world, seas and oceans occupy an area of 361 million square kilometers, accounting for 71% of the earth's area. Vietnam's sea has an area of over 1 million square kilometers, three times larger than the mainland. Currently, the whole world is making significant efforts to reach out to the sea to explore and exploit the available potential of the ocean. Every year, the world catches about 93 million tons of seafood, of which Asia accounts for 50%, and Vietnam alone exploits about 3.5 million tons of seafood each year. Vietnam is one of 16 countries possessing the highest biodiversity globally [1]. In particular, Vietnam's sea is considered one of the world's high biodiversity centers, with particular significance in terms of economy, politics, security, and defense. Along the coastline, running over 3,260 km, with more than 3,000 coastal islands such as Ha Long - Cat Ba; Offshore includes Paracel islands (Hoang Sa islands) and Spratly islands (Truong Sa islands) together with hundreds of large and small bays, creating particular ecosystems that can develop a variety of different industries but are also susceptible areas in the process in usage mining.

Over the past decades, the study of marine biological resources has made quite strong strides, making significant contributions to determining a high level of biodiversity, rich marine resources, and studies that have only. There are still many challenges to face. The pressure of socio-economic development and the environment has caused excessive exploitation, depleted resources, disrupted natural habitats, and negatively impacted biodiversity. Biodiversity loss, inefficient use of resources, industrial pollution and waste, and high consumption lifestyle will push the earth toward environmental disasters. Therefore, rational use and conservation of marine resources is a crucial issue in the immediate and future. Recognizing the importance of this issue, we have made considerable efforts in studying biodiversity and proposing sustainable management practices for many years. The content of the article published below aims to evaluate the achievements of marine biodiversity research in the recent 30 years and propose some solutions to conserve marine biodiversity in Vietnam.

RESEARCH MATERIALS AND METHODS

The sources used in the report include the following four primary sources:

Research documents on biodiversity and marine biological resources from National Science and Technology Programs surveys such as Programs KHCN.06 (1995–2000), KC.09 (2001–2005), KC.09/06–10 (2006–2010), KC.09/11–15.

Source material from the program of the East Vietnam Sea - Hai Dao program.

Sources of international cooperation documents:

The Vietnam - Russia mixed survey on the ship Academician Oparin in 2007, 2010, 2013.

Research on biodiversity conservation in Vietnam's coastal strip (theme belongs to the international cooperation program on science and technology under the Vietnam - Italy protocol).

Published data of marine scientific research institutes.

In addition to the four primary sources mentioned above, thematic research results on ecosystems and resources of localities and ministries are also gathered to assess the current status and changes in resources.

Determining the level of biodiversity: using statistical methods of species composition and ecosystems in the sea.

Variation of resources is determined through the change in the number of species, density, and mass of some major groups of organisms such as benthic, plankton and marine fish, etc.

Proposing solutions for sustainable development of biodiversity and resources: determined by logical analysis to find out the factors that ensure the exploitation management has little impact on the resources.

RESEARCH RESULTS

Current status of biodiversity and sea life resources of Vietnam

Diversity of marine species composition

In 2005, author Do Van Khuong published data about 11,000 known marine species in

Vietnam [2]. Among these, benthic animals account for the most significant number of species, about 6,000 species, accounting for 57.5% of total species. The second most notable is the marine fish group of 2,038 species, accounting for 19.5%; the remaining groups account for only 22.9% of the total species, including mangrove 94 species, seaweed 662, seagrass 15 species, phytoplankton 537 species, zooplankton 659 species. As for the coral coastal zone, Vietnam's sea has 346 hard corals, 43 seabirds, 32 species of marine mammals, reptiles, etc. Because many species have not been named yet, which are still in the archives of tens of thousands of specimens of research institutes, the number of marine species is expected to reach about 12,000 species [3]. The above figures partly show the high diversity of Vietnam's sea, one of the ten areas with high biodiversity [4]. In the first two decades of the 21st century, the study of marine biodiversity has made remarkable progress, giving new data on groups of offshore marine organisms, especially pelagic fish groups, massive tuna groups, sharks, and some other less known groups of creatures such as small benthic crustaceans, jellyfish, sponges, nematodes. Recent studies on Sponges have determined that Nha Trang bay has 100 species [5], Con Co has 112 species [6], and the limestone island in the Northeast Sea added 54 species, including one new species for science. [7]; coastal waters of North Central Vietnam 66 species. In a compilation of the complete list of Vietnamese sea sponges, there are about 223 species distributed in the sea of Vietnam. Similarly, 128 species of jellyfish have also been updated to the list of marine species in Vietnam; Other benthic crustaceans (Amphipoda - Gammaridae) were benthic, adding 106 species [8].

In addition to identifying some fewer known species in Vietnam's sea, the analysis results from the Vietnam - Italy cooperation project, 2000–2004's samples also show a shift distribution area of some benthic species from the southern sea to the Gulf of Tonkin. One of the typical examples of shifting ecological distribution of the blue starfish (*Linckia laevigata*) and the snail (*Cellana testudinaria*), before 2000, it was usually distributed only from the 16th latitude to the south, now found in most of the coastal waters of the central island as far as Con Co island (Quang Tri). This phenomenon, possibly due to the warming of seawater masses due to climate change, has created favorable environmental conditions for these species to enter the northern waters of Vietnam.

Research results on threatened and endangered species have shown a high threat to Vietnam's marine life, representing 134 species recorded in the Vietnam Red Book in 2007, accounting for 32.06% of our country's threatened animal species (a total of 418 species). In which five species of marine mammals, five sea turtles, 53 species of marine fish, 15 species of corals, five species of echinoderms, one species of Sam, 11 species of crustaceans, and 39 species of mollusks [9]. Currently, most hard coral species have been assessed as endangered and need to be protected and banned from fishing activities.

Recently, many studies have also shown that the unsustainable level of the structure of Vietnam's marine life is the cause of the complete loss of a species or family or order due to human or environmental impacts. A typical example is that in the coastal strip from Mong Cai to the North of Hai Van pass, there are about 1,790 species of benthic animals distributed. Annelids (Anelida) 378 species, accounting for 21% of the total species; Mollusca (Mollusca) 854 species, accounting for 47.7%; Crustacea 415 species - 23.2%; Echinodermata is the lowest with only 144 species - 8% of the total species. Statistical results have shown that, out of a total of 40 families of Angiosperms, there are 25 families, accounting for more than 50%, with only 1–|4 species/family; 120 families of Molluscs have 85 families with a low number of species, only 1–6 species/family, accounting for 70.8%; 44 families of crustaceans have 26 families, accounting for 59.1% with a low number of species, only 1–4 species/family. Similarly, among 144 species of echinoderms, there are 22 families in 39 families, accounting for more than 50% of families with only 1–2 species/family [10]. With such a very

unsustainable structure, it will contribute to accelerating the decline in the number of species in the waters of Vietnam.

Diversity of marine ecosystems in Vietnam

Developing the study of marine ecosystems, from structural to functional problems, causes of degradation, and initial restoration research, is a new point in biological and ecological research activities. Before 1990, because there was no deep diving equipment, the research was mainly on assessing the status of marine ecosystems. Due to the application of deep diving techniques, the research direction has been expanded to study marine ecosystems associated with environmental status assessment issues and build marine nature reserves—sea system in the past period. In the past 30 years, we have had a complete assessment of the primary ecosystems of Vietnam's sea. An in-depth understanding of the ecosystem in tidal zones, mangroves, seagrasses, corals, conifers, bays, and offshore and coastal islands has contributed to a complete assessment of Vietnam's marine resources.

Island ecosystem

Vietnam has more than 3,000 large and small islands distributed along the coast, from Tra Co island in Quang Ninh province to Phu Quoc island in Kien Giang province, offshore islands such as Bach Long Vi in the middle of the Gulf of Tonkin, the Pracel islands are located in the center, and the Spratly islands are located in the south of the East Vietnam Sea. In general, coastal islands are usually low mountain islands with an area from extremely small (< 0.001 km^2) to large (> 100 km^2 [11]. The richness and diversity of species composition depend on the island's area and the presence or absence of population, geographical location (continental zone), distance to the continental coast, and extent of exploitation. In terms of flora, so far, the islands have been enumerated. Limestone in Vietnam has a distribution of 1,594 species, belonging to 807 genera and 185 families of 5 vascular plants. Psilotophyta has one family, one species; Lycopodiophyta has seven species; phylum Polypodiophyta has 20 and 79 species; phylum Pinophyta has three families and ten species; phylum Magnoliophyta has 159 families, 1,291 species, and subspecies are mainly concentrated in 2 areas. The main areas are Ha Long - Cat Ba and Bai Tu Long; 1,097 species of animals living in the forest on limestone islands have been identified, of which 66 species of mammals, 295 species of birds, 80 species of reptiles and amphibians,193 terrestrial snails and 463 insect species (Topic KC09 .11/16–20). With the advantages of geographical location, topography, and geomorphology, the vegetation on the island has created its unique values, where it preserves the characteristics of the marine - island ecosystem in the waters of Vietnam. The environment and unspoiled natural landscape are an invaluable "treasure" of the country today and are considered the most unique in Southeast Asia in terms of ecology, science, education, and training. Especially the latest publications on biodiversity and conservation potential in the Spratly islands have identified 2,927 species of plants, animals, and 55 rare species distributed in the Spratly islands [12]. Together with specific ecosystems such as corals and seagrasses, it has created great potential for conservation in this area, and it has been proposed to add two conservation areas, Nam Yet and Thuyen Chai, to the system of marine protected areas in our country.

Lagoon ecosystems

They are concentrated mainly on the Central Coast of Vietnam (limited from Quang Binh to Binh Thuan). Due to the rugged terrain conditions with many different forms of abrasive accumulation, many lagoons have been created and distributed along the Central Coast. The lagoons usually have a flat bottom and a small depth of about 2–4 m of water. Bottom sediment can be divided into coarse sand, medium-, and fine-grained mud. Because lagoons connect with the sea by small gates, their hydrological regime is strongly influenced by the dry and rainy seasons, ranging from 1–32‰. The temperature regime is relatively stable; the average summer is 27–31^oC, and the winter is 22–26^oC. The main lagoons in Vietnam are Tam Giang - Cau Hai, having an area of over 20,000 ha, Lang Co (6,000 ha) in Thua Thien Hue province; Thi Nai lagoon (5,000 ha) (Binh Dinh province); Cu Mong lagoon (2,600 ha), O Loan (1,500 ha) (Phu Yen province); Nha Phu (5,000 ha), Thuy

Trieu lagoon (2,000 ha), belongs to Khanh Hoa; Nai lagoon covers an area of 130 ha in Ninh Thuan province. There are over 1,000 species of animals and plants living in the lagoon. The group of benthic animals has the most significant number of species, from 200–300 species, followed by phytoplankton and marine fish [13]. Biodiversity level the lagoon is assessed quite fully in terms of species composition and economic species in the main Central Coastal lagoon such as Tam Giang - Cau Hai (880 species), Truong Giang (632 species), An Khe (457 species), Nươc Man (444 species), Tra O (515 species), De Gi (595 species), Thi Nai (670 species), Cu Mong (501 species), O Loan (677 species), Thuy Trieu (721 species), Nai lagoon (561 species) [13]. The lagoon is an important economic center of the central provinces, and aquaculture activities are very active in this area.

Ecosystem of lagoons and bays

The coastal bays of Vietnam are mainly shallow, both freshwater from estuaries and coastal seawater. Therefore, the bay's ecosystem characteristics are mixed between the estuary ecosystems and the coastal waters, clearly reflected in the environment and the biota aspects. The most prominent is the intense fluctuation of salinity in the rainy season and the appearance of coral and mollusk communities representing the coastal waters of Vietnam. The major bays of Vietnam include Dam Ha - Ha Coi, Dong Rui, Co To, Quan Lan, Bai Tu Long, Ha Long, Cua Luc, Lan Ha, Dien Chau, Chan May, Da Nang, Dung Quat, Van Phong, Nha Trang, Phan Ri, Phan Thiet, Mui Ca Mau. Ha Long bay, Bai Tu Long bay, Lan Ha bay, and Nha Trang bay have been included in heritage sites and habitats, books, and national parks for strict protection. The bay has a close relationship with the sea, so the number of species is wealthy, and many species have high economic value. Currently, 12 types of ecosystems have been identified directly or indirectly related to the bay: dunes, planted forests, green forests on the island, mangroves, tidal zones, culture lagoons, seagrasses, corals, soft bottoms, hard bottom, estuary, bay mouth. The number of species also varies considerably depending on the bay's size, depth, and location. Seaweed has a variable number of species from 16–136 species; phytoplankton from 100–300 species; marine zooplankton from 25–124 species; benthic animals from 25–690 species. Similarly, deep-sea fishes are about 100–200 species; corals do not exceed 200 species [14].

Ecosystems of Kasters lakes (Tung, Ang) and Cave on limestone islands

We have had a complete assessment of the *Kasters lakes* (Tung, Ang), and Cave ecosystems. These are specific ecosystems for the Cat Ba - Ha Long - Bai Tu Long limestone Karst islands that are not present in other places. More than 47 kasters caves have been discovered in Ha Long bay and are concentrated in the center of Ha Long Heritage Area and about eight caves in Cat Ba, Bai Tu Long, and Kien Luong. The caves are home to about 21 species of crustaceans, 51 species of spiders, and 35 species of bats. The saltwater lake (Ang) ecosystem is a typical and unique ecosystem of the seas of the world and Vietnam. In particular, the Ang is densely distributed in the limestone islands of Ha Long bay - Bai Tu Long - Cat Ba. The waters of Ha Long - Cat Ba are characterized by limestone blocks formed from the Neogene period about 23 million years ago. This limestone mountain area is influenced by the tropical monsoon climate, characterized by a high yearly rainfall average, high humidity, and average annual temperature of about 25^{o}C. In terms of origin, the Ang ecosystem is karst sinkholes created during geological tectonics, connected to the sea by narrow gates or tunnels (possibly underground caves), or completely closed. The whole Ang is a reservoir of karst water - limestone mountains located between islands with no doors to the sea; water is circulated through small slits or underground cave systems. Due to parallel development with the historical formation of the Ha Long - Cat Ba limestone archipelago and relatively isolated from the outside environment, Tung and Ang often reflect the true evolutionary history of biological groups in this area. The isolation from the surrounding environment is also a good condition for forming new species that complement the genetic richness of the area. The specificity of

Ang and their too small number make scientists consider this a rare and sensitive ecosystem that needs to be studied and protected. In 1997, Ang was first understood as a complete ecosystem and continues to be studied today. In 1997, two authors, Do Cong Thung and Nguyen Chu Hoi, announced that they had found in the area of Ha Long bay, Bai Tu Long bay, and Cat Ba a total of 62 ag and 57 junipers. According to estimates, the total area of 62 Ang is 289.4 ha, and of 57 Tung is 1,186.2 ha. In 2017, when studying in detail on Google Map, biologist Jaap Vermeulen announced about 138 saltwater lakes in Ha Long bay - Cat Ba islands, accounting for nearly 50% of the world's saltwater lakes. [15]. Ang usually has a small area, the smallest is 0.7 ha (Ang Tro Moi), and the largest is 28.8 ha (Ang Vem - Cat Ba). The species composition of the biomes in saltwater lakes (the ponds) is quite diverse; in the tidal area, there is often an alternating structure between groups of organisms attached to the group of benthic organisms on the sand-gravel background. The submerged part of the lake has coral and seaweed growing, in many places quite dense. Therefore, here creates a beautiful landscape, beautiful to tourists. So far, more than 150 species of animals and plants living in saltwater lakes have been discovered. There are 21 species of seaweed, 37 species of mollusks (19 species of the Gastropods and 18 species of Bivalve), eight species of crustacean, six species of echinoderm, and 31 species of sponges, 41 species of coral and and six fish species [16].

Tidal ecosystem

Due to the tremendous tidal variation in the Tonkin Gulf and Southeastern region, more than 4 m/0 m on the chart, the tidal flats in this area are often long and wide. These are two areas with particular and typical tidal ecosystems. Large tidal flats in Hai Phong, Quang Ninh, Thai Binh, etc., are places with many food specialties of Vietnam. The tidal zone is divided into high-tide, mid-tidal, and low-tide zones based on the tide change. Each region often has different populations of organisms. On the intertidal flats, especially in the mid-to low-tide areas, there are often many specialty beaches distributed, such as asiatic hard clam (Hai Phong, Thai Binh, Nam Dinh, Thanh Hoa, Nghe An) and white hard clam (Ben Tre clam) (Tra Vinh), beach (Quang Ninh), ark clam (Hai Phong, Nha Trang, Nghe An), snout otter clam (Hai Phong, Quang Ninh). When studying the ecosystem's biodiversity in the intertidal zone of the Tonkin Gulf to a depth of 6 m, a total of 2,949 species of organisms have been identified, the highest being 1,146 benthic species, accounting for 38.9% of the total species, followed by marine fish with 473 species - 16% (14 rare species), phytoplankton 349 species - 11.8%, seabirds with 195 species - 10%, the lowest is seagrass with five species - 0.5%. Of which, 129 species were discovered for the first time in the Tonkin Gulf, including 24 species of mollusks, eight species of crustaceans, 18 species of echinoderms, and 29 species of sponges, 28 species of soft corals, and 22 species of seaweed [17]. The tidal zone ecosystem is divided into five different sub-branches, including intertidal reef zone, muddy bottom tidal zone, sandy intertidal zone, mangrove tidal zone, and estuarine tidal zone.

Mangrove forest ecosystem

Mangroves are distributed along the coastal estuaries of Vietnam. Before the war, Vietnam had roughly 400,000 ha, but in 2000 it was about 155,290 ha; the average rate of mangrove loss was 4,400 ha/year [18]. The major mangrove regions of Vietnam are concentrated in Mong Cai, Cua Ong, Quang Yen, Cat Hai, Tien Lang, Thai Thuy, and Xuan Thuy. The most developed mangroves in Vietnam are from Vung Tau to Ha Tien. Can Gio and Ca Mau cape are famous for mangrove forests, and the mouths of Tien and Hau rivers are famous for Ban forests. Recent research results in the northern coastal strip of Vietnam show that the recovery of mangroves is quite fast. Mangrove plants are distributed over 41,235.9 ha, most in Quang Ninh at 21,702 ha, and least in Quang Binh with only 70 ha. Of these 20,972 ha are natural forests, and 20,264 ha are planted forests (Table 1). The biological productivity of mangroves is very high. The average biomass of mature forest is 229,062 kg/ha, naturally regenerated forest is 14,004 kg/ha, and the

average age of 7 years old mangrove forest is 33,840 kg/ha. The mangroves are the habitat of the young, the spawning ground of many specialties such as boredom, shrimp, cobia, etc.

Table 1. Area of coastal mangroves from Quang Ninh to Quang Binh

Province, city	Total area (ha)	Area of natural forest (ha)			Area of planted forest (ha)		
		Protective	Special use	Manufacture	Protective	Special use	Manufacture
Quang Ninh	21,702.8	17,596.8	92.3	2,818.6	1,189.9	-	5.2
Hai Phong	4,742.1	176.7	255.6		4,309.8		
Thai Binh	7,084.0				5,064.0	2,020.0	
Nam Dinh	3,546.5				2,145.5	1,110.7	290.3
Ninh Binh	1,550.0				1,550.0		
Thanh Hoa	1,192.8				929.6	138.5	124.7
Nghe An	551.3	-			551.3		
Ha Tinh	796.5	32,0			764.5		
Quang Binh	70.0	0			70.0		
Total area (ha)	41,236.0	17,805.5	347.9	2,818.6	16,574.6	3,269.2	420.2

Source: Topic KC09.07/11–15 [17].

Seagrass ecosystems

In Vietnam, seagrasses are distributed along the coastal strip from Quang Ninh to Kien Giang, especially the tidal flats in the Central Region to Con Dao, Phu Quoc, and Spratly islands have quite a lot of seagrass beds on tidal flats and subtidal areas up to 5 m of water. Because of the different climate characteristics of the North and South sea, the composition of seagrass species is also different. In the North sea, there are nine species of seagrass distributed, mainly species of the genus Zostera, typical for the subtropical flora. The Southern region (from Hue to Kien Giang) has 14 species. About ten species are widely distributed in the Indo-Pacific; only four species, *Cymodocea rotundata, C. serrulata, Springodium isoetifolium, Thalassia ciliatum*, are distributed narrowly, from East Africa to Australia. In general, the number of species tends to increase gradually from north to south: Quang Ninh - Hai Phong (5 species), Tam Giang - Cau Hai (Hue) (6 species), Phu Yen (7 species), Khanh Hoa (9 species), Con Dao (Ba Ria - Vung Tau) (11 species), etc. In 2013, about 16 seagrass species were distributed in 33 regions along the coastal strip of Vietnam and Spratly islands, on an area of 18,130 ha [19]. Seagrass beds are ideal habitats for living creatures. According to the most recent research results, the number of species and density of benthic animals in the seagrass bed is many times higher than that of the seagrass beds. Seagrass beds are the habitat of the young and an essential source of food for dugong, one of the rare marine species in our country.

Coral ecosystem

A collection of research results shows that coral ecosystems have been studied and published continuously from 1926 to today. Especially after the Nha Trang Institute of Oceanography was established (1922), coral research was mainly conducted by French authors such as Dawydoft (1936–1952), Seren (1937, 1959), Pax and Muller (1957) [20]. From 1975–1990, Russian scientists conducted many studies on corals in South Vietnam and the Spratly islands. From 1991 to today, the coral ecosystem has been further studied by Vietnamese scientists, including the distribution and causes of the degradation of marine corals in Vietnam.

There are three types of morphological structures of marine reefs in Vietnam: fringing reef, platform reef, and Atoll reef. Coastal reefs are widely distributed in coastal waters - islands such as Ha Long, Cat Ba, Co To, Bach Long Vi, Cu Lao Cham, Ly Son, Phu Quy, Con Dao, Phu Quoc, Tho Chu, etc. This species often thrives around islands with hard bottoms and is less affected by estuary water.

Platform reefs or Patch reefs (Stoddard, 1970) are usually reefs that develop on shoals and hills. Along with the long-term

development process, often forming atolls (Cays), widely distributed in the southern continental shelf of Vietnam and the Paracel and Spratly islands. The large shoals in Nha Trang bay, Thuy Trieu shoal (Khanh Hoa), North Cu Lao Cau shoal (Binh Thuan), and Cays (low island) features in the Truong Sa and Hoang Sa areas are typical reefs in Vietnam's sea.

The Atoll Reef atoll is a very typical form for offshore islands such as Paracel and Spratly islands. In the Pracel and Spratly islands, atolls have a structure with large arcs formed by Cays and coral reefs surrounding a large lagoon with a depth of not more than 50 m. Typical reefs are Convex Reef (Pracel islands); Gemini Reef (including Song Tu Dong, Song Tu Tay, Dinh Ba, and Da Nam atolls); Nam Yet Reef, Sinh Ton, etc.

In terms of species diversity, corals have many species distributed in offshore islands and lower in nearshore areas. Recent publications show that corals' high species diversity is often concentrated on relatively offshore islands, such as in the Spratly islands, with 382 species, 70 genera, and 15 families [22]. When studying corals in 19 islands belonging to marine protected areas, 378 species of 69 genera and 15 families of hard corals have been identified; The order of soft corals identified 66 species belonging to 24 genera and ten families [23]. Out of more than 400 species of 80 known coral species, the diversity of marine coral species in Vietnam is comparable to that of the most diverse coral regions in the world [21].

The coverage of coral reefs in the sea of Vietnam is not high; the suitable type is only about 1% of high-coverage reefs, average coverage varies from 26–41%, and the rest are low-coverage [21]. However, the coral reef ecosystem is still home to about 1,258 species of reef fish, 552 species of algae, and over 1,000 species of benthic organisms.

Upwelling ecosystem

Research results for the period 1992–2017 in the coastal waters of Vietnam show that there are many seasonally stable upwelling areas (UI > 0) such as the South-Central Sea area (from May to September), the area around Bach Long Vi island (from June to September), the offshore area of Nghe An - Ha Tinh (from June to August), etc., alternating where there are submerged areas (UI < 0). In addition, there are areas of unstable upwelling water around the islands in the sea. The formation of upwelling is an oscillation of the Southwest monsoon from May to September every year, the period of strong upwelling is July, and the surface water temperature is always lower than 27^{o}C in the central region. Upwelling water is 24.5–25.5^{o}C, while the temperature of the neighboring water is higher than 28^{o}C. Anomalous surface water temperature for many years is 4^{o}C, and salinity is +1.2. Salinity is more than 34‰. Because the nutrient-rich water mass of the 10–20 m layer is brought to the sea surface to meet sunlight, photosynthesis and biochemical processes actively create the initial material source - primary biological productivity as a rich food source for living things. The research results also proved that the average primary production capacity in the South-Central region upwelling waters was 60.22 ± 45.27 mgC/m^3.day. This value is 1.3 times higher than primary production in the continental shelf. During the upwelling period, the abundant food source has attracted fish species to forage, fatten and breed, a significant fishing ground of Vietnam's sea [24].

Marine biological resources of Vietnam

According to statistics, 80% of catches are in the coastal areas of Vietnam. The research results so far have listed the main economically essential species in the coastal regions of Vietnam, such as fish, mollusks, crustaceans, and seaweed.

Marine fish: of about 2,400 fish species, there are 130 economic fish species, which are high-yielding species; they belong to 39 different families, typically mackerel sharks (Lamniformes), herring (Clupeidae), anchovies (Engraulidae), wolf herrings (Chirocentridae), Lizardfishes (Synodontidae), ariid catfish (Ariidae), flying fish (Exocoetidae), mackerel fish (Scombridae), tuna (Thumnidae), etc. Vietnam's marine fish reserves fluctuate in different periods, averaging 4,081,744 tons (Table 2).

Table 2. Marine fish stocks by different periods

Publication years	Fish stocks (ton)	Data sources
1990	4,100,000	Dao Manh Son et al., [2]
2003	3,072,800	Do Manh Son et al., [2]
2009	5,075,143	Do Manh Son et al., [25]
2016	4.360.000	Nguyen Viet Nghia and Vu Viet Ha [26]
Present	3,800,777	General Depart. Fisheries, unpublished data
Average	4,081,744	

Crustaceans: currently, we have identified 40 species of penaeids shrimp (Penaeidae), 9 species of spiny lobsters (Palinuridae), and 9 species of slipper lobsters (Scyllaridae), and four species of nephropids lobster (family Nephropidae) which have economic values. Among these, 11 species of penaeids shrimp are particularly valuable. The main shrimp fields are distributed in 30 m or fewer depth areas. According to published data in 2006, the crustacean reserve in the Tonkin Gulf is 1,408 tons, in the Central sea region is 2,300 tons, and in the Southeast sea region is 3,983 tons. On the other hand, the exploitation capacity in the Tonkin Gulf is 704 tons, in the Central Sea region is 1,150 tons, and in the southeastern is 1,946 tons. The sea area near the southwestern coast has a reserve of 3,383 tons and an exploitation capacity of 1,946 tons [27]. However, after quite a long research period, the crustacean resources have been more accurately identified, but most of them have not been published yet.

Mollusks: currently, there are about 2,500 mollusks species in Vietnam's sea, of which there are over 100 species with commercial value and rare species. The groups with an economic value focus mainly on the class of bivalve mollusks (Bivalvia), followed by the cephalopods (Cephalopoda) and gastropods (Gastropoda). It is estimated that the reserve of mollusks in the sea of Vietnam is about 1,000,000 tons, and the exploitation capacity is 500,000 tons/year [27].

Seaweed: 90 species of seaweed have economic value at different levels. Group of seaweed used to process industrial products 24 species, accounting for 26%; seaweed for medicinal purposes 18 species (20%); seaweed for food 30 species (33.3%); seaweed for fodder 19 species (11.1%) and seaweed for fertilizer eight species (9%) [27].

Seabirds: most of the 43 species of seabirds in our country are used as food sources in the form of specialties. Today's most important group of birds is the edible-nest swiftlet (*Callocalia fuciphaga germani*).

Other resources: in addition to the main groups of resources mentioned above, corals, echinoderms, marine mammals, and marine reptiles are also groups of particular economic value that need to be protected in the sea area. Vietnam.

Marine medicinal resources: this is the latest research result-oriented on the use of marine therapeutic resources from groups of organisms that are considered to have no economic value, such as sea sponges, soft corals, microorganisms, etc., become a group of organisms of exceptional value. The Institute of Marine Biochemistry, Natural Compound Chemistry, Institute of Marine Environment and Resources, etc., published many species of organisms containing precious medicinal herbs in the sea of Vietnam [28]. According to recent publications, steroid compounds in many species of Sea sponges are highly resistant to cancer cells. Research results also show that diterpenoids, lipids, and fatty acids have also been detected in soft coral species; Holothurins isolated from the sea cucumber group also showed activity against liver cancer [28].

Division of biodiversity and biological resources of Vietnam's sea

Most economic activities are related to the marine environment, such as sea transportation, aquaculture, fishing, mineral exploitation, tourism, industrial activities, etc. It is natural disasters, human activities, and environmental pollution factors that have been creating

significant pressures to degrade our country's marine and coastal environment. The consequences lead to the degradation of marine ecosystems, biological resources, and biodiversity.

The declining area of mangroves

The natural tidal zone in Vietnam is continuously narrowed for economic development and urbanization. The main activities are agricultural reclamation, aquaculture pond construction, salt field construction, ground leveling, river embankment construction, freshwater reservoir construction, etc. Most of the intertidal area is exploited to make agricultural land and raise seafood. If in 1998, the coastal area for aquaculture was estimated at 210,000 ha in 30 provinces and cities; in 2000, it was 280,000 ha, mainly for black tiger shrimp farming. Recent research shows that black tiger shrimp ponds in the North and North-Central Coast are mostly built on high tidal flats with mangroves in the estuaries, which has narrowed the mangrove area significantly. The area in 2001 was 46,111 ha of forest [30], in 2008 it was 31,788 (KC 09.26/06–10), and in 2014 it increased to 42,016 ha, including 20,972 natural forest and 21,044 ha as planted forest [KC09.07/11–15] (Table 3). A comparison of mangrove forest data shows that in developing brackish water aquaculture by 2008, the Northern coastal region of Vietnam has used about 14,322 hectares of forest to build ponds, accounting for 31% of the total area of mangroves. Due to the policy of restoring mangroves, aiming to protect the environment, by 2014, 21,044 hectares of mangroves had been planted, bringing the total area of mangroves along the northern coast to 42,016 hectares less than in 2001 is 4,095 ha, equivalent to a loss of 8.9% of the total area compared to 2001 [17]. Thus, after nearly 15 years, mangroves along the Gulf of Tonkin have recovered quite strongly in terms of forest area, but it has not been recovered in terms of species composition. The increase in mangrove area is always inversely proportional to the area of shrimp farming.

Table 3. Change in area of mangroves and shrimp ponds as of 2014 (from Quang Ninh to Quang Binh)

Location	Areas of shrimp ponds (ha)		Areas of mangroves, 2001** (ha)	Areas of mangroves, 2008*** (ha)	Areas of mangroves, 2014**** (ha)		
	2008*	2014****			Total	Natural forest	Planted forest
Quang Ninh	15,884	9,119	22,969	17,782.50	22,482.8	20,507.7	1,975.1
Hai Phong	9,655	3,086	11,000	3,719.90	4,742.1	432.3	4,309.8
Thai Binh	27,472	3,250	6,297	5,000.00	7,084.0	0	7,084.0
Nam Dinh	5,001	3,627	3,012	1,476.00	3,546.5	0	3,546.5
Ninh Binh	3,163	2,143	533	1,550.00	1,550.0	0	1,550.0
Thanh Hoa	6,058	4,073	1,000	708.00	1,192.8	0	1,192.8
Nghe An	1,711	2,190	800	819.00	551.3	0	551.3
Ha Tinh	3,549	2,050	500	733.00	796.5	32	796.5
Quang Binh	1,981	951	0	0	70	0	70
Total	74,474	30,489	46,111	31,788.4	42,016	20,972	21,044

Notes: *: Nguyen Duc Cu (2012) [7]; **: Lai Dinh Sam (2005) [18]; ***: KC09.26/06–10; ****: KC09.07/11–15 [17].

Coral ecosystem degradation: the distribution area of corals is also shrinking significantly. When studying coral reefs in the southeastern area of Cat Ba, in 2004, out of 19 reefs examined by diving, up to 11 reefs (58%) were destroyed or degraded [28]. In this reef area, the reef surface is covered with dead coral. The coral species composition is also inferior and monotonous. The research results on coral reef degradation in Nha Trang bay also gave similar results. Of the eight studied sites, in 1994, the coverage was approximately 30%, by 2009, 2010 it was reduced to < 10% (Southeast of Hon Mieu, Bai Lan, Bai Nghe, Hon Vung) only Hon Mun, Bai Bang, has a good percentage of living corals with good coverage,

instead of living corals are seaweeds and benthic species that eat seaweed and eat developed corals [31]. Not only the coastal coral reefs were destroyed, but even the coral reefs on remote islands such as Bach Long Vi were also seriously reduced. Monitoring the development of coral reef northeast of Bach Long Vi island from 1993 to 1999 showed a very rapid decline; in 1993, the coverage reached 95%, in 1996, it was 47.6%, and in 1999. The range is only approximately 20%. Currently, the average coverage is 18.75% [27]. A general assessment of the current status of coral reefs in Vietnam's sea shows that by 2005, only 1% of the reefs in Vietnam had high coverage, good coverage of 26% and 41% on average, and the remaining 30% was low coverage [21]. The general trend is that the range of coastal coral reefs is gradually decreasing over time. The KC09.11/16–20 project shows that, before 2000, in Ha Long bay, corals were distributed even on the edges of near-shore islands such as Dau Go, Hon Veu, and Dam Nam. Many reefs stretch wide up to hundreds of meters. However, due to the polluted environment, the strong development of tourism and shipping has caused corals in Ha Long Bay to change significantly in area and distribution range. Currently, coral reefs have been narrowed in terms of distribution and area; most of the reefs have a small distribution scale or just a narrow strip of reefs along with the islands. Today, the areas with the most distributed corals are Cong Do, Tra San, Bo Hung, Hang Trai, and Dau Be areas. Coral reefs in the inner island, such as Dam Nam, Bo Hon, Bu Gray, Co Ngua, and Tam Cung, have died a lot; the rest have negligible coverage. Of the 18 surveyed reefs, there are no reefs belonging to good and excellent reefs (range over 51%), only four reefs belonging to good reefs (level 3, coverage from 31–50%), nine reefs with moderate coverage (level 2, range from 11–30%) and there are five poor reefs (level 1, living coral cover less than 10%). In general, low-coverage reefs are located near the shore, where human activities are active and close to waste discharges from the mainland (Figure 1).

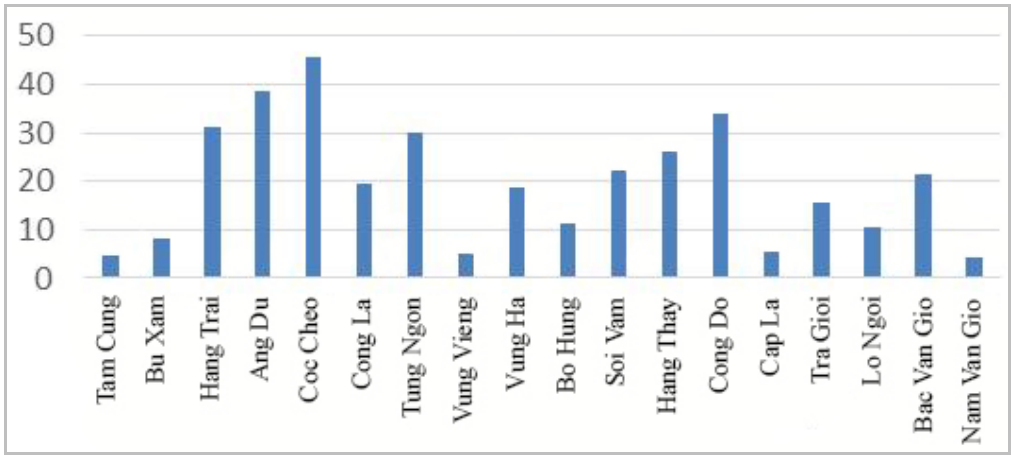

Figure 1. Coral cover at survey sites in Ha Long bay in 2018 (coverage %)

The decline of habitat within the ecosystem: The ecosystem is degraded, accompanied by the deterioration of the living environment. When the mangroves are dead in the aquaculture ponds in the North of Vietnam, the organic humus is decomposed anaerobically, producing H_2S gas in the lagoon. The bottom sediment is strongly reduced, causing O_2 deficiency, which adversely affects the aquatic life development of ecosystems in water bodies. As for farming ponds in the South, when the forest is destroyed, oxidizing sediments, forming a salty and acidic environment, often kill the creatures living in the lagoon. The research results of the project KC09. 11/16–20 also proved that the aquaculture rafts in the Cat Ba area often cause a sharp decrease in the dissolved oxygen concentration below three

due to the decomposition of excess feed, which is the cause of the water loss. Mass death of fish in rafts. Oil pollution and plastic waste have caused severe consequences for the island ecosystem of our country [32].

Table 4. Synthesis of biodiversity loss and resources in the littoral ecosystem

Objects	Declining expression	Notes
Habitat for the tidal area	Landscape	- Converting mangroves, tidal flats into farming ponds, reducing environmental quality - Building economic zones changes the landscape in the tidal zone - Tourist activities - Reclaiming encroachment on the sea
Decline in biodiversity typical groups of organisms	Seaweed	- Variation of taxa from 30.0% (blue algae) to 89.0% (brown algae) and average is 50.1% - Biomass: 22–72%
	Seagrass	- Loss of 1 species - Coverage: 25–86%
	Mangrove plants	Change from multi-species to mono-species
	Phytoplankton	Density decreases 60.8%
	Zooplankton	Density decreases 62.5%
	Benthic animals	- Some economic species are threatened of extinction: lobster ear abalon, topshell, etc. - Density reduction: 20.3–30.6% - Biomas s: 20.2–51.7% - Diversity index: 86.8% decline
Decline in resources	Mollusks resources	- Corrugate lucine resources:91.4% - Low-value species crowd out native, high-value species - Shrinking seed yards
	Crustacean resources	- The concentration of mud crabs, sentinel crab lost - Natural mining size reduced
	Fish resources	- Reducing the number of economic fish, trash fish accounted for 63.8% - Small fished size: 38.9–58.6% decline - Catches decreased by about 50–90%
Decline in seed sources	Source of clam seed	- Reduction 50%
Decline in coral reef	The decline in species numbers	- Reduction 64.8–67%
	Decline in coverage	- In Co To from above 60% to less than 5% - Ha Long - Cat Ba from 50–90% down to 20–40% (approximately 50% off)
	Decline in distribution	Space narrowing: distributed only at a depth of 5–6 m
Water environment	Pollution of plant protection chemicals	3 pollutants in 6 locations
	Pollution of organic material	2/3 of the survey sites are polluted
	Grease	Most of the survey points are polluted
Sediment	Grease	All points are polluted at least 1 season of the year

Source: Topic KC09.07/11–15) [17].

Decline in value of ecosystem: The most recent studies have proven that the value of the ecosystem is gradually lost due to the process of decline. The aquaculture ponds, after mangrove destruction, usually give stable output for the first 1–2 years; after 3–5 years of use, the yield will decrease by 50–90% and will gradually become deserted. There are differences when studying the biology of benthic animals living in coral reefs in the two areas of Cat Ba and Ha Long bays. Coral reefs in Cat Ba are reduced, the number of benthic animals is only 0.29%, and the density is 62.6% compared to that of Ha Long Bay, where coral reefs are still intact [27]. The decline in coral ecosystems also means a narrowing of species' habitats, losing the value of diving tourism to see coral reefs, one of the "Hot" types of tourism in the central provinces. In 2012–2015, the topic KC09.07/11–15 showed an alarming decline in biodiversity, resources, and ecosystem environment in the intertidal zone. The maximum number of species can be reduced by 50% (seaweed), and the biodiversity index of zoobenthos is reduced by 86%; The indicators of density and biomass both decreased significantly. The extent of environmental pollution is vast, accounting for about two-thirds of the tidal ecosystem (Table 4).

The decline in resources

Preliminarily, it can be seen that valuable seafood reserves in Vietnam's sea are approximately 4 million tons. Seafood objects are exploited for food, chemicals, cosmetics and export. Due to heavy fishing in the coastal strip and the use of destructive methods such as fishing with electric pulses, mines, anesthetics, and juvenile fishing, have caused a significant decline in resources. Studies on marine fish resources have shown a decreasing trend in fish stocks and production from 1984 to present. Research results on seabed fish stocks in Vietnam in 1984 was about 1,840,619 tons. In 1990–1994, it was only about 1,029,040–1,147,354 tons. It is also for this reason that the fishing productivity decreased continuously, the highest in Vung Tau - Con Dao reached 698 kg/hour (1986), in 1988 it decreased to only 120 kg/hour. The Southeast region, Cu Lao Thu also shows the same trend. The announcements in 2012–2013 showed that the reserve of benthic resources in the entire sea area of Vietnam in the period 2011–2015 decreased by 42.3% compared to the period 2001–2005 [26]. Due to the decline in stocks, fishing productivity has also decreased significantly in all waters of Vietnam (Table 5).

Some aquatic resources in the Central coastal lagoons have also been seriously reduced. Research results on eel species in Tra O lagoon, Phu My district, Binh Dinh province show that the number of eels caught before 1972 was about 100 eels/trap and in early 1990, it decreased to 30–40 eels/trap to 60–70%, and by 1996–1997, only 3–4 eels/trap, a 96–97% decrease. Research results at Bach Long Vi (1996–1999) on benthic production also show a similar picture. The output of abalone (*Haliotis diversicolor*) decreased from 35–50 tons/year (before 1990) to a few quintals/year (1995–1998). For some other benthic resources, such as purple clam (*Asaphis dichotoma*) and snail (Neritidae), within four years, the density decreased by 17–43.23%, and the biomass decreased from 15.5–45.76%. Research results on shrimp catch also show a relatively severe decline. The average yield in the Southwest region reached 23.0 kg/batch/hour (1975–1985); by 1993–1995, it was only 6.42 kg/batch/hour (decreased 82%). At My Mieu shrimp farm, the output in 1975 reached 5.88 kg/hour; in 1995, it was only 2.65 kg/hour. The most recent research results in the Gulf of Tonkin show that the most apparent resource changes are in the benthic group. In two surveys in November 2003 and August 2004, 517 species of benthic animals were identified and equal to 48.27% of the species in the entire of Tonkin Gulf in 1961 [27]. Survey results in 2 years (2003, 2004) show that the density and volume of benthic animals in the Gulf of Tonkin are very low. In the dry season of 2003, the average density of the whole bay was 56 fish/m^2, a weight of 4.39 g/m^2. In the rainy season, the density and biomass were higher than in the dry season, but not much: density of 76 fish/m^2 and weight of 5.54 g/m^2. On average, for the whole year, the density of benthic animals in the Tonkin Gulf reached 66 individuals/m^2, and the weight was 4.97 g/m^2. A comparison of previous research results shows that in 1959–1962, the average density of the

whole bay was 103.2 fish/m^2, and the weight was 11.03 g/m^2. Thus, after over 40 years, the total production of benthic fauna in the Gulf of Tonkin decreased sharply, the density was only 54.4% (decreased 45.6%), and the weight was 50.2% (decreased 49.8%) [27].

Table 5. Variation of bottom fishing productivity (kg/hour)

Sea area	2001–2005	2012–2013			Declining rate (%)
	Average	Max.	Min.	Average	
Tonkin Gulf	100	100	61	80.5	19.5
Central of Vietnam	238	62	77	69.5	70.8
Southeast of Vietnam	285	68	86	77.0	73.0
Southwest of Vietnam	60	42	50	46	22.3

Source: Statistical data based on published data by Nguyen Viet Nghia, Vu Viet Ha [26].

Discussion and proposed solutions for sustainable use

The marine biology investigation and research activities in our country from 1990 to now have made remarkable changes; especially there have been changes in thinking, scale, content, level, research skills, research, and international relations in research. From the primitive activities, mainly performed by foreigners, we now have actively overcome the limitation of general, preliminary, and undirected investigation in marine biology research, a situation that has lasted for many years, to shift to new thinking about marine biology gradually, maritime studies, including:

(i) From being limited to research in each coastal and coastal area, it has expanded to include the entire marine vocabulary, initially reaching even sea regions such as Truong Sa and Hoang Sa islands.

(ii) The research content has made remarkable progress from the primary investigation and description of current situations, the statistics of the phenomena to studying the problems of the causes, the laws of variation, and the mechanism of the phenomenon to control the impact of marine processes such as coastal upwelling ecosystems, corals, seagrasses, tidal zones, red tides, effects of pollutant transmission at sea, laws of fluctuations, degradation and restoration of coastal ecosystems.

(iii) Research activities have also progressed to researching the basis of technology application, creating new technologies to solve practical problems such as remote sensing technology, scuba diving, and extraction of active ingredients in marine biology to achieve the application goal of aquatic research activities.

(iv) In terms of qualifications and research skills, we have quickly absorbed the world's achievements of modern oceanography, biology, and ecology, using research methods and techniques with modern technical equipment for marine research activities in our country, such as mathematical modeling methods, GIS, information technology and deep diving techniques, etc. in marine research. Therefore, compared with the 90s of the last century, the marine biology research in our country is no longer a long-distance, lagging behind other countries in the region as before.

(v) Statistical marine life surveys have focused on little-known groups of organisms such as small crustaceans, small seabed mollusks, marine mammals, sea turtles, seagrasses, toxic algae, and beneficial microorganisms marine medicine. Previously, seagrass beds had not been studied much because deep diving techniques were not available. An expanded research direction is the study of marine ecosystems associated with environmental status assessment issues, building a system of marine nature reserves, and focusing on coral ecosystems.

(vi) A new point in marine biological and ecological research activities in the recent period is studying both structure and function, the causes of degradation, and the study of the restoration of distinct ecosystems.

(vii) Expanding marine biology research to offshore and deep-water areas is the third new point in biodiversity research and aquatic biological resources research to serve the policy of developing offshore fishing resources to meet the Government's policies. In this new research direction, it is noteworthy that the activities of investigation and assessment of biodiversity and biological resources in the Truong Sa and Hoang Sa archipelagos and cooperation with foreign countries (the Philippines, Russia Federation, etc.).

Research activities to discover and deploy technology to exploit potential bioactive substances with medicinal, nutritional, and industrial values from marine organisms, a possible in-depth exploitation direction. viii. In the past period, there have also been additional activities, completing research on the assessment of marine life resources and re-evaluating marine fish resources and non-fish products, both in coastal and offshore areas, to evaluate Vietnam's potential marine biological resources. Marine biological resources have many prospects, which is the current world news.

Although there have been many efforts in studying biodiversity and marine resources, conservation solutions and sustainable exploitation have also been mentioned, contributing to preventing the rate of biodiversity and marine resources decline useful marine life, but they do not meet the conservation and sustainable development requirements. The number of biological species is currently decreasing, and the economic fish species are being exhausted, replaced by trash fish species, less valuable; scarce species along the islands are in danger of disappearing. It is necessary to have appropriate orientations and solutions to protect the decline of marine biodiversity in Vietnam. Solutions include human actions to conserve and sustainably develop biological resources and biodiversity. Solutions focus on three main groups: policy, technical and financial.

Institutional and policy solutions

In addition to participating in the implementation of international conventions and agreements related to biodiversity protection, in the light of Agenda 21, countries have directed their efforts toward formulating policies and institutions to protect biodiversity. In Vietnam, a national conservation strategy was introduced in 1986, and in 1995, the Government also approved Biodiversity Action Plan. This plan recognizes the cultural and economic significance of biodiversity in Vietnam and acknowledges the growing pressures on this heritage resource due to the increasing needs of the people's lives depending mainly on biodiversity. This plan has identified priority actions for the period 1996–2000 to protect and manage species and natural ecosystems of Vietnam.

Biodiversity plans usually have three main objectives, which are:

Protect endemic and vulnerable ecosystems due to pressures of economic activities.

Protection of BD components due to overexploitation.

Encourage and identify the rational use of the values of biodiversity to serve economic indicators. It is necessary to identify the action contents as the basis for specific BD action plans to achieve the above tasks.

In the context of Vietnam, the biodiversity action plan should focus on the following contents:

Strengthening policies and laws for Biodiversity conservation and management.

Establish and manage protected areas with the co-management of local communities.

Raise awareness of biodiversity.

Scientific research.

Encourage a sustainable development approach.

Strengthening international cooperation.

The biodiversity action plan has proven to be an essential tool for Biodiversity conservation at the national level with the above objectives and areas of action. The program is used not only by the Government but also by donors and international organizations that support biodiversity conservation. To implement this plan in Vietnam, the Government needs to continue to issue documents related to biodiversity protection.

Develop and manage conservation zones, artificial reefs, and areas where exploitation is

prohibited from time to time: The program includes studies on the construction and management of marine protected areas or establishing models for the sustainable use of ecosystems. In this area, we have done too little compared to the requirements. Over the past 20 years, we have supported focus on researching and building a scientific basis for marine nature conservation with different types and criteria such as World Heritage Site (Ha Long Bay); World Biosphere Reserve (Cat Ba islands, Kien Giang, Can Gio, etc.); National Parks (Cat Ba, Con Dao, Son Tra - Hai Van and Bai Tu Long); Proposed system of marine protected areas (Tran island - Co To, Cat Ba, Bach Long Vi, Hon Me, Con Co, Son Tra - Hai Van, Cu Lao Cham, Ly Son, Phu Quy, Hon Mun, Hon Cau, Hon Thu, Con Dao, Nam Yet, Phu Quoc, Boat Fish, etc.) and coastal wetland conservation areas (Xuan Thuy, Tam Giang - Cau Hai). Many zones were recognized, while several are waiting to be recognized at the international and national levels. This action is an essential and practical contribution to protecting marine resources and the environment toward sustainable development and affirms Vietnam's active participation in international environmental protection and protection conventions. DDSH. In particular, the marine nature reserve of the Spratly islands also had the type of marine nature reserve and was later renamed the Nam Yet island marine reserve in the area. Wetland ecosystems with precious biodiversity resources and environmental protection were registered for inventory in 2000. Sustainable use and management of wetlands started in 2001. Investment in marine protected areas Hon Mun (Khanh Hoa) and Cu Lao Cham (Quang Nam) has also supported many international organizations and has many good prospects. However, most marine protected areas in Vietnam have not been approved by the authorities. The management of marine protected areas in Vietnam should be given due attention in the coming time. An important issue is the need to quickly promulgate regulations on restricted fishing zones and artificial reef stocking areas to support the conservation of breeding grounds for marine life.

Sustainable exploitation of marine resources

The orientation set for fisheries management must be integrated with the goal of integrated coastal zone management, which is the intelligent regulation of reducing the number of inshore fishing vessels by prioritizing mechanisms for offshore fishing and shifting a part of labor to other service activities such as tourism services, aquaculture, etc.

The situation of seafood exploitation is still inadequate, significantly the rapid increase of small boats exploiting inshore, which is a significant problem today. According to the fisheries industry's statistics, only from 1981 to 2005 did the number of fishing boats increase by an average of 2,554 units/year. Most of these are ships with a small capacity from < 90 CV, accounting for 84%, equivalent to 3/4 of the boats focusing on coastal fisheries. This situation, leading to the depletion of resources, is inevitable. The extraction efficiency (tons/CV/year) decreased from 0.92 tons to 0.32 tons during the same period. The decline in mining efficiency signaled resource depletion very clearly. Thus, the significant problem in exploiting marine resources is the too high concentration of inshore fishing power.

A sustainable fishing strategy must create a multi-industry, multi-objective exploitation method and encourage and adjust the fishing force to potential objects such as jellyfish, sea crabs, mollusks, mantis shrimps, etc. Strong technical support, improving offshore fishing capacity for fishers. Enhance exploitation of the potential of ecosystems for marine ecotourism activities. Focusing on strongly developing marine ecotourism based on exploiting the potential of ecosystems will undoubtedly reduce the pressure of exploitation and contribute to protecting the resources of our sea.

Exploitation associated with conservation is one of the solutions being used worldwide, an issue that has been proposed in most scientific projects, but there is still a big gap between exploitation and conservation. The concept that protection is to limit their exploitation capacity, affecting daily life. Therefore, raising people's knowledge of fishing is very important; understanding conservation creates more

extensive seafood reserves and higher value of resources for their generations and their descendants in the future after. Therefore, in addition to the state's policies and support, international support also needs to mobilize the community to self-govern, self-control, and prevent destructive mining methods such as using electricity and small-mesh nets, anesthetics, explosives, etc.

Sustainable farming: sustainable farming concerning integrated coastal management will create a suitable living environment, ensuring the maintenance of marine biodiversity. It is imperative to define the integration between raising productivity and desired quality while ensuring safety for the cultural climate. Sustainable farming criteria must be integrated into each local aquaculture planning to harmonize aquaculture productivity and the environment. Aquaculture development policy has been identified as a priority and spearhead in the aquaculture industry, having a growth rate of about 19% per year, and the farming area is also increasing. Our goal is to transform from self-sufficient production to producing goods that meet domestic and export requirements. Aquaculture, such as shrimp, clam, and grouper, has contributed a lot to export turnover, but we are still facing many inadequacies in sustainable development in aquaculture. Exploitation and depletion of parent and adopted breeds occur in all localities in the country. The decline in the quality of parent and adopted species often leads to low farming productivity, affecting the economic value of livestock. The issue of farming techniques and the farming environment is also prominent. Inappropriate clam farming techniques have caused the death of thousands of tons of clams in coastal localities. Spontaneous farming, not according to the planning but according to the movement, has caused local pollution, killing the cultured species and destroying coral reefs in most of the coastal provinces of Vietnam, including the coastal areas west coast of the Northern Gulf. Exploitation is associated with aquaculture, mainly focusing on marine farming and raising environmentally friendly species. In particular, the development of agriculture of bivalve mollusks has high economic value and contributes to cleaning the environment. Recent research results show that there is very little investment in mollusk farming. Most of them start from people with little technical support, so the problem of farming planning and farming techniques is still inadequate.

Sustainable marine economic development: protecting marine biodiversity will not succeed without creating a sustainable maritime economy. In the integrated management framework, it is crucial to develop a supportive relationship between mechanisms and policies for developing fisheries, transportation, and marine tourism with current legal regulations. From an economic perspective, resource exploitation and aquaculture, tourism, and shipping are all dependent on weather and luck. Therefore, prioritization mechanisms should be in place, especially capital priority, tax priority, and risk allowance priority. Tools and policies to support seafood import and export gradually creating international integration in the fisheries economy are probably also an essential issue in the goal of sustainable development of Vietnam.

CONCLUSION

1. In the last 30 years, the field of marine biodiversity research has made remarkable progress, from the initial activities, mainly carried out by foreigners; Up to now, we have actively overcome the limitation of general, preliminary, undirected investigation in marine biology research, to shift to new thinking about research gradually. We have expanded the scope of study to the whole sea, deep-water areas, and offshore islands such as Truong Sa and Hoang Sa. We are focusing on research on the causes of formation, the law of fluctuations, and the mechanism of action of marine processes. Research activities have also progressed to the basic technology application research, creating new technologies to solve practical problems. In terms of qualifications and research skills, we have quickly absorbed the achievements of modern oceanography, biology, and ecology globally, using research methods and techniques with the latest scientific research and modern technology in

marine research activities in our country. So, there have been outstanding results compared to the last time.

2. It has been identified that there is a high level of biodiversity in Vietnam's sea, with about 12,000 marine species and 134 species recorded in the Vietnam Red Book, but the structure of biodiversity and marine resources in our country. is also susceptible, vulnerable.

3. There are about 20 specific ecological systems and sub-systems in the sea and coastal areas, with a reserve of nearly 4 million tons of seafood, which is an essential basis for developing eco-tourism, fishing, and aquaculture.

4. To fully identify the types of decline in biodiversity and marine resources caused by economic activities, including narrowing the area of ecosystems; the reduction in density, number of species, and stock of resources; The decline in the value of the ecosystem; The loss of habitat within the ecosystem.

5. Basic solutions for conservation and sustainable use of biodiversity and marine life resources include:

Institutional and policy solutions.

Strengthen the construction and management of conservation zones, artificial reefs, and areas where exploitation is prohibited from time to time.

Sustainable exploitation and sustainable cultivation of marine resources.

Sustainable marine economic development.

Acknowledgments: The author thanks topic code NVCC 23.02/21–21 for providing new data on Vietnam's sea sponge for this article.

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