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NATIONAL REPORT

on

Seagrass in the South China Sea

VIET NAM

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1. INTRODUCTION

In Viet Nam, seagrasses are poorly studied compared to other marine flora and fauna, including macroalgae, mangroves, plankton, invertebrate zoobenthos, fishes, birds, reptiles, and mammals. There are some reasons for this: (1) resource planners and managers have not regarded seagrasses as important as other species; (2) seagrasses have a relatively small number of species; and (3) they are not used directly for human food and are not exploited for commercial trade (Nguyen Van Tien and Nguyen Chu Hoi 1995).

Historically, no publications on Vietnamese seagrasses have been produced, although some information has been published in the form of books and newsletters about higher plants or seaweeds. In 1885, Balansa discovered *Halophila ovalis* and *H. beccarii* in the Song Hong Meo River (now part of the Ruot Lon River) near Quang Yen District, Quang Ninh Province. Balansa also recorded *Zostera japonica* in Nha Trang, south central Viet Nam (Den Hartog 1970), although it has not been recorded in the country since then. This could be due to environmental degradation or uncertain species identification.

2. REVIEW OF DATA AND INFORMATION ON SEAGRASSES OF VIET NAM

2.1 Biology and Ecology of Seagrass

2.1.1 Species Diversity and Distribution

Following analysis of more than 100 dried specimens stored at the Hai Phong Institute of Oceanography and gathered during field surveys at Hai Phong tidal flats (1985), Cat Ba and Long Chau Islands (1991 to 1992), Bach Long Vy Island and Quang Ha District (1995), Ha Long Bay and Tam Giang-Cau Hai Lagoon (1994 to 1995), Truong Sa (Spratly) Islands (1995 to 1998), Con Dao Islands (1996, 1999), and from the central and southern coastal zones of Viet Nam (1997, 1999) and Phu Quoc Island (2002), we have identified 14 species of seagrasses, falling into 4 families and 9 genera. Some researchers have proposed to exclude the species *Ruppia maritima* from seagrasses, however, this study recognises this species as seagrass as it is widely distributed with a high biomass in Viet Nam.

Table 1 shows the family Cymodoceaceae has the greatest number of species present in Viet Nam (five species), whilst the two families of Zosteraceae *and* Ruppiaceae have only one species each. Table 2 shows codes of seagrass sites.

Table 1 Diversity and geographic distribution of seagrass in Viet Nam

Species	Sites
Fam. Hydrocharitaceae	
Halophila beccarii	NM, DV, TC, CH, DL, NS, KT, TL, XH, CG, TG, HE, TB, NP, TT
H. ovalis	HC, DH, QL, TG, LC, TN, CM, OL, VP, HK, NY, MG, NP, NT, TT, MH, PI, CD, PQ
H. minor	VP, MG, NP, NT, TT, PI, CD, PQ
Thalassia hemprichii	LC, CM, VP, HK, NY, MG, NP, NT, TT, MT, MH, PI, CD, PQ
Enhalus acoroides	CM, VP, HK, MG, NP, NT, TT, MT, CD, PQ
Fam. Cymodoceaceae	
Halodule pinifolia	TG, LC, CD, PQ
H. uninervis	TN, CM, VP, HK, MG, NP, NT, TT, MT, MH, PI, CD, PQ
Syringodium isoetifolium	PI, CD, PQ
Cymodoceae rotundata	CM, VP, HK, MG, NT, MT, PI, CD, PQ
C. serrulata	MG, CD, PQ
Fam. Zosteraceae	
Zostera japonica	HC, DH, QL, CG, NL, TG, HE, TB
Fam. Ruppiaceae	
Ruppia maritima	NM, DV, TC, CH, DL, NS, KT, TL, XH, NL, CG, TG, HE, TB, OL, NP, NT, TT

(Sources: Cheung et al, *1994, Lang Van Ken, 1997, Le Thi Thanh, 2002, Nguyen Huu Dai, 2002a and 2002b; Nguyen Huu Dai and Pham Huu Tri, 2002, Nguyen Huu Dai* et al, *1997, 1998; Nguyen Trong Nho, 1994; Nguyen Van Tien and Dam Duc Tien, 1996; Nguyen Van Tien, 1999, Nguyen Van Tien* et al, *2002; Nguyen Xuan Hoa, 1998; Nguyen Xuan Hoa, 2002; Nguyen Xuan Hoa and Tran Cong Binh, 2002; Pham Huu Tri, 2002, Tu Thi Lan Huong, 2002).*

Table 2 Seagrass site codes and areas in hectares.

CODE	SEAGRASS SITES	AREA (HA)
HC	Ha Coi embayment (Quang Ninh)	150
DH	Dam Ha embayment (Quang Ninh)	80
QL	Quan Lan tidal flat (Quang Ninh)	100
NM	Nha Mac pond (Quang Ninh)	500
DV	Dinh Vu (Hai Phong)	120
TC	Trang Cat (Hai Phong)	60
CH	Cat Hai (Hai Phong)	100
DL	Dong Long (Thai Binh)	150
NS	Ngan sand dune (Nam Dinh)	30
KT	Kim Trung (Ninh Binh)	120
TL	Thanh Long (Thanh Hoa)	80
XH	Xuan Hoi (Ha Tinh)	50
CG	Cua Gianh (Quang Binh)	500
NL	Nhat Le (Quang Binh)	200
TG	Tam Giang - Cau Hai lagoon (Hue)	1,000
LC	Lang Co lagoon (Hue)	120
HE	Han estuary (Da Nang)	300
TB	Thu Bon estuary (Quang Nam)	50
TN	Thi Nai lagoon (Binh Dinh)	200
CM	Cu Mong (Phu Yen)	250
OL	O Loan (Phu Yen)	20
VP	Van Phong (Khanh Hoa)	200
HK	Hon Khoi embayment (Khanh Hoa)	100
NY	Nam Yet island (Spratly islands)	30
MG	My Giang (Khanh Hoa)	80
NP	Nha Phu embayment (Khanh Hoa)	30
NT	Nha Trang Bay (Khanh Hoa)	50
TT	Thuy Trieu lagoon (Khanh Hoa)	800
MT	My Tuong tidal flat (Ninh Thuan)	15
MH	My Hao tidal flat (Binh Thuan)	15
PI	Phu Qui island (Binh Thuan)	300
CD	Con Dao (Ba Ria-Vung Tau)	200
PQ	Phu Quoc islands (including Bai Bon: 2,000ha, Rach Vem: 900, Da Bac: 200, Trau Nam: 200, Ong Doi: 120, Bai Dam: 100 and five other small sites)	3,650
Total		**9,650ha**

In littoral zones:

The seawaters of coastal littoral zones and around islands are characterised by stable salinity, clear water and strong wave action. There are approximately 3,000 islands in the coastal and marine zone of Viet Nam, including some remote islands, such as the Hoang Sa (Paracel) Islands 300km east of Da Nang in central Viet Nam; the Truong Sa (Spratly) islands 500km southeast of Nha Trang (south central Viet Nam); and Bach Long Vy Island, 100km east of the port of Hai Phong in the north. In general, these islands are surrounded by vast tidal flats, on which many seagrass species develop and show great tolerance to high salinity. The species commonly found are *Enhalus acoroides, Thalassia hemprichii, C. serrulata, C. rotundata, H. ovalis, Halodule uninervis, Halophila minor, H. decipiens and H. pinifolia, T. hemprichii, C. serrulata and H. ovalis* are the most dominant species on sandy coral substrates in the large coastal areas of Khanh Hoa and Ninh Thuan provinces and around some remote islands, where they grow densely. In littoral areas, where coral reefs protect seagrasses from waves, such as at Ninh Hai in Ninh Thuan provinces, seagrasses are diverse with the appearance of *Enhalus acoroides, Cymodocea* spp., *Halophila* spp. and *Halodule uninervis*. Occasionally these species are mixed with *Halophila ovalis*. These beds provide suitable habitat for many valuable species of marine life.

In estuaries and mangroves:

In estuaries and mangrove areas, fewer species have been recorded than in the littoral zone. Species such as *Halodule uninervis*, *Halophila ovalis*, *Halophila beccarii* and *Cymodocea rotundata* are prevalent. In aquaculture ponds and mangroves, *H. ovalis*, *H. beccarii* and R. *maritima* are abundant, growing on mud or muddy sand bottoms. In channels and ditches, *H. ovalis* and *H. beccarii* cover the

substratum (maximum density over 10,000 shoots/m^2). In particular, the species *Zostera japonica* is widely distributed in river mouths of northern and central Viet Nam. Plants of this species are found along river banks and typically penetrate 3 to 4km upstream. Several beds have been observed up to 7km inland (Nhat Le Rivermouth, Quang Binh Province) (Nguyen Van Tien 1999).

In brackish-water aquaculture ponds:

Along the coasts of Viet Nam, many ponds have been established for aquaculture production purposes. *Ruppia maritima* and *Halophila beccarii* are often prevalent in these ponds.

In bays and lagoons:

In the north of Viet Nam, especially in the small creeks in Dam Ha and Ha Coi, a two-species seagrass community of *Zostera japonica* and *Halophila ovalis* commonly exists. In the higher salinity creek at Lang Co, three seagrass species were recorded: *Thalassia hemprichii, Halodule pinifolia* and *Halophila ovalis*. The bays and lagoons in Da Nang, Thi Nai (Binh Dinh Province), Cu Mong, O Loan (Phu Yen Province), Van Phong, Nha Trang and Cam Ranh (Khanh Hoa Province) are very suitable for the development of seagrass species (Nguyen Huu Dai *et al* 1997). The best substrate type for seagrass development is mud or muddy sand bottom.

Almost all seagrass species have been observed in bays and lagoons, and their distribution depends on their ability to adapt to variable salinity. Species such as *Halophila ovalis* and *Halodule uninervis* are well adapted to salinity variations. These two species can grow in the upper-end of lagoons or bays, while *Thalassia hemprichii* occurs only in the middle or the mouth of lagoons. During the rainy season, when salinity decreases, seagrass leaves die and decompose, but the rhizomes survive and new shoots quickly grow as salinity increases.

2.1.2 Physical Characteristics

Depth

In the northern region, water transparency is low (0.7 to 3m), particularly in estuaries. Almost all seagrass species occur from the medium belt of intertidal flats to 3 to 5m deep. In the southern region, seagrass species occur mainly at depths from 3 to 5m, and only *C. serrulata* is observed at depths greater than 15m (Table 3).

Table 3 Depth distribution of seagrass species in Ninh Hoa.

Depth	Species	Average Density (shoots/m^2)	Shoots Biomass (g dry/m^2)
Low tide to 3m	*H. ovalis*	3,800	40
	H. uninervis	4,880	68
	E. acoroides	75	342
	T. hemprichii	730	389
	C. serrulata	650	
	C. rotundata	732	
3-5m	*C. serrulata*	460	
	H. ovalis	2,100	32
	H. uninervis	2,600	40
6-12m	*H. ovalis*	1,800	9
12-15m	*H. ovalis*	1,400	6,4

Source: Nguyen Huu Dai et al 1997.

In littoral zones, seagrasses grow from the low intertidal level to a depth of 10 to 15m, with the greatest abundance in the area from the low tide mark to 2 to 3m deep. Transects studied in Ninh Hoa (Khanh Hoa Province) showed the distribution of some seagrass species according to the depth, as well as their variation in density and biomass. Studies carried out in 1998 on the distribution of seagrasses in Con Son Bay (Con Dao Island, Ba Ria-Vung Tau Province) reported that from the low tide level to a depth of 10 to 15m, the occurrence of seagrass species was: *H. pinifolia, H. uninervis, H. ovalis, T. hemprichii, C. serrulata, S. isoetifolium, H. decipiens,* and *H. ovalis,* respectively. *H. decipiens* and *C. serrulata* are often found at depths of 15 to 20m (Loo 1994).

Salinity

This study uses the salinity scale defined by A. C. Constantinov (1967). Some distribution patterns of seagrass in relation to salinity in Viet Nam are as follows:

- Euryhaline species (5 to 32ppt): *Zostera japonica, Halodule pinifolia, Halophila ovalis.*
- Mixohaline species (below 25ppt): *Halophila beccarii, Ruppia maritima.*
- Euhaline species (over 25ppt): *Enhalus acoroides, Thalassia hemprichii, Cymodocea serrulata, Cymodocea rotundata, Thalassodendron ciliatum, Halodule uninervis, H. decipiens, H. minor.*

Substrata

Differences in seagrass species may be distinguished by their relation to substrata. *Zostera japonica* often occurs in sheltered tidal areas, in estuaries, or in brackish water coastal lagoons on fine silt and soft mud. *Halophila ovalis, Halophila beccarii,* and *Ruppia maritima* are common on riverine tidal flats, in aquaculture ponds with silty clay sediment, and in areas with fine sandy bottoms. In Lang Co Creek (Thua Thien Hue Province, central Viet Nam) these species grow in the intertidal zone up to the mangrove fringe. In waters adjacent to the Con Dao islands, *Thalassia hemprichii* is found on clean coral sand or coral debris of subtidal flats and dead reef platforms. *Cymodocea serrulata* has been recorded on sandy mud and coral sand substrates and develops poorly on coarse sand and gravel. Table 4 shows the distribution of seagrass in key sites and their corresponding type and class of sediment.

Table 4 Seagrass distribution in relation to sediment class and type.

Class of Sediments	Type of Sediment	Specific Seagrass Species	Location
Muddy	Aleuritic mud	*Zostera japonica*	Dam Buon (Quang Ninh),
	Aleuritic – pelitic mud	*Halophila ovalis*	Cat Ba (Hai Phong)
	Aleuritic – pelitic mud	*Ruppia maritima, Halophila beccarii*	Xuan Loc (Thanh Hoa), Kim Trung (Ninh Binh)
Sandy-muddy	Coarse aleuritic fine	*Halodule pinifolia*	Hon Nom (Quang Binh),
	Fine sand	*Halodule pinifolia*	Tam Giang lagoon, Lang Co (Hue), Con Dao (Ba Ria-Vung Tau)
	Sandy-muddy	*Enhalus acoroides*	Cam Ranh (Khanh Hoa) Phu Quoc (Kien Giang)
Sandy-coralline	Coralline sand	*Cymodocea serrulata, Thalassia hemprichii*	Con Dao (Ba Ria-Vung Tau)
	Medium sand	*Syringodium isoetifolium*	Phu Quoc (Kien Giang)

Source: Nguyen Huu Dai et al, *1997, Pham Huu Tri, 2002 and Nguyen Van Tien, 1999.*

2.1.3 Biomass

The aboveground biomass of eelgrass varies from 16g wet weight/m^2 in Gia Luan to 600g wet weight/m^2 in Nhat Le, with a mean value of 239g wet weight/m^2. The highest belowground biomass is observed in Thanh Trach (2,000g wet weight/m^2) while the lowest belowground value occurred in Gia Luan (48g wet weight/m^2).

The total biomass of eelgrass *Zostera japonica* ranged from 144g wet weight/m^2 in Gia Luan to 4,400g wet weight/m^2 in the Han River (Da Nang). Thanh Trach and Nhat Le (Quang Binh Province) have high biomass of this species, both over 4,000g wet weight/m^2. The mean total biomass from Quang Ninh to Da Nang is 2,290.3g wet weight/m^2. The lowest total biomass (816g wet weight/m^2) for this species was recorded in Gia Luan (Hai Phong) and the highest (3,492.5g wet weight/m^2) in Tam Giang Lagoon (Thua Thien - Hue).

Ruppia maritima is common in coastal zones in northern Viet Nam. Total biomass varies from 67g fresh/m^2 in Dinh Vu to 3,200g wet weight/m^2 in KT_3 and Xuan Loc. Leaf biomass ranges from 20g wet weight/m^2 in Dinh Vu to 1,820g wet weight/m^2 in Dong Long (Thai Binh Province). The highest aboveground biomass was recorded in Xuan Loc (400g wet weight/m^2) and the lowest value in Quynh

Long (75g wet weight/m^2). This species has the lowest belowground biomass in Dinh Vu (43g wet weight/m^2) and the highest value in Xuan Loc (1,200g wet weight/m^2). Cover and biomass of *Ruppia maritima* in brackish lagoons has been influenced by human activities. In Dinh Vu, the site with the lowest biomass, households grow *Gracilaria asiatica*. This species is replacing *Ruppia maritima*, hence the low biomass of this species here. *Ruppia maritima* was shown to grow rapidly in Dong Long (Thai Binh), Kim Trung (Ninh Binh), Xuan Loc (Thanh Hoa), Xuan Hoi (Ha Tinh), with an average biomass of 2,600g wet weight/m^2 in Kim Trung (Ninh Binh), 2,266.7g wet weight/m^2 in Xuan Loc Lagoon (Thanh Hoa) and 2,066.7g wet weight/m^2 in Dong Long (Thai Binh).

Halophila ovalis is widespread in coastal zones and around islands in north and central Viet Nam. The leaf biomass of *H. ovalis* ranges between 51g wet weight/m^2 (Lang Co) and 336g wet weight/m^2 (Gia Luan), with a mean value of 160.8g wet weight/m^2. Belowground biomass varies from 69g wet weight/m^2 in Lang Co to 640g wet weight/m^2 in Gia Luan, with an average value of 271.7g wet weight/m^2. The mean total biomass of *H. ovalis* is 432.5g wet weight/m^2, with the highest value in Gia Luan (976g wet weight/m^2) and the lowest value in Lang Co (120g wet weight/m^2).

Halodule pinifolia is particularly prevalent in southern areas of Viet Nam. One site, Lang Co, has both the highest and lowest leaf biomass values of this species with values of 873g wet weight/m^2 and 294g wet weight/m^2, respectively. The mean value is 549.5g wet weight/m^2.

The aboveground biomass varies from 60g wet weight/m^2 (Hon Nom) to 582g wet weight/m^2 (Lang Co), with an average of 219.7g wet weight/m^2. Belowground biomass ranges between 650g wet weight/m^2 in the third site at Hon Nom and 2,425g wet weight/m^2 in Lang Co. The average belowground biomass is 1,094.1g wet weight/m^2. This species has the lowest total biomass in Hon Nom (site 2) at 1,200g wet weight/m^2, and a peak value of 3,880g wet weight/m^2 at Lang Co (site 2). The mean value is 1,863.3 g wet weight/m^2.

This is a summary of quantitative characteristics of *Thalassia hemprichii* and *Halophila beccarii*, which occur in Lang Co (Thua Thien - Hue Province) and across the country in estuaries and brackish lagoons. The average leaf biomass is 1003.3g wet weight/m^2, while the leaf biomass is highest in Lang Co_7 (1,350g wet weight/m^2) and lowest in Lang Co_9 (580g wet weight/m^2). Aboveground biomass has an average value of 630g wet weight/m^2, ranging from 340 to 900g wet weight/m^2. The range of belowground biomass is 1,080g wet weight/m^2 to 4,020g wet weight/m^2, with a mean value of 2,700g wet weight/m^2. The total biomass of *T. hemprichii* ranges from 2,000 to 6,000g wet weight/m^2, with a mean value of 4,333.3g wet weight/m^2. *Halophila beccarii* is widely distributed in estuaries and brackish lagoons in Quang Ninh, Hai Phong, Thai Binh, Nam Dinh, Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Thua Thien - Hue and Da Nang. The mean value of aboveground biomass is 56g wet weight/m^2, belowground biomass is 150.7g wet weight/m^2, and total biomass is 206.7g/m^2.

The biomass of *Ruppia maritima* in the brackish water of Dinh Vu (Hai Phong) is also higher in the dry season than in the rainy season. Total biomass varies from 227g wet weight/m^2 (rainy season) to 463g wet weight/m^2 (dry season).

2.1.4 Growth Rate and Production

Elongated rate of *Ruppia maritima*: Ten young seagrass plants were measured on 10 October 1996 in Dinh Vu (Hai Phong), with a mean length of 2.15cm. After three months (1 January 1997) they reached 6.87cm. Analysis showed that the growth rate of *Ruppia maritima* in brackish water zones in the dry season was 0.06cm/day.

Elongated rate of *Zostera japonica*: Twenty-seven seagrass shoots of different sizes were marked by plastic tape and the shoot length measured over a four-month study period from April 1997. All seagrass shoots were divided into five experimental quadrats. It highlights the results of this study. In the first quadrat, the elongated rate ranged from 0.16% to 0.45%/day, from 0.79% to 1.22%/day in the second quadrat, from 0.54 to 1.43%/day in the third, from 1.05 to 1.36%/day in the fourth and from 1.19 to 1.46%/day in the last quadrat. The mean elongated rate of the five experimental quadrats was 0.98%/day.

Table 5 highlights the growth characteristics of *E. acoroides* and *T. hemprichii* at this site, clearly demonstrating the impact of the rainy season on abundance and growth Dong Ba Thin. Table 6 shows density, biomass, growth rate and leaf production of *Enhalus acoroides, Thalassia hemprichii and Cymodocea serrulata* in My Giang.

Table 5 Density, biomass, growth rate and leaf production of Enhalus Acoroides and Thalassia Hemprichii in Dong Ba Thin, Thuy Trieu Lagoon.

Month	Average density (shoots/m^2)		Average biomass (g dry/m^2)		Growth rate (cm/day)		Leaf production (g dry/m^2/day)	
	Enhalus acoroides	*Thalassia hemprichii*	*Enhalus acoroides*	*Thalassia hemprichii*	*Enhalus acoroides*	*Thalassia hemprichii*	*Enhalus acoroides*	*Thalassia hemprichii*
6/1998	*100*	350	305	63	1.36	0.36	3.02	1.71
7/98	82	400	246	*	1.74	0.48	3.86	1.96
8/98	95	410	220	82	1.71	*	4.04	*
9/98	108	420	383	110	1.80	0.66	5.24	3.79
10/98	90	410	168	43	1.12	0.53	2.97	2.61
11/98	120	224	106	36	0.54	*	1.10	*
12/98	57	*	83	*	0.53	*	0.91	*
1/1999	55	*	53	*	0.56	*	0.53	*
2/99	60	*	46	*	0.86	*	1.14	*
3/99	74	*	121	*	1.29	*	1.80	*
4/99	70	48	76	45	1.19	*	1.62	*
5/99	71	140	79	22	1.20	0.47	1.72	0.58
6/99	72	83	133	13	1.12	0.56	1.14	0.49

Source: Nguyen Huu Dai et al *(1997, 1998)*

Table 6 Density, biomass, growth rate and leaf production of *Enhalus Acoroides, Thalassia Hemprichii* and *Cymodocea Serrulata* in My Giang.

Month	Average density (shoots/m^2)			Average biomass (g dry/m^2)			Growth rate (cm/day)			Leaf production (g dry/m^2/day)		
	Enhalus acoroides	*Thalassia hemprichii*	*Cymodocea serrulata*	*Enhalus acoroides*	*Thalassia hemprichii*	*Cymodocea serrulata*	*Enhalus acoroides*	*Thalassia hemprichii*	*Cymodocea serrulata*	*Enhalus acoroides*	*Thalassia hemprichii*	*Cymodocea serrulata*
7/1998	*150*	600	700	105	149	61	1.10	0.59	0.62	4.48	3.30	1.27
8/98	112	620	850	108	106	73	1.14	0.61	0.51	3.36	3.27	2.12
9/98	144	925	1100	154	113	121	1.54	0.66	0.47	5.96	5.55	3.42
10/98	112	950	1050	128	148	130	1.50	0.62	0.59	3.32	5.40	4.73
11/98	*	*	*	*	*	*	*	*	*	*	*	*
12/98	*	*	*	*	*	*	*	*	*	*	*	*
1/1999	120	750	625	114	68	37	1.02	0.54	0.49	3.24	3.56	1.39
2/99	128	875	675	130	78	84	1.12	0.66	0.50	3.17	4.18	1.37
3/99	136	860	915	153	139	112	1.57	0.56	0.48	5.50	5.16	2.89
4/99	138	970	1250	158	123	107	1.40	0.62	0.55	5.60	5.27	3.47
5/99	130	1050	1120	132	133	109	1.23	0.55	0.50	4.05	4.61	3.20
6/99	108	890	870	121	121	69	1.07	0.45	0.47	4,35	3.78	3.11

*Note: * - no data because of dead seagrass or flood*
Source: Nguyen Huu Dai, 2002, Nguyen Huu Dai et al, *1998.*

Primary productivity of seagrasses in Gia Luan (Cat Ba, Hai Phong)

Photosynthetic experiments of *Halophila ovalis and Zostera japonica* were carried out in May 1998 and June 1999. Experimental seagrass samples were fresh, wet with intact leaves, roots, and rhizomes. The experiment took place in the intertidal area at Gia Luan at three different times of day (6 to 7am, 1 to 2pm, and 6 to 7pm). Study results indicated that the photosynthetic rate of both species was highest from 1 to 2pm, and lowest from 6 to 7pm. The studies on both seagrass species (*H. ovalis and Z. japonica*) showed a strong correlation between photosynthetic rate and irradiance level, i.e., the photosynthetic rate of seagrasses increased linearly with increasing light. As irradiance levels decreased in the evening, photosynthesis rates decreased to a minimum value.

Primary productivity of seagrasses in Lang Co Lagoon (Thua Thien - Hue)

A study of three species (*Thalassia hemprichii, Halodule pinifolia, and Halophila ovalis)* was conducted in Lang Co Lagoon in May 1998. Results of this study highlight a positive correlation between irradiance level and photosynthesis rate, with the greatest photosynthesis rates occurring with the highest levels of irradiance.

2.2 Associated Biota

2.2.1 Macrobenthos

A review of survey results on species composition of *macrobenthos* in northern and southern Viet Nam defined 127 species belonging to 54 families (*Polychaeta, Crustacea*, and *Echinodermata*) (Table 7).

Table 7 Group structure of macrobenthos in seagrass beds of Viet Nam.

No	Macrobenthos	Families	Genera	Species	Rate (%)	Note
1	*Polychaeta*	8	16	16	12.5	Survey site: *Northern zones*: from Quang Binh to Da Nang *Southern zones*: from Khanh Hoa to Ninh Thuan
2	*Crustacea*	12	20	29	23.5	
3	*Gastropoda*	13	18	25	19.5	
4	*Bivalvia*	14	29	45	35	
5	*Echinodermata*	7	9	12	9.5	
Total		**54**	**92**	**127**	**100**	

Source: Do Cong Thung, 2000; Nguyen Huu Dai et al, *1997.*

2.2.2 Algae

Marine algae: The species composition of algae in seagrass beds of the littoral zones, bays, lagoons, and estuaries of Viet Nam varies according to a range of environmental conditions. In littoral zones, and around coral reef fringed islands characterised by clear water with stable salinity levels and strong wave action, algae are more abundant than in bays, lagoons, and estuaries where water masses are typically more turbid and subject to variations in salinity levels. Together, seagrasses and algae provide a diversity of habitats and a source of food for marine life.

Macroscopic benthic algae: 151 species have been collected and identified from seagrass beds. Red algae are the most abundant, with 73 species (49%), followed by blue algae: 36, blue-green algae: 26, and brown algae: 16. Benthic algae are often attached to dead coral, stone or dead oyster shells. The presence of species belonging to the family *Corallinaceae* contributes to the sedimentation of lime and provides stability to soft substrata.

Epiphytic algae: Epiphytic algae are a ubiquitous component of seagrasses and important part of the seagrass ecosystem. Epiphytes are a potentially significant food source for animals living in seagrass beds. The occurrence and development of algal epiphytes depends significantly on the life-span of seagrass leaves and varies by seagrass species. This study identified 58 species of algal epiphytes on seagrasses in Khanh Hoa Province. The most significant is red algae, represented by 24 species (41%), and 17 species of blue green algae, 11 blue algae species, and 6 brown algae species were observed. Commonly occurring genera are *Hormothamnion, Lyngbya, Ceramium, Acrochaetium, Polysiphonia, Centroceras, Hypnea, and Cladophora*. In Ninh Hoa (Khanh Hoa Province), the biomass of epiphytic algae on *E. acoroides* leaves peaked at 10.40g dry/m^2 in February, declining to a minimum of 5.75g dry/m^2 in August and September.

Algal epiphytes use seagrasses as a host. The morphology, shape, and life span of seagrass leaves are important factors for the diversity and colonisation of epiphytes. Different stem and leave morphologies affect water flow, influencing the ability of epiphyte propagules and larvae to settle. The life span of various portions of seagrasses also controls epiphyte diversity and biomass. The mean life span of *E. acoroides* and *T. hemprichii* ranges from 1 to 3 months.

The distribution of epiphytes on seagrass leaves also depends on the relative age of different sections of leaf surfaces. The diversity and abundance of epiphytic algae decreases from the apical to basal zone of leaves, and decreases from old to young leaves. The majority of epiphytic algal species are algal tuft, with the remainder mostly being macroalgae. We can separate epiphytic algae into three groups according to temporal variations in their occurrence:

- Permanent - species found growing throughout the year.
- Seasonal - only at certain times of the year.
- Transient - intermittently occur, no apparent temporal pattern in their occurrence.

Seagrass beds in the littoral zone of My Giang and Dong Ba Thin Lagoon were selected for case studies of associated biota. Twenty-four samples of ichthyoplankton were taken from dense seagrass beds with an abundance of *Enhalus acoroides* (40 to 110 shoots/m^2) and *Thalassia hemprichii* (120 to 500 shoots/m^2) from depths of 1 to 2m during May 1998 to June 1999. Samples were also taken from the bare substrata zone (area without growth) approximately 2km from the seagrass beds. Ongoing analysis of the samples indicates that 828 fish eggs, 76 juvenile fishes, 1,378 larvae and juvenile shrimps, and 1,047 crab larvae were taken from Dong Ba Thin. In the area of My Giang, 1132 fish eggs, 17 juvenile fishes, 280 larvae and juvenile shrimps, and 26 crab larvae were taken (analysis of crab larvae data is not yet completed).

2.2.3 Crustacean

Larvae and juvenile shrimps

During the sample period in Dong Ba Thin, the percentage composition of larvae and juvenile *Penaeidae* in shrimp samples was 9.00%. Juvenile *Penaeidae* were absent in samples from areas of bare substrata, where juveniles of other shrimp groups are found. In the seagrass beds of Dong Ba Thin, the density of *Penaeidae* was highest in June and July (7 to 8.5 unit/m^3) and there were no *Penaeidae* in areas of bare substrata. The density of other shrimp groups is high in February, May, and June, when the mean value ranges from 38 to 41.25 unit/m^3. In the bare substrata, other shrimp groups have the highest density in May (43.25 unit/m^3).

In My Giang, the percentage of larvae and juvenile *Penaeidae* was marginally higher than at Dong Ba Thin, with 10.50% of the sample from *Penaeidae* and 89.50% from other shrimp groups. In the bare substrata, the percentage of *Penaeidae* was 6.30%, while other shrimp groups made up 93.70% of the sample (Table 8).

Table 8 Variation in density of larvae and juvenile shrimp groups in Dong Ba Thin and My Giang Areas (unit/m^3).

Month	Dong Ba Thin				My Giang			
	Seagrass beds		Bare substrata		Seagrass beds		Bare substrata	
	Penaeidae	Other Shrimp groups	Penaeidae	Other Shrimp Groups	Penaeidae	Other Shrimp Groups	Penaeidae	Other Shrimp Groups
May 98	1.0	41.25	0	43.25	*	*	*	*
Jun 98	8.5	40.25	0	0.62	*	*	*	*
Jul 98	7.0	38.00	0	1.63	5.25	28.75	0.62	8.12
Aug 98	*	*	*		0	18.00	0	0.75
Sep 98	0	0	0	7.25	*	*	*	*
Feb 99	0	38.59	0	9.52	*	*	*	*
Mar 99	*	*	*	*	0	0.5	0	0
Apr 99	0	1.8	0	9.68	0	0	0	0
Jun 99	0	1.51	0	0.06	0	0.15	0	0.16

Source: Nguyen Huu Dai et al, *1998* * - *No samples.*

Crab larvae

Crab larvae occur densely in seagrass beds in Dong Ba Thin in May and September (57.57 and 78 unit/m^3). In the bare substrata, crab larvae are reasonably abundant in May (30.5 unit/m^3). In My Giang, abundance is low in both seagrass beds and the bare substrata (Table 9).

Table 9 Variation in density of ichthyoplankton, juvenile fish, and crab larvae in Dong Ba Thin and My Giang (unit/m^3).

Month	Dong Ba Thin						My Giang					
	Seagrass beds			Bare substrata			Seagrass beds			Bare substrata		
	Fish eggs	Juven. fish	Crab larvae	Fish eggs	Juven. fish	Crab larvae	Fish eggs	Juven. fish	Crab larvae	Fish eggs	Juven fish	Crab larvae
5/98	0.5	1.25	57.57	22.5	0.25	30.5	*	*	*	*	*	*
6/98	0	0	0	0	0.5	1.0	*	*	*	*	*	*
7/98	0	0.5	0	6.38	0	2.57	0	1.75	0	131.5	0.12	2.75
8/98	*	*	*	*	*	*	0	2.0	0	0	0	0
9/98	52.25	0.25	78.0	8.38	0.25	17.12	*	*	*	*	*	*
2/99	7.05	4.57	17.43	50.00	5.00	3.57	*	*	*	*	*	*
3/99	*	*	*	*	*	*	0	0	0	0.20	0	0.04
4/99	2.40	0.30	0.44	4.00	1.33	1.63	0.73	0	0	2.77	0.05	0
6/99	0.15	0.10	0	1.15	0.12	0	0.20	0	0.10	0.10	0	0.05

Source: Nguyen Huu Dai et al, *1997, 1998 *: No samples.*

2.2.4 Fish

Juvenile fish

Table 10 shows the characteristics of juvenile fish stocks in the two sites of Dong Ba Thin and My Giang. In Dong Ba Thin, the percentage of juvenile Gobridae is 42.31% in seagrass beds and 36% in areas of bare substrata. Additionally, the percentage of juvenile Clupeidae and Atherinidae is the same by substrate type (16%). Only a small percentage of other fish species are observed to occur in these areas. In the seagrass beds of Dong Ba Thin, juvenile fishes are present throughout the year, with the highest density in May (4.57 unit/m^3). In bare areas, juvenile fish density is low. However, data analysis and species identification is not yet complete for juvenile fish in Dong Ba Thin. In the seagrass beds of My Giang, Atherinidae and Labridae had the same percentage abundance (40%), while the family of Balistidae comprised 20% of the samples. In My Giang, juvenile fish density is high in July and August (mean value of 1.85 unit/m^3). As with Dong Ba Thin, density is low in areas of bare substrata.

Table 10 Juvenile fish groups in seagrass and non-seagrass places in Dong Ba Thin and My Giang, Khanh Hoa Province.

Species group	Dong Ba Thin				My Giang			
	Seagrass beds		Bare substrata		Seagrass beds		Bare substrata	
	Quantity	Percentage (%)	Quantity	Percentage (%)	Quantity	Percentage (%)	Quantity	Percentage (%)
Stolephorus	0	0	2	4.00	0	0	0	0
Atherinidae	4	15.38	8	16.00	6	40.00	1	50.00
Theraponidae	2	7.69	3	6.00	0	0	0	0
Gobridae	11	42.31	18	36.00	0	0	0	0
Labridae	0	0	0	0	6	40.00	0	0
Clupeidae	1	3.85	8	16.00	0	0	0	0
Balistidae	0	0	0	0	3	20.00	0	0
Blenniidae	2	7.69	3	6.00	0	0	0	0
Scaridae	0	0	0	0	0	0	1	50.00
Group not yet identified	6	23.08	8	16. 00	0	0	0	0
Total	**26**	**100**	**50**	**100**	**15**	**100**	**2**	**100**

Source: Nguyen Huu Dai et al *1997,1998.*

Fish eggs

Observations on the occurrence of fish eggs in the two ecological zones of both sites is summarised in Table 11. In Dong Ba Thin, the percentage of *Stolephorus* eggs sampled in seagrass beds was 0.07%, significantly lower than that observed in areas of bare substrata (8.96%). In My Giang, the percentage of *Stolephorus* eggs in the bare substrata was 0.18%; however, data analysis is not yet completed for this site.

Table 11 Fish egg groups in the Dong Ba Thin and My Giang study sites.

Species groups	Dong Ba Thin				My Giang			
	Seagrass beds		Bare substrata		Seagrass beds		Bare substrata	
	Quantity	Percentage (%)	Quantity	Percentage (%)	Quantity	Percentage (%)	Quantity	Percentage (%)
Stolephorus	3	1.07	49	8.96	0	0	2	0.19
Atherinidae	2	0.71	0	0	0	0	0	0
Synodontidae	0	0	0	0	0	0	2	0.18
Scaridae	0	0	2	0.67	0	0	0	0
Groups not yet identified	281	98.12	496	90.67	19	100	1,109	99.64
Total	**281**	**100**	**547**	**100**	**19**	**100**	**1113**	**100**

Source: Nguyen Huu Dai et al *1997,1998.*

2.2.5 Molluscs

Molluscs account for the highest number of species (37spp.) in the seagrass beds of Khanh Hoa Province. Among them, common species such as *Anadara antiquata* (with densities in some areas ranging from 2 to 10 individuals/m^2), *Circe scripta* (5 to 35 individuals/m^2), *Katelysia hiantina* (3 to 20 individuals/m^2), *Strombus* spp. (8 to 12 individuals /m^2 in some concentrated areas) and *Pina* spp (1 to 4 individuals/m^2) were recorded. *Anomalocardia squamosa* was commonly observed on *E. acoroides* leaves (1 to 3 individuals/shoot).

2.2.6 Dugong and Marine Turtles

Dugong

Until recently, it was widely considered that the only remaining population of dugongs in Viet Nam inhabited areas of Con Dao National Park, an archipelago of 14 islands in the southern province of Ba Ria-Vung Tau. To date, the only scientific research conducted on dugongs in Viet Nam has been undertaken in Con Dao National Park (Cox, 2002). Most other information is anecdotal, including reports of recent sightings in Quang Ninh Province (Bai Tu Long National Park) and Kien Giang Province (Phu Quoc and Ha Tien districts). Despite the lack of scientific observations of dugongs in Quang Ninh Province, the area contains habitat capable of supporting small dugong populations. Viet Nam's offshore island areas are relatively isolated and less intensively fished than coastal areas, providing areas suitable for the maintenance of dugong populations. Estimates of dugong population sizes are largely based on observations of local environmental conditions, in particular the state of seagrass habitats, and anecdotal evidence from local fishers of incidence of sightings. There are reports from several other locations where dugongs have existed in the past, including sites in Quang Ninh Province (Co To Islands), Haiphong Province, Khanh Hoa Province, and Binh Thuan Province (e.g. Phu Quy Island). Extensive seagrass habitats still exist in these areas, but intensive fishing in seagrass habitats has probably led to localised extinctions of dugongs. There are also reports from Can Gio Biosphere Reserve (near Ho Chi Minh City) and Bac Lieu Province that dugongs have been seen in certain seasons, but these reports are unconfirmed and require further investigation.

Con Dao National Park is the only known location in Viet Nam where regular dugong sightings occur. Dugong movements in Con Dao align with patterns of tidal movements, with individuals regularly seen in the same locations relative to the tidal cycle. Typically, dugongs graze seagrasses in deeper water during low tides and move into shallow habitats at higher tides, with feeding mostly occurring in the shallowest seagrass beds (2 to 3m) during peak high tides. Based on seagrass assessments made by scientists from the Nha Trang Institute of Oceanography and the National Park, the estimated number of dugongs in the Con Dao area is around 10 individuals. From 1997 to 2002, 10 dugong mortalities occurred in Con Dao. Scientists now believe that this population is at a high risk of local extinction within 5 to 10 years.

Dugong sightings in Phu Quoc range from occasional sightings in the eastern and southern portion of the island, to frequent sightings in the eastern town of Ham Ninh and the northern village of Bai Thom. Local fishers have excellent local knowledge of sea conditions, and can accurately set fixed gill nets at certain times of the month in order to increase the chance of catching a dugong. Based on this information, and considering the relatively large areas of suitable habitats in Kien Giang Province, the distribution and frequency of sightings and the frequency of dugong catches, the dugong population in this area is estimated at approximately 100 to 300 individuals. However, this population is at high risk.

The major threats to dugongs in Viet Nam are:

- Hunting – not widespread, but still significant, particularly in Phu Quoc, Kien Giang province.
- Gill nets – fixed nets in shallow seagrass habitats, significant cause of accidental dugong drowning (Phu Quoc).
- Starvation through habitat destruction – destructive fishing in seagrass beds, especially in Kien Giang Province, and sedimentation from coastal development, including Con Dao.

Marine turtles

Five species of marine turtle are found in Viet Nam's marine and coastal zone (*Chelonia mydas, Eretmochelys imbricata, Dermochelys coriacea, Lepidochelys olevacea*, and *Caretta caretta* (Pham Thuoc *et al*, 2001), although only green turtles (*Chelonia mydas*) are known to nest in any significant numbers, mostly in the southern islands of Con Dao. The diet of marine turtles varies between species, with the green turtle mostly dependent on seagrass species *Thalassia hemprichii* and *Halophila ovalis*. Marine turtle nesting beach programmes have been carried out in Con Dao National Park since 1995. This programme has recently been extended to sites in Nui Chua National Park, in south central Viet Nam, and Bai Tu Long National Park in the north. However, Con Dao remains the most significant nesting area for marine turtles in the country, with approximately 250 green turtles nesting each year. No studies have been carried out on migratory patterns of other turtle species found in Vietnamese waters. The biggest threats to marine turtles are thought to be incidental catch by fishing vessels and illegal trade in marine turtle products.

2.3 Threats to Seagrass

2.3.1 Natural stress

Typhoons: In northern Viet Nam's Tonkin Gulf, there is an annual average of 35 typhoons, with a maximum wind speed of 50m/s. Typhoons, storms, surges or strong winds cause increased wave action on the sea bottom. Seagrass beds of *Thalassia hemprichii* around Co To Island and Nam Yet Island (Truong Sa Archipelago) have been seriously affected by storm waves. In southern Viet Nam, 1997's "Typhoon Linda" is believed to have resulted in the local extinction of *Thalassodendron ciliatum.* This typhoon caused serious damage to some seagrass areas in the waters of Con Dao. In 1998, permanent transect lines were established on seagrass beds at five sites in order to monitor their natural rehabilitation. The results of annual monitoring from 1998 to 2002 indicate that the rehabilitation of seagrass beds was slow due to the simultaneous impacts of human activities, including rapid coastal development, the expansion of fishing effort, and associated service activities for the fishing industry. These factors have disturbed the coastal marine environment, leading to reductions in the regenerative ability of seagrass beds. Due to the combined influence of "Typhoon Linda" and human-induced impacts, 20 to 30% of Con Dao's seagrass areas have been lost. The pre-typhoon density of *Halophila ovalis* in Con Dao was 2,250 units/m^2, this has now declined to 1,551 units/m^2 (Nguyen Xuan Hoa and Tran Cong Binh, 2002).

Turbidity and sedimentation: Along the coast of Viet Nam, there are a series of rivers flowing into the sea. These water masses often contain large quantities of suspended alluvial soil that acts to increase water turbidity of coastal ocean areas, which often leads to reductions in seaweed and seagrass growth rates. High turbidity levels during the rainy season will often lead to a reduction in the photosynthetic ability of seagrass plants. Experiments conducted in Ha Long Bay during 2002 showed that a 4mm thick layer of sediment on seagrass leaves is lethal for *Zostera japonica*, while a 6mm thick layer of sediment is lethal for *Halophila ovalis* (Nguyen Van Tien and Nguyen Huy Yet, 2001). Increased turbidity also occurs due to human activities on land, including agriculture, foresty, and urban development. In waters of Dau Go Cave and Tuan Chau Island, the distribution and abundance of seagrass has declined significantly over the past 30 years. Prior to 1972, seagrass (*Zostera japonica*) grew at a high density and reasonable depth (7 to 8m) at the sites of Hon Soi Co (Hai Phong) and Bo Hon (Ha Long Bay). However, due to destruction during the Viet Nam-American war, seagrass beds at these sites have almost all been lost due to strong sedimentation and increases in water turbidity (Nguyen Van Tien, 1998; Nguyen Van Tien and Nguyen Chu Hoi, 1995).

Increase in freshwater: Seagrass species are adapted to salinity levels ranging from 15 to 30%. Increases in the quantity of freshwater flowing into coastal water bodies can cause reductions in salinity levels that do not corresponded with the adapted range of most species, especially those growing on tidal flats (*Zostera japonica, Halophila ovalis* and *H. beccarii*).

2.3.2 *Human-induced Stress*

Destructive fishing methods: In Viet Nam, fishers employ many kinds of destructive fishing methods and gears, such as fishing with explosives, trawling, gill net, drift net, bottom net, blanket nets, fine square nets, electro-fishing, and use of cyanide. Destructive fishing practices have devastated seagrass beds. One set of bottom fishing nets in 4 to 6m of water in Quang Tri Province, resulted in the incidental removal of 32 species of seaweed and one species of seagrass from the seafloor. The trampling, gleaning, and digging of animals and plants from intertidal flats in Song Han and Cua Viet River mouths has severely affected seagrass beds.

Aquaculture ponds: Tidal flats containing seagrasses have been converted to aquaculture ponds. This is particularly prevalent in Khanh Hoa Province. As a result, the distribution of *E. acoroides* in Thuy Trieu Lagoon declined 20 to 30% in 1998 (Nguyen Huu Dai *et al*, 2002). Furthermore, there were no seagrass plants bearing flowers and fruits in degraded areas, suggesting that the natural recovery ability of seagrass is very low. The continued disturbance of the coastal system may ultimately lead to seagrass communities disappearing. Seagrass meadows in Ha Long Bay, Bai Tu Long, and Tam Giang-Cau Hai lagoon have been reduced by 45 to 50% due to this kind of reclamation (Nguyen Van Tien, 1998; Nguyen Van Tien *et al*, 2000.

Coastal construction: Coastal construction of roads, bridges, houses, ports and fishing effort increased dramatically. These activities contributed to the degradation of the coastal environment, which may be linked to seagrass loss. Dredging of canals in Ha Long Bay and Cat Hai District has led to increases in water turbidity and affected seagrass meadows.

Pollution: Information relating to the impacts of pollution on seagrass is scarce. Wastewater discharges composed of heavy metals, suspended sediments, nutrients, and oils are probably the most harmful for seagrasses. Many seagrass beds are located in areas adjacent to boat anchorages and slipways, and oil spills from ships and fishing boats cause great damage to seagrass beds, especially younger plants.

Agricultural reclamation: Seagrass ecosystems are under increased stress from the reclamation of tidal flats for agricultural purposes. In Quang Ninh Province, thousands of hectares of seagrass beds have been lost due to this kind of reclamation.

2.3.3 *Causal Chain Analysis of Threats to Seagrasses*

Approximately 45 to 50% of Viet Nam's seagrass habitat has been lost over the past 2 decades (Tu Thi Lan Huong, 2003). Most losses have been caused by anthropogenic activities (sedimentation, aquafarms, reclamation, urbanisation, land-based pollution etc.), and natural phenomena such as storms and typhoons. Poorly planned coastal development is the root cause of seagrass destruction. The lack of public awareness of the ecological, economic, and social importance of seagrass beds is also a problem. Consequently, the lack of awareness about this resource amongst coastal dwellers, users, policy-makers, and managers is a root cause of seagrass habitat loss in Viet Nam. Figure 1 shows causal chain analysis of threats to seagrass in Viet Nam.

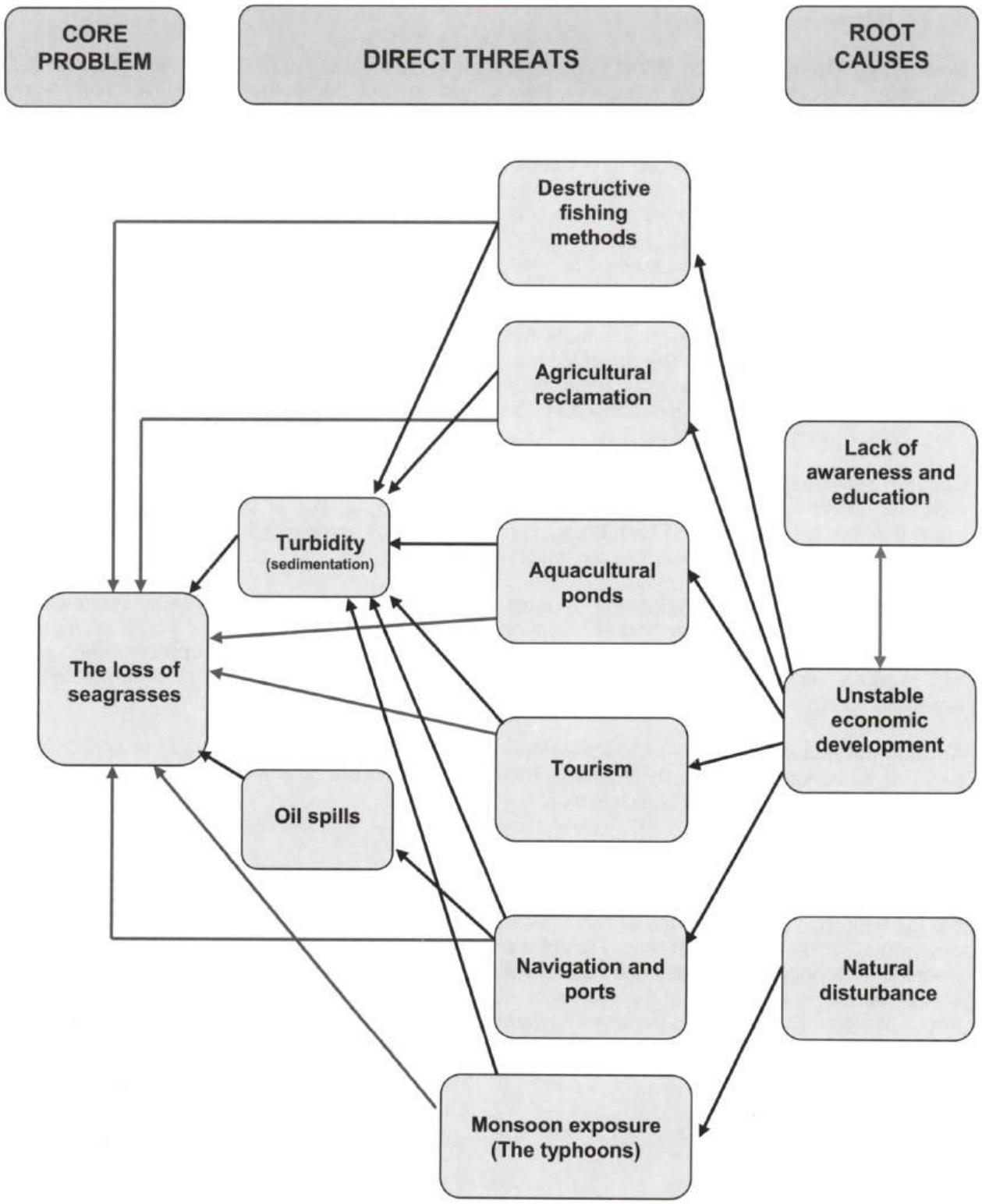

Figure 1 Causal chain analysis of threats to seagrass in Viet Nam.

3. ECONOMIC VALUATION

3.1 Human Use of Seagrass

3.1.1 Direct Use of Seagrass

The majority of exploited seagrasses are used as feed for livestock and fertiliser. Coastal communities from Quang Ninh Province to Thua Thien-Hue harvest seagrasses (mainly *Zostera, Ruppia* and other Hydrophytes) for this purpose. Fishers living around Tam Giang-Cau Hai Lagoon (Thua Thien-Hue) regularly harvest hydrophytes. Annually, harvested production amounts to 100,000 tonnes. Fishers from the village of Vinh Mi (there are 41 villages around the lagoon) harvested seagrasses and sold them in the market with a total value of 300 million VND (US$20,000) during a period of six months.

3.1.2 Use of Associated Biota

Algae
Among these species, *Gelidiella acerosa*, *Gracilaria eucheumoides*, *Gracilaria* spp., *Hypnea* spp., *Sargassum* spp., and *Turbinaria* spp. are of commercial value and collected at My Giang (Nguyen Huu Dai and Pham Huu Tri, 2000).

Crustacea
Harvesting of the swimming crabs *Portunus pelagicus* and *P. sanguinolentus* takes place throughout the year. In Thuy Trieu Lagoon (Khanh Hoa Province), the density of juvenile *Portunus pelagicus* was observed to range from 5 to 20 individuals/m^2 in December, 1997 (Pham Huu Tri, 2002). At this site, approximately 50 boats harvest crabs every day from seagrass beds during the main fishing season (from June to July), catching up to 20kg of crab/boat/day.

Echinodermata
Twelve species of *Echinodermata* were collected from seagrass beds in Khanh Hoa Province. The density of the commercially important species of *Holothuria scabra* and *Halodeima atra* in these beds was observed to range from 4 to 6 individuals/m^2 (juveniles). The species *Holothuria scabra* has been harvested intensively in recent years and is now rare.

Fish
Eighty-seven species of fish were recorded, including 34 commercially important species. Important fish species that are caught throughout the year include *Mugil* spp., *Leiognathus equulus, Sillago shihama*, *Apogon* spp., *Hemiramphus georgii* and *Siganus fuscescens*. Exploitation of at least 67 species of fish occurs in the area around Phu Quoc. These include many Carangids (jacks and trevallies) such as *Carangoides ferdau, Caranx sexfasciatus*, *Selaroides leptolepis* and *Atule kalla*, Scombrids (mackerels) *Rastrelliger kanagurta* and *Scomberomorus commersonii*, as well as reef-dwelling genera such as groupers *Epinephelus* and *Cephalopholis*, snappers *Lutjanus* and monocle breams *Scolopsis*. The local market value of grouper ranges from 40,000 to 50,000 VND/kg (US$2.6 to 3.3), while *Scombrids* are valued at approximately 15,000 VND (US$1)/kg. There are large markets for live groupers in neighbouring countries, especially Hong Kong. Larger quantities of the small schooling genera of *Siganus* and *Caesio*, and the demersal Saurida are traded throughout the year.

Seahorses
Some species of seahorses, including *Hippocampus kuda, H. histrix,* and *H. trimaculatus*, inhabit seagrass beds. In Viet Nam, these species have been heavily exploited. In waters adjacent to Phu Quoc Islands, fishers employ trawl and gleaning methods to take large quantities of seahorses.

3.2 Estimation of Economic Values of Selected Seagrass Beds in Viet Nam

3.2.1 Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province

Approximately 300,000 inhabitants live around the lagoon earning their livelihoods directly or indirectly from natural resources. Six species of seagrass are present in the lagoon, and the production of seagrass is estimated at 190,000 tonnes per year. The seagrass beds occupy an area of approximately 1,000ha and are located adjacent to the inlets of Thuan An and Tu Hien.

Extractive use value

An important economic value of seagrass beds in Tam Giang-Cau Hai Lagoon relates to their role in fisheries production (Table 12). The total annual income from this locally operated fishery is US$461,869.*

Table 12 Direct values of fisheries production from Tam Giang-Cau Hai Lagoon (2001).

District	Mugilus Cephalus aver. 35,000 VND/kg **		Cyprinus Centralus aver. 40,000 VND/kg		Other kinds aver. 30,000 VND/kg		Direct values	
	Productivity (kg)	Income VND	Productivity (kg)	Income VND	Productivity (kg)	Income VND	VND	US$
Quang Dien	456	15,960,000	0	0	4,812	144,360,000	160,320,000	10,688
Phu Loc	27,432	960,960,000	2,844	113,760,000	88,610	2,931,180,000	4,005,900,000	267,060
Huong Tra	900	31,500,000	720	28,800,000	240	7,200,000	67,500,000	4,500
Phong Dien	2,244	78,540,000	1,380	55,200,000	3,000	90,000,000	223,740,000	14,916
Phu Vang	18,050	631,750,000	11,485	459,400,000	63,157	1,379,430,000	2,470,580,000	164,705
Total	**49,082**	**1,718,710,000**	**16,429**	**657,160,000**	**159,819**	**4,552,170,000**	**6,928,040,000**	**461,869**

**Note: US$ – American dollar, **VND – Vietnamese Dong, Exchange rate US$1=15,000VND (2001).*
Source: Do Nam, (2003).

The lagoon provides many kinds of fishery products, including shrimps (*Penaeus monodon* and *Metapenaeus ensis*), crabs (*Scylla Serrata* and *Portunus sanguinolentus*), seaweed (*Gracilaria*), etc. The annual production of shrimp and crab is approximately 342 tonnes at an average local market price of 50,000 VND/kg. This generates an income of 17.1 billion VND (or $1.140 million). Seaweed production in the lagoon reached a total of 216 tonnes, with an economic value of 110 millions VND (approximately US$7,400).

To estimate the value of seagrass used directly as fertiliser, the research team conducted a rapid interview with inhabitants of Vinh My Commune, Phu Loc District (Thua Thien Hue Province) where seagrasses are used as fertiliser. Fertiliser from seagrass is used for tobacco, chilli, and fruit crops. Almost 82 hectares of gardens in Vinh My Commune are fertilised with seagrasses. According to Nguyen Van Tien (1996), seagrass species in Tam Giang-Cau Hai include *Halophila beccarii, Zostera japonica, Ruppia maritima,* and *Halodule pinifolia*. Research by Le Thi Nam Thuan *et al* (2000) revealed the total annual value of the direct use of seagrass as fertiliser to be approximately 300 million VND (US$20,000). Research using the contingent valuation method by Tran Huu Tuan (2002) also gave similar results. A summary of resource direct use value of Tam Giang-Cau Hai Lagoon is provided in Table 13.

Table 13 Direct use values of Tam Giang-Cau Hai Lagoon.

	Productivity (kg)	Income (VND)	US$
Fish	225,330	6,928,040,000	461,869
Prawn and crab	342,000	17,100,000,000	1,140,000
Seaweed	216,000	110,000,000	7,333
Fertiliser	N/A	300,000,000	20,000
Subtotal	**N/A**	**24,438,040,000**	**1,629,203**

Source: Do Nam, (2003), Tran Huu Tuan, (2002); Exchange rate US$1=15,000VND.

Non-extractive values

Due to the proximity of the lagoon to both Da Nang and Hue (the two largest cities in the central region), there is potential for the development of this area as a destination for tourists. The non-extractive use value for this site is high due to its role in education, training, and tourism potential.

Environmental services

It is known that the Tam Giang-Cau Hai Lagoon provides important spawning, feeding and nursery grounds for fish and shellfish. Primary productivity in the lagoons is also higher than in adjacent coastal waters, because of the influx of organic matter from coastal rivers. These factors combine to support a productive fishery and benthic invertebrate community. In turn, this productivity supports large numbers of migratory waterfowl and shorebirds, as well as an economically important fisheries industry.

Fisheries represent the natural resource use of highest economic value at the Tam Giang-Cau Hai Lagoon complex. Fishery production was estimated to be around 100 to 150kg per hectare per year in 1997. Marine algae *Gracilaria* spp. is harvested on a large-scale basis for algae production. Hydrophytes of various species, including *Najas indica, Valisneria spiralis, Hydrilla* spp., *Paspalum* spp., and some macroscopic algae are harvested for fertilisers and organic matter for crops, including rice and tobacco, which are grown on the dry, sandy soils nearby.

Biodiversity value

To date, 223 species of fish have been recorded in the lagoon, including one endemic species, *Cyprinus centralis*. It is known that the Tam Giang-Cau Hai Lagoon complex supports a range of wetland habitat types (marshland, mudflats, and sand flats, submerged wetlands supporting seagrasses). Wetland habitats serve as seasonal habitat for large numbers of migratory waterfowl that use the lagoons in winter. There are reports of up to 20,000 waterfowl (ducks and geese) using the lagoon during winter. There are 70 species of seabirds found in the Tam Giang-Cau Hai Lagoon, of which 21 species are listed in the EU Red List of endangered species requiring strict protection. All values of Tam Giang-Cau Hai Lagoon, both market and non-market, are summarised in Table 14.

Table 14 A Summary of Tam Giang-Cau Hai Lagoon resource valuation.

USES	Use Values			Non-Use Value		
	Direct	Indirect	Option	Quasi-Option	Bequest	Existence
EXTRACTIVE USE						
Fish	461,869	-	-			
Prawn and crab	1,140,000	-	-			
Seaweed	7,333	-	-			
Fertiliser	20,000	-	-			
Medicine	N/A	-	-			
Handicraft	N/A	-	-			
NON-EXTRACTIVE USE						
Research & Education	VS	-	S		S	S
Aesthetic/culture	VS	-	S		S	S
Tourism	VS	-	S		-	-
ENVIRONMENTAL SERVICES						
Shoreline protection	-	VS	-		S	S
Carbon sequestration	-	VS	-		S	S
Water purification	-	VS	-		S	S
Oxygen release	-	VS	-		S	S
Sediment and nutrient retention	-	VS	-		S	S
Nursery area	-	VS	-		S	S
Waste catchment	-	VS	-		S	S
Erosion prevention	-	VS	-		S	S
BIODIVERSITY SERVICES						
Biodiversity	-	VS	VS			

Note: Marketed value is given in US$; Values can be considered according to how their significance varies; VS – very significant, S – significant, N/A – not available.

3.2.2 Thuy Trieu Lagoon, Cam Ranh Town, Khanh Hoa Province

Extractive values

Mollusc species are the most significant contributors to the economic value of seagrass beds in Thuy Trieu lagoon. Twice a year, four tonnes of molluscs per hectare are harvested, including economically valuable species such as *Katelysia hiatina, Anadara antiquate*, and *Strombus* spp. A summary of this value is provided in Table 15. Fishes and crustaceans are also marketed products from seagrass beds.

Table 15 Direct use values of Thuy Trieu lagoon (2001).

	Productivity (kg)	Income from 1ha per year		Income (VND)	US$
		VND	US$		
Fish	N/A	38,750,000	2,500	31,000,000,000	2,066,667
Crustacean	20 kg/day/ha	37,200,000	2,400	29,760,000,000	1,984,000
Molluscs	4,000	58,900,000	3,800	47,120,000,000	3,141,333
Others	N/A	18,600,000	1,200	14,880,000,000	992,000
Subtotal	**N/A**	**153,450,000**	**9,900**	**122,760,000,000**	**7,920,000**

Source: Nguyen Xuan Hoa and Nguyen Huu Dai (1996, 2001); Nguyen Xuan Hoa,(2003); Exchange rate US$1=15,000VND.

Non-extractive value

Thuy Trieu Lagoon, like Tam Giang Cau Hai Lagoon, is important for education, training, and possesses a high aesthetic value. There is also potential to develop tourism activities.

Environmental services

Thuy Trieu Lagoon is used for hatching shrimp. Each year, Khanh Hoa Province supplies around 300 million post larvae shrimp for the Vietnamese shrimp farming industry, of which a third is supplied by Thuy Trieu Lagoon. Commercial shrimp farming is a very important economic activity in the area.

Biodiversity value

The centre of the site supports an estimated 800ha of seagrass beds. These contain 6 species of seagrass, 15 gastropods, 4 penaeids, 2 urchins, 4 starfishes, 8 holothurians, 12 echinoderms, 13 crustaceans, 2 reptiles, 87 species of fish including 3 siganids, 2 seahorses, and 37 species of molluscs (Nguyen Huu Dai, 2002; Nguyen Xuan Hoa, 2003). A summary of the resource valuation for Thuy Trieu Lagoon is presented in Table 16.

Table 16 A summary of Thuy Trieu Lagoon resource valuation.

USES	Use Values			Non-Use Value		
	Direct	Indirect	Option	Quasi-Option	Bequest	Existence
EXTRACTIVE USE						
Fish	2,066,667	-	-			
Crustacean	1,984,000	-	-			
Molluscs	3,141,333	-	-			
Other fishery	992,000	-	-			
Medicine	N/A	-	-			
Fertiliser	N/A	-	-			
Handicraft	N/A	-	-			
NON-EXTRACTIVE USE						
Research & Education	S	-	S		S	S
Aesthetic/culture	S	-	S		S	S
Tourism	S	-	S		-	-
ENVIRONMENTAL SERVICES						
Shoreline protection	-	S	-		S	S
Carbon sequestration	-	S	-		S	S
Water purification	-	S	-		S	S
Oxygen release	-	S	-		S	S
Sediment and nutrient retention	-	S	-		S	S
Nursery area	-	VS	-		S	S
Waste catchments	-	S	-		S	S
Erosion prevention	-	S	-		S	S
BIODIVERSITY SERVICES						
Biodiversity	-	VS	VS			

Note: Marketed value is given in US$; Values can be considered according to how their significance varies; VS – very significant, S – significant, N/A – not available.

3.2.3 Bai Bon Site, Phu Quoc Island, Kien Giang Province

Extractive value

Settlement of migrants from other parts of Viet Nam is leading to rapid population growth in Phu Quoc. The dominant economic sector is fisheries and aquaculture, both Bai Bon and the whole of Phu Quoc Archipelago in general. The direct use values of this site are presented in Table 17.

Fishing is the most important economic activity of the local population. However, growing populations in the area are placing high demands on the productive capacity of most marine resources. Although fisheries production is actually increasing, it is not keeping pace with the number of boats in operation.

Table 17 Direct use values of Bai Bon site (2001).

	Income from 1ha per year		Income (VND)	US$
	VND	US$		
Fish	2,000,000	129.00	4,000,000,000	258,000*
Crustacean	1,567,000	101.00	3,134,000,000	202,000
Mollusc	167,000	10.75	334,000,000	21,500
Hydrophytes and seaweeds	N/A	N/A	N/A	N/A
Subtotal	**3,734,000**	**240.75**	**7,468,000,000**	**481,500**

** Environmental value has not been estimated; Exchange rate US$1=15,000VND; Valuation conducted for 2000ha.*
Source: Nguyen Xuan Hoa, (2002, 2003).

Non-extractive values

Although access to this area is not as easy as that for other seagrass beds along the coastline of mainland Viet Nam, the area still plays an important role for training and development of the natural sciences. Coastal and marine biodiversity, geomorphology, sedimentology, environmental chemistry, and the ecology of the lagoon system are all areas of interest to local and international researchers and students.

The area is considered one of the most promising eco-tourism sites in the south of Viet Nam, with the number of tourists visiting this site growing at an alarming rate. The value of international and national tourism investment in Phu Quoc in January 2004 amounted to 400 billion VND.

Environmental services

The Bai Bon site is a part of the Phu Quoc archipelago. It is considered one of the most important fishing grounds in southern Viet Nam, for both local communities and fishing communities throughout mainland Viet Nam. The fishing ground is also used by Thailand. The regional importance of the area is emphasised by its proximity to Cambodia and Thailand. The use of the area as a marine protected area may produce successful regional fisheries management outcomes, especially in the conservation of migratory fish species.

Biodiversity

Bai Bon represents all the biodiversity values of Phu Quoc Islands, which support ecosystems characteristic of the shallow coastal waters off southwestern Viet Nam, including coral reefs and wetlands. It includes seven seagrass species and many other species of economic and international importance. These include three species of penaeids, three species of holothurians, three species of starfish, three species of urchins, 46 species of gastropods, and one species of siganids. Of these species 6 are threatened and 2 are indigenous species (Nguyen Xuan Hoa, 2002). A summary of the resource evaluation at Bai Bon is presented in Table 18.

Table 18 A summary of the Bai Bon site resource valuation.

USES	Use Values			Non-Use Value		
	Direct	Indirect	Option	Quasi-Option	Bequest	Existence
EXTRACTIVE USE						
Fish	77,420	-	-			
Crustacean	60,645	-	-			
Mollusc	6,452	-	-			
Medicine	N/A	-	-			
Fertiliser	N/A					
Handicraft	N/A	-	-			
NON-EXTRACTIVE USE						
Research & Education	VS	-	VS		VS	VS
Aesthetic/culture	VS	-	VS		VS	VS
Tourism	VS	-	VS		-	-
ENVIRONMENTAL SERVICES						
Shoreline protection	-	S	-		S	S
Carbon sequestration	-	S	-		S	S
Water purification	-	S	-		S	S
Oxygen release	-	S	-		S	S
Sediment and nutrient retention	-	S	-		S	S
Nursery area	-	VS	-		S	S
Waste catchments	-	VS	-		S	S
Erosion prevention	-	VS	-		S	S
BIODIVERSITY SERVICES						
Biodiversity	-	VS	VS			

Note: Marketed value is given in US$; Values can be considered according to how their significance varies; VS – very significant, S – significant, N/A – not available.

4. INSTITUTIONAL ARRANGEMENTS AND NATIONAL LEGISLATION

4.1 Hierarchical Structure of Legislation

4.1.1 National Policies and Plans

This section is based on Nguyen Chu Hoi and Nguyen Huy Thu (2002).The most important national strategies include the National Conservation Strategy (1985), the National Plan on Environment and Sustainable Development (1991), and the Government of Viet Nam Report for the UN Conference on Environment and Development (1992).

National Conservation Strategy (1985)

This is a national programme addressing different areas relating to the conservation and appropriate use of natural resources.

National Plan on Environment and Sustainable Development 1991 to 2000

This document drafts a framework for national plans of action in environment and sustainable development. The objectives of this plan are to:

1) Provide a comprehensive framework for development in different stages of environmental management and planning at national and provincial levels, and
2) Guide specific, urgent and short-term actions aimed at addressing priority issues in the 1991 to 2000 period.

Based on the national strategies and plans, the Principle of Chapter 17 of Agenda 21, and international conventions on prevention of marine pollution, some priority areas for environmental protection have been identified:

- Strengthen capacity for State environmental management agencies to develop policies for the marine environment and finalise the Law on Environmental Protection of Viet Nam.
- Prevention and control of pollution from the mainland.
- Shifting of the fisheries to the orientation of encouraging deep sea fishing and strengthening the enforcement of the ordinance on protection of seafood resources.
- Protection and recovery of coastal ecological systems (lagoons, mangrove forests, tidal areas, coral reefs, algae-seagrasses, and other water submerged ecosystems).
- Development and implementation of national plans for remedial actions against oil spills.
- Development and implementation of the plan on protection of marine biodiversity.
- Mapping of degradation and sensitivity of coastal zones to identify plans for recovery of environment and natural resources of the degraded ecological systems.
- Establishment and implementation of a comprehensive management programme of the coastal areas linked with management of the coastal basin areas.

4.1.2 National Laws

Viet Nam has promulgated the following laws and documents:

- The constitution of the Socialist Republic of Viet Nam (1992)
- The declaration on the territorial water, the area nearby exclusive economic zone and continental shelf. In this declaration, the territorial water of Viet Nam extends 12 nautical miles; the area nearby exclusive economic zone extends 24 nautical miles and the exclusive economic zone to 200 nautical miles from the baseline that is used for calculating territorial water width and continental shelf (12/5/1977).
- The declaration on the base line for defining length of territorial water of Viet Nam (12/11/1982).
- The promulgation of the environmental protection law (10/2/1994).
- Law of water resources.
- Law of land (1995).
- Law of petroleum (1992).
- Law of minerals.
- Ordinance for fisheries resource protection, environmental protection (adopted by parliament in 1993).
- Law on fisheries, approved by Vietnamese Parliament in 2003. The Article 6 of the law focuses on prohibition of devastating seagrass beds.

4.1.3 Enabling Regulations, Ordinances

- Ordinance on the protection and development of living aquatic resources.
- Ordinance 195/H§BT 1990 on the protection and development of fisheries resources, and circular 01 TS/TT that provides amendments to Ordinance 195.
- Ordinance 86 CP/TTg on fisheries enterprise conditions and circular 02 for implementation.
- Instruction 01/CT-TTg 1998 on prohibition of destructive fishing methods such as dynamite, electricity, and poison for fisheries exploitation.
- Regulations to handle administrative violations in destructing seagrass beds, and rare and valuable animals and plants in ordinance 48 CP/1998 for the fisheries resources protection sector.

4.2 Substantive Instruments for Marine Environmental Protection

4.2.1 Economic Instruments – Provisions

Economic instruments for marine environmental protection include:

1. Regulations regarding rewards and punishments in protection and development of fisheries resources with different levels (money, disciplinary or administrative treatment following the regulations, laws).
2. Regulations regarding rewards and punishments at different levels (administrative treatment or criminal proceedings) for all activities in violation of the environment law passed in 1993.
3. Ordinance by the Finance-Fisheries Inter-Minister for charging licence fees when issuing permission for fisheries activities (4/3/1993).
4. Regulations that permit fines (from 100,000 to 500,000 VND) and stopping fishing activities if offenders destroy 20 to 50kg of coral or marine flora, and fines up to 1,000,000 VND for offenders who destroy 50kg of coral or marine flora (22/11/1993).
5. Regulations in which anyone will be fined an amount of 500,000 to 1,000,000 VND for disposing of greater than 10 to 20% of the allowable value of toxic water discharge, and fines of 2,000,000 VND for concentrations of allowable discharge over 20% (22/11/1993).

4.2.2 Licensing-permit Systems for Marine Environment Management

In October 1992, the Government reorganised the State Committee on Science and Technology into the Ministry of Science, Technology and Environment (MOSTE). Within MOSTE, the Department of Natural Resources and Environment was transformed to the National Environment Agency (NEA) following the ratification of the Law of Environmental Protection during December 1993.

A summary of the key environmental protection functions and tasks of the MONRE include:

- Formulation of policies and legal documents, including regulations on environmental protection and sustainable development.
- Development of strategies and long-term programmes on environmental protection.
- Development of human resources in the environmental sector.
- Planning of finance and information management for environmental protection.
- Implementation of environmental protection solutions to preserve environmental health.
- Surveys of projects and selection and organisation of environmental monitoring systems across the country.
- Organisation and guiding of activities of the masses in environmental protection and education, training as well as promotion of environmental awareness for communities.

VEPA has the following main functions and tasks (Figure 2):

- Develop and submit national policies and draft laws and other legal documents for MONRE, which make recommendations of comprehensive solutions for environmental protection to ensure a clean environment, thus contributing to national sustainable development.
- Audit organisations and individuals in the implementation of the laws on environmental protection and legal documents on environmental protection.
- Implementation of the National Plan on Environment and Sustainable Development and action plans for environmental protection of concerned ministries (sectors) and provinces, and report to ministries/sectors regarding the incorporation of environmental protection activities into the National Economic Plan.
- Appraisal of environmental impact assessment reports for development planning, projects, and production throughout the country for ministries, sectors, provinces and localities.

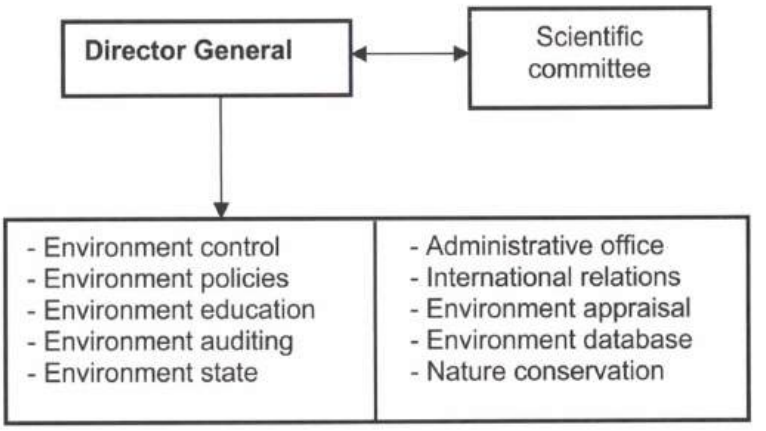

Figure 2 Organisational chart of the Viet Nam environment protection agency.

The Law on Environmental Protection defines main environment management functions. However, it does not clearly define the roles of the VEPA in its implementation. In fact, the existing capacity of VEPA in this field remains limited, particularly in marine and coastal environment management. VEPA does not posses a specialised unit responsible for marine environment management.

Marine environment protection requires the coordination of all ministries and sectors. The Law on Environmental Protection calls for all ministries and government agencies to coordinate with MONRE for environmental protection in the agencies, organisations, and companies under their management. Most ministries/sectors have subsequently set up a unit responsible for the environment. These agencies are under the direct guidance of the provincial/municipal People's Committees. The relationship between MONRE and other ministries and provinces is shown in Figure 3.

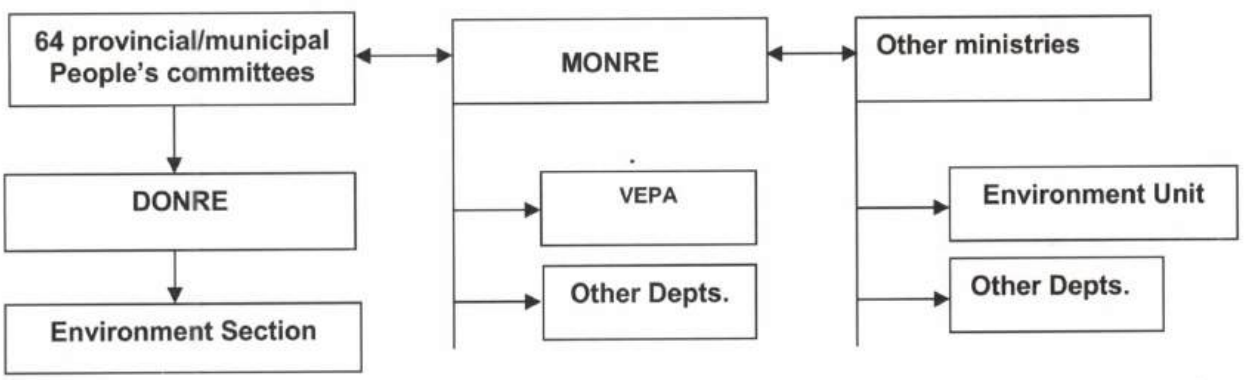

Figure 3 The relationship between MONRE and other environmental agencies.

4.2.3 *Certification*

- Council of Ministers' decisions for issuing certification of water use and solving conflicts (23/3/1989).
- Prime Minister's decision on issuing permission for fishers and fishing gears, including the issuance of licenses for changing fishing grounds (1/3/1993).
- Prime Minister's decision for issuing, registering, and licensing of fishing gear (1/3/1993).

4.2.4 *Protected Area Regulations*

A Prime Ministerial Decree (2/6/1990) defined protected areas under two main categories:

a. Non-exploitation areas:

1. Areas used by marine creatures for breeding throughout the year.
2. Year-round habitat of non-mature marine creatures.
3. Conservation areas of marine creatures.

b. Seasonal non-exploitation areas:

1. Areas used by marine creatures for seasonal breeding.
2. Seasonal habitat of non-mature marine creatures.

Based on the characteristics of marine species and actual situations, the decree has assigned areas under these four categories as follows:

- Sea areas of Bach Long Vi, Con Dao, Phu Quoc, and Truong Sa Islands.
- Marine areas influenced by the hydrological regime of the Red River and Mekong River.
- Mangrove forest areas.
- Lakes and reservoirs containing rare and highly valuable species that require protection.

Based on above regulations, the Minister of Fisheries works with other sectors and relevant local authorities to delineate and announce boundaries. The Minister also coordinates the mapping and management of protected.

4.3 Institutional Arrangement/authority

4.3.1 National Institutions

Parliament is the highest institution of the state. It has legislative authority, and is responsible for the approval of new laws, regulations and ordinance, and amending existing laws before submission to the President for signing and promulgation. The Government is state's highest executive body, with responsibility for national level management of marine resources and environmental protection. Other marine management agencies and institutions include the Ministry of Science and Technology, Ministry of Natural Resources and Environment, Ministry of Fisheries, and Viet Nam Environment Protection Agency (VEPA).

4.3.2 Provincial/local Institutions

Peoples' Committees in coastal provinces have responsibility for marine activities and management of the marine environment. Coastal provinces also subject to the administrative activities of the Department of Fisheries, Department of Science and Technology (DOST), and Department of Natural Resources and Environment (DONRE).

4.3.3 Mechanisms for Stakeholder Involvement

Other stakeholders become involved in marine management in the following ways:

- Urban environmental companies: construction and the operation and maintenance of all wastewater and solid waste treatment factories.
- Enterprises: take responsibility for marine resources and environmental protection in accordance with existing laws, and apply methods for reducing and treating wastes generated by their activities.
- Community: work under guidelines of the local government to manage marine resources and form environmental protection groups.
- Research institutes.
- Universities and colleges.
- NGOs.

4.3.4 Community Based Management

Organisations with responsibility for the general coordination of marine activities include:

- The National Space and Marine Search and Rescue Committee.
- The Coast Guard (established in 1998) collaborates with other sectors and local organisations to ensure the security and safety of marine resources and the environment.
- Local associations that encourage agricultural and fisheries expansion.

4.4 International Obligations

4.4.1 Legally Binding Obligations

The Ministry of Foreign Affairs assists the Minister's Council in the preparation, negotiation, and ratification of international treaties. Relevant ministries are responsibility for the implementation of Viet Nam's commitments under international law. Obligations when joining international agreements include:

- Obligation of international cooperation in the field of marine environment,
- Obligation for information on marine environment,
- Obligation for protection of marine environment,
- Obligation for protection of air environment,
- Obligation for water environment on mainland,
- Obligation for protection of biodiversity, and
- Obligation to peacefully solve disputes on marine environment.

International Convention on the Prevention of Pollution from Ships (1973 MARPOL CONVENTION)

This convention is supplemented by the 1978 protocol banning and limiting pollution causing wastes associated with the exploration and exploitation of natural resources. The 1973 MARPOL Convention replaced a 1954 convention and put forth some additional measures to prevent marine oil pollution. MARPOL came into force in 1983 with an aim of providing the comprehensive guidance required to prevent marine pollution from ships.

United Nations Convention on Biological Diversity, 1992

The Convention on Biological Diversity is the most comprehensive and important convention for the protection of biodiversity and contributed greatly to development of the Law on Environmental Protection in Viet Nam.

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR Convention) 1971

This convention deals with wetlands of international importance, and was signed on 2 February 1971 and amended according to the Paris Protocol on 3 December 1982. Viet Nam ratified the Convention on 20 September 1988 and selected Xuan Thuy wetlands in Nam Ha province as the priority area for protection by RAMSAR. The objective of the Ramsar Convention is to protect wetlands which are habitats supporting flora and fauna. Parties to the Convention are required to designate at least one suitable wetland within their territories for inclusion in a list of "Wetlands of International Importance".

4.4.2 Non-Legally Binding Obligations

In June 1992, leaders from many countries participated in the Earth Summit in Rio de Janeiro and developed Agenda 21. The key objective of the Agenda 21 is to achieve sustainable development in the 21st century. Governments of nations have to formulate national strategies and action programmes to secure the integration of economic growth, social development, equity and environment protection. In September 2002 the World Summit on Sustainable Development (Rio+10) held in Johannesburg, South Africa. The meeting has assessed the results achieved 10 years after the Earth Summit and evaluated the obstacles to implementing Agenda 21. In Viet Nam, the Ministry of Planning and Investment is responsible for the formulation of Viet Nam Agenda 21 (Prime Minister's letter 3143/VPCP-QHQT, 1 Aug. 2000) with the help of UNDP, DANIDA and other international organisations. The first phase (VIE/01/21project) was finished by the end of the year 2002. Contents of Viet Nam Agenda 21 consist of detailed proposals for how to protect environment, biodiversity and resources, reduce wasteful consumption patterns, minimise pollution, promote sustainable agriculture-forestry-aquaculture, keep ecological balance, combat poverty, grow economy, increase income and overall quality of life etc. All these actions aimed step by step to achieve sustainable development.

4.5 Analysis and Discussion

4.5.1 Law

Effectiveness/coverage

Marine and coastal environmental management has been implemented on a sectoral basis in Viet Nam. Typically, this has resulted in insufficient consideration of the multiple use aspect of these areas. As a result, marine and coastal resources law and policy have been ineffective in achieving emerging goals for coastal areas that recognise the need for sustainable development. Marine policy has mostly focused on national security and sovereignty issues, with little emphasis on marine environmental protection.

Conflicts/harmonisation

Conflict is common in most coastal and marine areas and may have serious consequences. Stemming from a lack of awareness of their potential impacts on coastal and marine resources, the policies of a number of economic sectors have led to unsustainable outcomes in Viet Nam's coastal areas.

4.5.2 Compliance and Enforcement

Enforcement actions:

- Prohibition of the use of dynamite, electricity, and poison for fisheries exploitation, with punishments for violation.
- Strict action taken against individuals and organisations that causes damage to seagrass ecosystems.
- Strictly punish all the administrative violations relating to destroy the seagrass ecosystem and hunt up rare/endangered aquatic species

The Agencies involved in the National Framework for Environmental Management are summarised in Table 19, and Table 20 provides Summaries of promulgated national legislations and policies related to preventing degradation of marine environments and protecting marine ecosystems in Viet Nam.

Table 19 Agencies involved in the national framework for environmental management.

Policy making	Communist Party of Viet Nam Prime Minister National Assembly Provincial people's committees
Law making	National Assembly Prime Minister and Governors Ministry of Justice
Planning	Ministry of Planning and Investment Ministries and National committees Provincial people's committees (Department of Planning and Investment)
Consultancy	Government offices Ministries, universities and institutes NGOs
Task forces	MONRE/VEPA and Ministry of fisheries Ministries/environmental units Provincial people's committees (DONRE) National committees (Border Department)
Implementation organisations	Environment units of ministries/sectors, committees VEPA, NGOs, DONRE, Institutes of Oceanography and Communities

Table 20 Summary of promulgated national legislations and policies related to preventing degradation of marine environments and protecting marine ecosystems in Viet Nam.

Issued Year	Title	Description	Implementating Levels	Targets	Constraints
1993	Environmental Law	General Provisions (The law on the regulations of environmental protection) Preventing, protecting Environmental degradation, pollution and accidents Overcoming Environmental degradation, pollution and accidents Governmental Management on environmental protection International cooperation on Environmental degradation, pollution and accidents Rewarding and penalty	National	The components of Environment consists of elements compounding environment such as atmosphere, water, soil, sound, light, forest, river, lake, sea, biology, ecological systems, residents, manufacture sector, natural sanctuary, famous landscapes historic ruins and other physical status	Article 8 regulating obligation of financial contribution of organisations, individuals using environmental components for purpose of production, business in the necessary cases to obligate financial contribution for environmental protection. Until now, these regulations have not guided detail by Ministry of Science, Technology and Environment, so that it has not been implemented actually (except the obligation of natural resources tax according to ordination of natural resources). The experiences from some countries in the world has shown that the regulations on finance has effected in use and preservation.
1989	Ordinance on Protection and Development of Fishery Resources	General Provisions Regulations on protection and development of fishery resources Regulations on management of protection and development of fishery resources Regulations on International cooperation and coordination in the area of protection and development of fishery resources	National	Fishery resources	Department for Conservation of Fishery Resources – Ministry of Fisheries has been assigned to protect fishery resources and related issues under this ordinance. Their responsibility has been identified carefully but has only been focused on fishing rather than on the other sea species such as coral reefs and marine plants. Without the GOV institutions have been assigned to take responsibility to manage and protect the marine sanctuary, the marine diversified biological areas.
1994	The guiding on implementation of Environmental protection (Decree No. 175 CP)	This Decree regulates in detail the implementation of Environmental protection. Assign to take responsibility of GOV management to protect environment, the responsibility of Organisations and Individuals in protection of environment Evaluation of environmental impacts (including the contents as below: Evaluation of environmental status in the activities of the project area or location; evaluation of impacts made by the activities of the project or units on the environment; recommendation of the treatment methods of environment) Prevention, protection and overcome environmental degradation, pollution and accidents Regulation of financial source for protecting environment	National	The components of Environment consists of elements compounding environment such as atmosphere, water, soil, sound, light, forest, river, lake, sea, biology, ecological systems, residents, manufacture sector, natural sanctuary, famous landscapes historic ruins and other physical status	
1996	Regulation on penalising administrative violation in the protection of environment (Decree No. 26 – CP)	Regulation on the types and levels of penalising administrative violation in protection of environment, the following violations related the sea: + Violation in preventing pollution and degradation of environment; + Violation in protecting diversified biology and natural sanctuary; + Violation in exploitation, trade of the rare and precious species of animals and plants belong to the list issued by the Ministries of Agriculture and Rural Development and Fisheries; + Violation in the licenses of export and import chemicals of high toxicity, products of microbiology concerned environmental protection; + Violation in import and export of waste materials; + Violation in prevention of environmental accidents in exploring, exploitation and transportation of oil; + Violation in regulation on pollution of land; + Violation in transportation and treatment of sewage and waste materials). Regulation on authority levels, procedures of penalty	National	Environment (includes diversified biology, natural sanctuary, rare, precious species of animals, plants, soil, oil, gasoline, waste water, waste materials, etc)	As the type of administrative penalty so that the penalty for the administrative breaks in the exploitation of natural resources is low (only from 5,000 VND to 100,000,000 VND according to the Ordinance of administrative penalty. At present, the Council of Assembly has been conducting amendment of Ordinance on administrative penalty and expected to amend the penalty level from 5,000 VND to 500,000,000 VND) for ensuring the stricture and education of legislation, preventing the persons who have broken the law and are ready to pay money for this violation to gain more benefit or make penalty become into "the fee for administrative violation".
1998	Regulations on the penalty for administrative violation in the protection of Fishery Resources (Decree No. 48/CP)	General Provisions Regulations on the penalty degrees and types for administrative violations in the protection of Fishery resources Regulations on the authorities, procedures and measures of penalty	National	Fishery resources	Some degrees of penalty are still low so that people have paid money for this penalty and then they continue to break the law.
1990	On the implementation of Ordinance of the protection and development of Fishery resources (Decree No. 195/HĐBT)	Given some main contents of Fishery Ministry and The people's Committee at the all levels under their functions to guide. Given the concept of forbiddance exploitation areas, forbiddance exploitation areas for limited time. Basics to consider when assigning water areas.	National	Fishery resources	This Decree regulating the authority of assigning the water areas, licensing certificate of use the water areas and resolving the disputation in accordance with the law on land. While the law on land assigns the provincial institutions to take the responsibility for planning, zoning and boundary management of province. The province's authority has actually come into efficiency to the limited shore line, and the boundary of province does not stretch to sea water, so that the ocean water of Viet Nam has properly been opened, not belong to management systems from central level to local level in land.
1995	The approval of " the action plan of the protection of diversified biology in Viet Nam" (Decision No 845-TTg) (attached the action plan of the protection of diversified biology in Viet Nam")	The protection status of diversified biology in Viet Nam (utilisation status of economic valuable species; diversified biology hazards). Objective of the action plan of the protection of diversified biology in Viet Nam (Protecting rich and precious diversified biology of Viet Nam within the sustainable development framework). The main contents of plan as follows: + Policy and legal. + Construction and management of protection areas. + Improving the public awareness. + Strengthening resources, training. + Science research. + The plan for protection of diversified biology brings the long-term profit to our country in the field of social economic plan. + Development of International cooperation.	National	Diversified biology	Some issues of this plan have concerns about general degree, have no regulations on responsibilities of the State Institutions, therefore the diversified biology areas have great economic benefit, which are interested by the Sectors of Fisheries, forest and geology etc, resulting in across-cutting management, ineffectiveness.
1997	Tax preference for fishing activities in offshore areas. (Decision No358/TTg)	Regulations on tax preference Regulations on responsibility of organisations and Individuals to be taxable preference Regulations on responsibility of Ministries of Finance, Defense, Fisheries	Vessels conducting exploitation in offshore areas	Offshore areas	
1991	Issuing regulations on the registration and all kinds licenses related fishery activities (decision No. 407/TS-QD) (attached regulations)	General Provisions Regulations on the monitoring registration and all kinds of licenses Regulations on licensing fishery activities	National	Fishery	Article 8 has not concerned the responsibility of Fishery Resources Conservation Department for registration and monitoring technical safety of fishery facilities.
1992	Technical management and safety inspection of fishery facilities (Decision No. 211/TS-QD)	Regulations on responsibility of Fishery Ministry and Department for Fishery Resources conservation Regulations on all kind of fishery facilities to be safety Regulations on responsibility of the sub-Dept. for Fishery Resources conservation Regulations on the finance responsibility of owners of facilities	National	Fishery	

Table 20 *cont.* Summary of promulgated national legislations and policies related to preventing degradation of marine environments and protecting marine ecosystems in Viet Nam.

Issued Year	Title	Description	Implementating Levels	Targets	Constraints
1998	Strengthening protection of environment in the period of the country industrialisation and modernisation (Instruction No. 36-CT/TW)	Objective of circular Basic views Implementation approaches; + Education and propagation + Completion of legal written documents system on environment + Active prevention and protection of environmental pollution, and accidents, prevention of environmental degradation + Exploitation, reasonable utilisation, saving of natural resources, protection of diversified biology, preservation of nature + Strengthening and diversifying investment for activity of environmental protection + Strengthening the State management + Promotion of science research and technology, training staffs + Development of international coordination in environmental protection			
1996	Urgent methods for protection and development of wildlife animals (Instruction No. 359-Tag)	Given some urgent methods as follows: + Closely guiding in monitoring, controlling, preventing the shoot of the precious, wildlife animals. + All organisations, individuals making break to be penalty. + Monitoring the previous, wildlife animals to be collected + Controlling the shooting facilities + Forbidding the special restaurants trading dishes processed from the previous, rare wildlife animals. Encouraging in development ofwild life animals culture Strengthening management of natural sanctuaries.			
1998	Forbidding utilisation of dynamite, discharge pulse, toxic products for exploiting fisheries (Circular No. 01/1998/CT-TTg)	Forbidding all organisations and individuals producing, trading, storing, transporting and utilising of dynamite, discharge pulse, toxic products for exploiting fisheries in the whole water bodies. Instructing Ministry of Defense, Home Affair and related Ministries to strictly manage sources of dynamite, and pursuing and arresting the persons who trading, keeping dynamite. Instructions of propagation and education for people to take part in protection and development of fishery resources and prevention of fishery exploitation by dynamite, toxic product and discharge pulse.	National	Resources and habitats for fishery species	
1998	Guide implementation of Decree No. 49/1998/ND-CP dated on July 13th, 1998 of Gov. on management of fishery activities for Foreigners and Foreign facilities operating in Ocean and Sea regions of Viet Nam (Circular No. 03/1998/ TT-BTS)	Regulations on fishery activities in the Sea regions of Viet Nam Regulations on penalty for violations	Sea regions of Viet Nam	Ocean and Sea of Viet Nam	
1996	Guide protection of environment in Ha Long Bay (Circular No. 2891-TT/KCM)	Detailed regulations on: + Strict protection zones + Buffer and adjacent zones Regulation on inspection, reward, penalty and financial contribution Regulation on organisation of implementation	Ha Long Bay	Sea regions, space of sea coastal areas, islands, ocean dimension, ecosystems, aquatic plants and aquatic animals and plants, animals on land, historic ruins, architectures, natural sights belong to strict protection zones, adjacent and buffer zones of Ha Long Bay.	
1996	Guide implementation of Decree No. 26-CP dated on April 26, 1996 of Government regulating on penalty of breaking administration of Environmental Protection (Circular No. 2433-TT/KCM)	Regulation on the forms of penalty			
1990	Guide implementation of Ordinance of Fishery Resource protection and Decree No. 195/HDBT (Circular No. 04/TS-TT)	Regulation on habitats for aquatic species Regulation on management, protection and development of fishery resources Regulation on the areas of exploitation forbiddance and areas of exploitation forbiddance for limited time Regulation on international coordination in protection and development of fishery resources Regulation on organisation of implementation	National level	Fishery resources	Ministry of Fisheries has immediately forbidden exploitation in forbidden areas for limited time and so that what are areas of exploitation forbiddance?
1989	Regulation on investigation, and exploitation of Marine species (Official letter No. 394/NN)	Assigning Ministry of Fisheries to decide temporary regulation on areas of investigation and exploitation marine species in the Sea of Viet Nam Ministry of Fisheries in accordance with the law of Viet Nam and uniting sectors for issuing regulation on activities of Foreign Vessels conducting investigation and exploitation in the Sea of Viet Nam	In the sea of Viet Nam	Marine fishery species	
1999	Decree No. 36/1999/ND-CP dated on June 9, 1999 of Government: regulation on penalty of administrative violation in the sea region, boundaries of Sea region, special Economic Zone and the terrace of the Socialist Republic of Viet Nam (Including 5 chapters, 3 parts, 42 articles)	Article 2: The Sea police have authorities for penalty of Administrative violation in the protection of environment, fishery resources, mineral resources etc. in the Sea regions, boundary of Sea regions and continental shelf of Viet Nam. The professional Agencies of the State management find out violations for penalty and if without authorities, they make the report submitted to the Sea police for penalty. Chapter II violation on protection of marine environment Article 22: Penalty for violation on discharge of sewage and toxic products: + Into the sea not according with the regulation on environmental protection; + Exceeding allowable limits in the sea regions; + Into the forbiddance zones, limited exploitation zones; Chapter III. Violation of exploitation and protection of fishery resources Article 28: Penalty for violation of habitat protection and fishery species conservation, management of fishery exploitation, fishing boats to be applied in Decree No. 48/CP of August 12,1996 of Government regulating penalty for administrative violation in the protection of fishery resources.	National level Executive Agency : Ministry of Defense	Marine environment (Not including to marine ecosystem and grass)	Difficulty for penalty of violation for marine ecosystem and grass
1999	Decision No. 224/1999/ QD-TTG of December 8, 1999 of Prime Minister approving development programmes for aquaculture in period of 1999-2010, including 2 articles	Chapter II principle instruction Term 1 Article 1 Development of aquaculture toward sustainable development, connection with protection of ecological environment; ensuring production and stabilisation of people's life	National level executive agency Fishery Ministry	ecological environment (not concerned marine ecology)	Concerning ecological environment but mainly concerning Environment for fresh farming and brackish farming not much for coastal areas

5. MANAGEMENT PERSPECTIVES – THE DEVELOPMENT OF NATIONAL ACTION PLAN

5.1 Some Existing Management Activities

The local tourism authority (Ha Long Bay Management Authority) has established an anchoring zone for tourism boats. This is an example of a management activity in a seagrass area.

In Tam Giang-Cau Hai Lagoon (Thua Thien-Hue Province), the local Department of Fishery Resource Protection has proposed a zoning plan for the lagoon that will provide protection for some areas. According to the plan, the strict protection zones proposed for Con Dai-Con Noi seagrass beds (in Tam Giang Lagoon) and Ba Con (in Cau Hai Lagoon) are those with the highest biodiversity and number of economically important species. Some seagrass species in this lagoon are used daily by the community for animal feed and fertiliser. In some agricultural areas adjacent to the lagoon, the local community has created a zone for seagrass protection. Zoning has also been used in Con Dao National Park, where the park authority has defined an area of 290ha for seagrass and dugong protection in Con Son Bay.

5.1.1 Objectives of the National Seagrass Action Plan 2003 to 2010

Overall objectives: Protection, restoration, and development of seagrass areas will aim at contribute to sustainable utilisation of marine and coastal zones in Viet Nam.

- **Concrete objectives:**

+ Increasing people's knowledge in general and raising coastal community awareness of the protection, restoration and development of seagrass ecosystems.
+ Improving research and investigatory abilities of concerned research and development groups in Viet Nam. Continue specialised investigation and study in terms of seagrass ecological features, breeding and growing process, material conversion, environmental balance, trap accumulation, and erosion resistance ability. Based on this research, determine priority solutions for protection, restoration, development, exploitation, and effective use of seagrass ecosystems in Viet Nam.
+ Protect, restore, and develop 33 concentrated seagrass areas with the total area of 9,650ha in coastal and island areas of Viet Nam. Effectively exploit profits from seagrass ecosystems.
+ Improve the policy system and organisational structure of State management for seagrass ecosystems.

5.1.2 Key Actions of the National Seagrass Action Plan

The National Action Plan with the proposed objectives will be carried out through a framework of National Actions, each of which will have one or several prioritised projects.

Action 1: Increasing people's knowledge in general and raising coastal communities' awareness in particular of the protection, restoration and development of seagrass ecosystems.

Targets of the action:

- Raising the communities' knowledge and awareness of the protection, restoration, exploitation, and target of the action: effective use of seagrass resources.
- Building a division data bank.
- Establishing a website for information exchange on seagrass in Viet Nam.
- Expanding international relations in research, protection, conservation, and restoration of disturbed seagrass areas in Viet Nam.

Action 2: Capacity building for specialised institutions-offices involved in seagrass research.

Targets of the action:

- Increase the capacity for research-development divisions on seagrass in Viet Nam, especially in-terms of improving research processes and building the capacity of research staff.

- Widen the scale of basic studies on seagrass ecosystems.
- Apply technology to study the protection, restoration, and development of seagrass resource.

Action 3: Studies on seagrass protection, restoration, and development in Viet Nam

Targets of the action:

This action will aim to protect, restore, and develop 33 seagrass sites totalling 9,650ha in Viet Nam.

Action 4: Improving policies and State management structures for the management of seagrass ecosystems.

Target of the action:

- The action is aimed at enforcing and carrying out policies in protection, restoration, development, exploitation, and effective use of seagrass ecosystems in Viet Nam.
- Establish organisational structures for State management functions in protection, restoration, development, exploitation, and effective use of seagrass ecosystems in Viet Nam.
- There should be special emphasis on the policy system and State management organisational structure, which requires them to have close contact with the policy system and management organisation structure in coastal areas.

5.1.3 The Implementation of the National Seagrass Action Plan

In order to achieve effective implementation of this National Action Plan, and to create basic principles for development after 2010, the following recommendations have been prepared:

+ Government has to play a monitoring role in the implementation of the National Action Plan for the protection, restoration, and development of seagrass ecosystem on both aspects: manage the implementation phases and provide funds for high priority projects.
+ Increase the role of the community through extension of information and stimulating activities, as well as economic incentives (natural resources tax, environment expenditure, and pollution punishment).
+ Strengthen international relations, stimulate donations, and promote investment in protection, restoration and development of seagrass ecosystems.
+ Improve the capacity of State management agencies connected with the implementation of the National Action Plan. Determine clearly the obligation and responsibility of each management unit.

5.1.4 Implementation Arrangements of the National Seagrass Action Plan

The Ministry of Natural Resources and Environment is the key agency involved in the protection, restoration, and development of seagrass ecosystems in Viet Nam. Some concerned agencies such as the Ministry of Fisheries, Ministry of Science and Technology, Vietnamese Academy of Science and Technology, Ministry of Agriculture and Rural Development, Ministry of Planning and Investment will collaborate with the MONRE in the implementation of the NAP.

5.2 Seagrass Areas Prioritised for Management

* *Biodiversity criteria*

- The site selected must have more than 6 species of seagrass, with an average cover of at least 60%.
- The site selected must be of a large area (more than 500ha) and posses a diversity of species, genetic resources, and adjacent habitats (coral reefs, mangroves, and wetlands) in comparison with other sites.
- The site must have a variety of economic, endemic, rare, and endangered species (dugongs, turtles, seahorses, starfish, gastropods, penaeids, holothurians etc.).

6. CONCLUSION

In Viet Nam, seagrasses are poorly studied when compared to other marine flora or fauna. There were no official projects on seagrasses prior to 1995. Since then studies on seagrasses of Viet Nam have been more widely promoted. At present, fourteen seagrass species have been identified in Viet Nam. The total area of seagrass in Viet Nam is 9,650ha, with beds occurring from Viet Nam's northern border with China, through to the south-western border with Cambodia.

Seagrass beds in Viet Nam have suffered serious degradation, with 40 to 50% of their areas lost. Root causes of seagrass degradation are low awareness and unstable economic conditions. The Government of Viet Nam urgently needs to implement the National Action Plan to reach the goals and objectives of the UNEP/GEF project entitled "Reversing environment degradation trends in the South China Sea and Gulf of Thailand". The data and information presented in this National Report was gathered from a diverse range of sources. The scarcity of information in a number of areas of seagrass ecology and management in Viet Nam highlights the need for seagrass research and development activities in Viet Nam.

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