Building a Futenma Air Staion Replacement Facility at Cape Henoko and Its Impacts on Japan's Dugong Population

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Summary

Although dugongs were once common south of the Amami Islands in Japan, their distribution continued shrinking even after designation as a natural monument by the Government of the Ryukyu Islands in 1955. Currently the remaining dugongs form a small isolated population which uses the few scattered seagrass meadows along the central and northern coastal zones of Okinawa Island while avoiding human activities. The main causes of population decline are believed to be habitat degradation and accidental death due to fishing. If nothing is done to remedy this situation, the number of individuals will continue to decline, and there is a high probability of extinction. To ensure the long-term habitation of dugongs in Japanese waters, urgent action is needed so that the population recovers to a safe level. This requires enhancing protection measures, preventing further habitat deterioration, and providing for future habitat improvement. Construction of the Futenma Air Station Replacement Facility (FRF) would threaten to destroy seagrass meadows now in use, and perhaps used in the future, by dugongs owing to land reclamation and soil extraction. Noise from aircraft and docking ships in conjunction with construction and operation of the new airfield would drive away dugongs living near Cape Henoko and block the north-south movement and interaction of dugongs across waters off the FRF. These indirect impacts from construction and operation of the airfield would not only disrupt the lives of dugongs in the Henoko/Abu/Kayo region, which constitutes a major element of Okinawa's dugong population, but also would decrease the environmental carrying capacity for Okinawa's dugongs and hinder interaction of individuals between habitats, thereby reducing opportunities for population recovery and by extension increase the probability of the dugong's disappearance from Japan's coast. Additionally, airfield construction and operation would inevitably lead to increased ship traffic in the vicinity, but the proposed mitigation measures to prevent collisions are merely symbolic and would have little effectiveness. We are certain that if dugongs were to be killed in collisions with ships, that would have a fatal impact on the continued existence of the Okinawa dugongs.

1. Introduction

The Japanese government plans to reclaim a marine area at Cape Henoko in Okinawa Prefecture and build a new airfield (called Henoko Airfield below) and auxiliary port as a facility to replace Marine Corps Air Station Futenma in Ginowan City, Okinawa, currently in use by the US military. The Okinawa Defense Bureau (OBD) (formally the Naha Defense Facilities Administration Agency) conducted an environmental impact assessment (EIA) for this purpose and published the results in its Environmental Impact Statement (EIS) (Reference 1) in December 2011 and its Final Environmental Impact Statement (Final EIS) (Reference 2) in December 2012. Based on a study of the Okinawa dugong population, these EISs assessed the impacts of the airfield construction and operation on Okinawa's dugongs, and proposed measures to mitigate those impacts. But our impression is that they purposely assessed the impacts on the survival of Okinawa's dugong to be small, and have overblown expectations for the effectiveness of the proposed mitigation measures. Below we set forth our views on these issues.

2. Status of Dugongs in Okinawa

2.1 History of Dugongs in Okinawa

In the 19th century dugongs were widely distributed south of the Amami Islands in southern Japan, and records show that they were frequently seen there (Reference 3). Around 1880 the institution by which dugongs were given as tribute was abolished, but fishers continued capturing them. Fishing catch records remaining in Okinawa Island, Miyako Island, and the Yaeyama Islands, which are south of the Amami Islands, indicate that the total annual catch in these islands averaged 15 dugongs from 1894 through 1904, and it declined to nine from 1905 through 1916 (Reference 4). In 1933 Hirasaka (Reference 5) stated that Okinawa's dugongs were already nearly extinct, and advocated that in order to ensure that the same thing would not happen in Taiwan, which at that time was ruled by Japan, the Taiwan dugong should be designated a natural monument. In response, the Governor-General of Taiwan designated the Taiwan dugong a natural monument in 1933. It appears that a similar designation was made in Okinawa, but details are lacking (Reference 6).

Dugongs were captured as food in Okinawa during the chaotic period following World War II, but in 1955 the Government of the Ryukyu Islands designated the Okinawa dugong a natural monument and banned catching it. In 1972 when Okinawa was reverted to Japanese government control, the Japanese government designated the dugong a natural monument of Japan, and in 1993 added it to a list of species to be protected under "the Act on the Protection of Fishery Resources." Protection measures by the Japanese government were limited to banning the intentional capture of dugongs; it made no effort to reduce the number of fishing-caused accidental deaths or effort to conserve dugong habitat. The distribution of Okinawa dugongs gradually shrank to a smaller region under these insufficient protection measures. Records indicate that the– last confirmed sighting of dugongs at Miyako Island was in 1965, and that at Iriomote Island was in 1967. Dugong sightings have been limited to Okinawa Island since 1974. Experts believe it is highly possible that the dugong is already extinct at Miyako Island and in the Yaeyama Islands (Reference 4). Their reasoning is based on the inability to confirm their survival with aerial surveys and feeding trail studies, and on the likelihood that dugong survival would be difficult owing to the heavy use of nets in fisheries.

Since World War II there have been no reports offering proof that dugongs still survive in Taiwanese waters.

2.2 Dugong Habitat at Okinawa Island

In 1998 Shirakihara et al. (Reference 4) performed an aerial survey including Okinawa Island and the region as far south as the coastal areas of the Yaeyama Islands, and concluded that dugongs live only around Okinawa Island. This was followed by surveys of dugong distribution and habitat in the vicinity of Okinawa Island by the Ministry of the Environment in 2001 through 2004 (Reference 7), and by the OBD in 2007 through 2011 (Reference 1, Reference 2 and Reference 8). In addition to these organized surveys, an environmental NGO on the island has collected records of opportunistic sightings.

These surveys and records revealed that stable habitats of the Okinawa dugong, where dugongs are constantly observed, are on the east coast, Kin Bay and to the north, and, on the west coast, north of the north shore of the Motobu Peninsula. Some of the shallow marine areas in these regions have seagrass meadows where dugong feeding trails have been discovered. Dugongs are often sighted in offshore areas outside coral reefs near seagrass meadows with feeding trails, and particular individuals identified with characteristic external scars are known to make long-term use of certain seagrass meadows. However, it is risky to interpret this to mean that dugongs always inhabit a certain coastal zone. Sometimes they leave an area they are used to, and relocate to a distant area, and this should be seen as an opportunity to encounter individuals in remote places, or as a search for new feeding grounds. This is inferred from cases in which the same individuals have been observed on both the east and west coasts of Okinawa Island, and from cases in which individuals tracked by helicopter have moved long distances along the coast. This thinking is also supported by the movements of Australian dugongs fitted with wireless tracking devices (Reference 9), and makes sense also in consideration of their breeding behavior and feeding ecology (Reference 10; Chapter 5).

Judging by the range of dugong movements around Okinawa Island as described above, the length of the marine area currently used by the dugongs as their habitat is barely over 100 km, comprising the approximately 70 km measured in a straight line from the south shore of Kin Bay on the east coast to the northern tip of Okinawa Island, and the approximately 36 km from the north shore of the Motobu Peninsula on the west coast to the island’s northern tip. This figure does not, however, indicate the total length of the coastline of Okinawa Island. Two facts that are noteworthy in assessing the feeding environment of Okinawa dugongs are that seaweed meadows suitable for dugong feeding do not exist along the entire coastal zone described above, and that because dugongs prefer certain seagrass species, they do not consume all the 10 seagrass species reported to exist in Okinawa (Reference 11) to the same extent. It is sometimes difficult to accurately distinguish seagrass and seaweed communities from aircraft, and therefore no one has accurately measured the total length or total area of seagrass meadows. A guesstimate puts the extent of seagrass meadows at about 10% of the above coast length (Reference 12).

When assessing the dugong feeding environment, one must keep in mind disturbance by human activities. The seagrass meadows described above are found at shallow depths of 2–3 m in lagoons closed off from ocean waves by coral reefs. Daytime diving in these places often turns up dugong feeding trails, but dugongs are not there in the daytime. Aerial surveys of dugong distribution find that during the day dugongs are outside coral reefs at depths of several tens of m (Reference 1 and Reference 2). At night they visit shallow places inside lagoons for feeding. Although one cannot say for sure that dugongs do not feed on the deep ocean floor during the day, feeding in shallow lagoons makes far more sense in terms of energy expenditure (Reference 10; Chapter 5). This behavior is interpreted to mean that Okinawa dugongs are placed in a stress-filled environment which does not allow them to feed in shallow lagoons during daytime hours owing to disturbance from human activities. This inference is supported by knowledge from observations in other countries showing that, along coasts with much human activity, dugongs approach the shore at night to feed, but that along coasts without much human activity, they feed in shallows during the day (Reference 4).

2.3 Number of Okinawa Dugongs

Two study methods have been used to estimate the number of dugongs in Okinawa: Observing the ocean from aircraft to estimate the density, and direct counting of identifiable individuals. The former was used by the Okinawa Defense Bureau (ODB)- for its Environmental Impact Assessment in the fiscal years 2007/08–2008/09 (Reference 1, Reference 2 and Reference 8), while the latter was used by the Ministry of the Environment in the fiscal years 2001/02–2004/05 (Reference 7) and by the OBD for its EIA in the years 2005/07–2010/11 (Reference 1 and Reference 2). Both of the latter surveys covered only certain limited marine areas, which are where dugongs are frequently observed. They were, on the west coast, the vicinity of Kouri Island, and on the east coast, the ~~zone~~ areas running from Henoko to Kayo. Data obtained with both methods suggest that there are very few-Okinawa dugongs, but no convincing data analysis has been done, and reliable estimates have yet to be obtained. To ensure reliability with such surveys, it is desirable to seek the participation of third parties at every stage from survey planning and implementation to analysis, but this has not been done.

In the ODB's EIA, the first method, estimating density using aircraft, was used and it was called "Wide-Area Survey" (Reference 1 and Reference 2). It involved using two small aircraft which made observations while flying courses generally 1 km apart and at right angles to the coast. Several days were spent covering virtually the entire marine area around Okinawa Island, which was counted as one session. The survey season lasted virtually the entire year. Table 2-1 (Reference 1 and Reference 2) shows the total number of dugongs sighted per session in the OBD's EIA. Flight courses and distances (survey effort) were about the same in each session.

It should be noted that it is nearly impossible to sight dugongs on the water surface over 300 m to the right and left of the aircraft, and even within 300 m one cannot expect to find 100%. Additionally, the turbidity of sea water in Okinawan waters likely creates difficulty in sighting submerged individuals, but the extent to which sighting is hampered has not been measured. This makes it necessary to make adjustments for the miss rate (Reference 4 and Reference 13). Additionally, dugongs may move during a session, and depending on the direction of their movement, it may result in too few or too many sightings. But because the direction of dugong movement is unrelated to the direction in which a survey proceeds, even if they enlarge the variance of the number of individuals, they do not create bias in average estimates.

The number of individual dugongs sighted in each session in the EIA ranged from zero to 13 for a total of 117 individuals. The mean number of individuals sighted per session was 2.0 (2007/08) and 7.5 (2008/09). Although herd size is not given, it was likely 1 or 2 individuals. There is a widely used mathematical method which uses such data to calculate abundance estimates adjusted for the miss rate, and the confidence interval (Reference 14). It seems unusual that, despite this widespread use, the ODB's EIA did not do this. It is also hard to see why there is a large difference between the first and second years in number of individuals sighted.

Dugongs /session	0	1	2	3	4	5	6	7	8	9	10	11	13	Mean no. dugongs/session	No. sessions
2007/08	3		2		1		1							2.0	7
2008/09				1	1	2	1	2	2	2	1	1	1	7.5	14
Total	3		2	1	2	2	2	2	2	2	1	1	1	5.7	21

Table 2-1. Total number of dugong individuals sighted per session in the wide-area aerial survey (Reference 1 and Reference 2).

The second method involves estimating the number of individuals dugongs by identifying individuals based on external appearance. According to the OBD's Final EIS (Reference 2), the confirmed numbers of individuals were three to five in the survey by the Ministry of the Environment (2001/02–2004/05) and three in the ODB's EIA surveys (2007/08–2008/09). The makeup of the three dugongs in the latter survey was two adults (individuals A and B), wherein A was often with B, and a juvenile individual (C), construed to be their offspring. A was always sighted in the Kayo area on the east coast, while B was always sighted on the west coast, and C was sighted off both coasts. Other than these three, there was a total of six encounters with unidentifiable individuals.

However, based on the weakly supported assumption that these were one of the above three dugongs, the Final EIS offers the minimum estimate for the number of Okinawa dugongs at three (Reference 1 and Reference 2). Because the OBD's EIA surveys limited its target areas to two "priority habitat survey" areas, one on each coast, this raises doubts about the extent to which the data faithfully indicate the total number of Okinawa dugongs. And depending on how one assesses the unidentified individuals, the abundance estimate should be larger than three. Another question is how much significance there is to the minimum estimate, which has no accompanying maximum estimate. The minimum abundance obtained in this manner was used as the basis for the EIA (Reference 1 and Reference 2), therefore constituting the grounds for arguing that a mere two dugongs will be affected by the FRF construction. If the legitimacy of the above minimum abundance estimate is recognized, it is also possible to interpret the results as showing that about 67% of Okinawa dugongs will be directly impacted by construction of the FRF.

Given that data from the first method — the wide-area aerial survey — are effective for examining relative dugong distributions by marine area (Reference 13), we have created Table 2-2 to show the numbers of dugongs sighted in each marine area in the 2008/09 survey of Table 2-1. According to this table, of the total 105 dugongs sighted in the 14 sessions of that year, 41 individuals (39%) were sighted in the Oura/Kayo area. This is one indicator showing the importance of this area to the survival of Okinawa dugongs.

Marine area	East Coast		North	West	Totals
	Oura/Kayo	Teniya/Cape Ban	Cape Hedo	Kouri	
Total individuals sighted	41	2	1	61	105

Table 2-2. Geographical distribution of dugongs sighted in the 14 wide-area aerial

sessions in 2008/09 (Based on Table 6.16.1.15 and Figure 6.16.1.38 in Reference 8).

2.4 Distribution of Seagrass Meadows and their Use by Dugongs

According to a 1994 report (Reference 15) by the Nature Conservation Bureau of the then Environment Agency (now the Ministry of the Environment), the seagrass meadow at Henoko is the largest of those around Okinawa Island (173 ha), and far larger than that offshore from Kayo (8 ha). As shown in the Final EIS (Reference 2), the most recent survey by the ODB puts the size of the seagrass meadow in the Henoko marine area at 141–148 ha, but even this range still makes it the largest seagrass meadow in Okinawa Island's waters. It is important to note that while the Final EIS presents a table (here shown as Table 2-3), indicating a total seagrass meadow size of 177–187 ha for the Ayahashi Marine Road area, this is the total size of several seagrass meadows scattered in the vicinity of the road as shown in Figure 2-1, and therefore it is not a single meadow that is larger than the seagrass meadow at Henoko.

According to sighting and by-catch records, dugong use of seagrass meadows on the east coast of Okinawa Island, which includes the Cape Henoko/Oura Bay area, is concentrated in the zone from Abu/Kayo to the vicinity of Ayahashi Marine Road (Figure 2-2). As the Final EIS shows, the Okinawa Defense Bureau surveys spotted dugongs in the areas of Henoko and Kayo from fiscal 1997 to fiscal 1999 (Table 2-4 and Figure 2-3), and feeding trails in the Henoko area every year from fiscal 1998 until fiscal 2003 (Table 2-5). Figure 2-4 shows locations in the vicinity of Cape Henoko where the Ministry of the Environment found dugong feeding trails and droppings in February 2003, and the Nature Conservation Society of Japan found dugong feeding trails in January 2004 (Reference 11).

It appears that after fiscal 2003, dugongs did not use the Cape Henoko/Oura Bay area for a time, but in fiscal 2009, feeding trails were found in the western and inner parts of Oura Bay (Table 2-5). The Final EIS (Reference 2) also shows that a dugong was sighted in the Henoko area in fiscal 2010. Additionally, information disclosure requested by Kyodo News revealed a sighting of a dugong moving from the mouth of Oura Bay towards the interior in May 2011 (Reference 16) (this information was not provided in the EIS which had been released by the ODB at the time). In June 2011 private citizens found feeding trails in the interior of Oura Bay (Reference 17), and in March 2013 citizens again found feeding trails in Oura Bay (Reference 18). Furthermore, information disclosure requested by Kyodo News revealed that at the very site where the Henoko Airfield is planned to be built, four feeding trails were found in April, seven in May, and one in June in 2012 (Reference 19) (this information was not released to the public until Kyodo News obtained it in September 2013). Aerial Surveys conducted by the ODB on 35 days between September 2011 and January 2013 sighted dugongs off the Kayo coast and near Kouri Island on 29 of those days (total 31 sightings) (Reference 20). Most recently, seagrass surveyes conducted by local NGO and citizens groups from May to July 2014 confirmed some 110 dugong feeding trails in the proposed construction site (Reference 34).

資料：「第 4 回自然環境保全基礎調査 海域生物環境調査報告書 第 2 巻 藻場」（環境庁自然保護局・ 財団法人 海中公園センター、平成 6 年 3 月）をもとに作成。

Figure 2-1. Distribution of seagrass meadows off the east coast of Okinawa Island (from Kin Bay to Abu/Kayo) (from Figure 6.16.1.77 of Reference 21).

市町村	平成元年(1989年)		平成20年度（2008年度）			
	地区	面積(ha)	地区	面積(ha)		
				6-7月	8-9月	11-12月
名護市	嘉陽	8	安部・嘉陽	23	22	21
	嘉陽南	6				
	安部崎	2				
	瀬嵩南側	14	大浦湾奥	8	9	9
	辺野古	173	辺野古	148	147	141
	松田湯原	4				
宜野座村	松田	5	松田	68	76	70
	宜野座	11				
	漢那ビーチ	26	漢那	3	3	5
金武町	金武岬北	33	金武	80	81	74
			伊芸	7	7	7
うるま市	池味	3	海中道路	187	190	177
	宮城島南	59				
	海中道路北	41				
	平安座西	5				
	浜比嘉島東	3				
	海中道路南	15				
	海中道路南	57				
	藪地島東	60				
計		525	計	524	534	503

注）平成元年については、「第4回自然環境保全基礎調査 海域生物環境調査報告書 第2巻 藻場」（環境庁自然保護局・ 財団法人 海中公園センター、平成6年3月）による面積を示しています。

Table 2-3. Change in sizes of seagrass meadows off the east coast of Okinawa Island (from Kin Bay to Abu/Kayo) (from Table 6.16.1.42 of Reference 21).

Figure 2-2. Areas of confirmed dugong sightings and distribution of seagrass meadows around Okinawa Island (Dugong Network Okinawa).

年度	ジュゴンの確認状況（確認個体数）					最小発見個体数
	嘉陽沖	辺野古沖	金武湾～宜野座沖	古宇利島沖	その他海域	
平成 9 年度		1				1
10 年度	〇	〇	〇	−	〇(安田)	−
11 年度	1	1	4			6
12 年度	2	−	2	1	−	5
13 年度				−	−	0
14 年度	1	−	2	−	−	1～2
15 年度	1	−	1～2	1	2(恩納村沖)	3～5
16 年度	1	2		2		5
17 年度	1	−	−	2		3
19 年度	1	−	−	(〇)	2(辺戸岬)	3
20 年度	1	−	−	2	−	3
21 年度	2	−	−	1	−	3
22 年度	2	(〇)		1	−	3

注）1.「ジュゴンの確認状況」欄の〇印は確認されたことを示し、「−」は調査を実施したが確認されなかったことを示します。
2. 網掛けの欄は、調査対象外であることを示します。

Table 2-4. Confirmed dugong sightings and minimum discovered populations around Okinawa Island (from Table 6.16.1.41 of Reference 21).

調査地区	H9 年度	H10 年度	H12 年度	H14 年度	H15 年度	H16 年度	H17 年度	H19 年度	H20 年度	H21 年度	H22 年度	H23 年度
安田		〇	−	−		−		−	−			
嘉陽		〇	−	〇	〇	〇	〇	〇	〇	〇	〇	〇
安部		−	−	−	〇			−	〇	−	−	−
辺野古	−	〇	〇	〇	〇	−		−	−	〇 (大浦湾西部)	−	−
久志		〇	−	−		−		−	−			
松田		〇	−	−	−			−	−			
宜野座			−	−				−	−			
漢那		−	−		−			−	−			
金武		−	−	−				−	−			
海中道路		〇	−		−			−	−			
その他	−	−	〇 (屋我地島東側)	−	〇 (屋我地島東側) (古宇利島南側) (知念村志喜屋)	〇 (古宇利島南側)	〇 (古宇利島南側)	−	−	〇 (大浦湾奥部)	−	−

Table 2-5. Feeding trails found in each survey period (from fiscal 1997 to fiscal 2011) (from Table 6.16.1.40 of Reference 21).

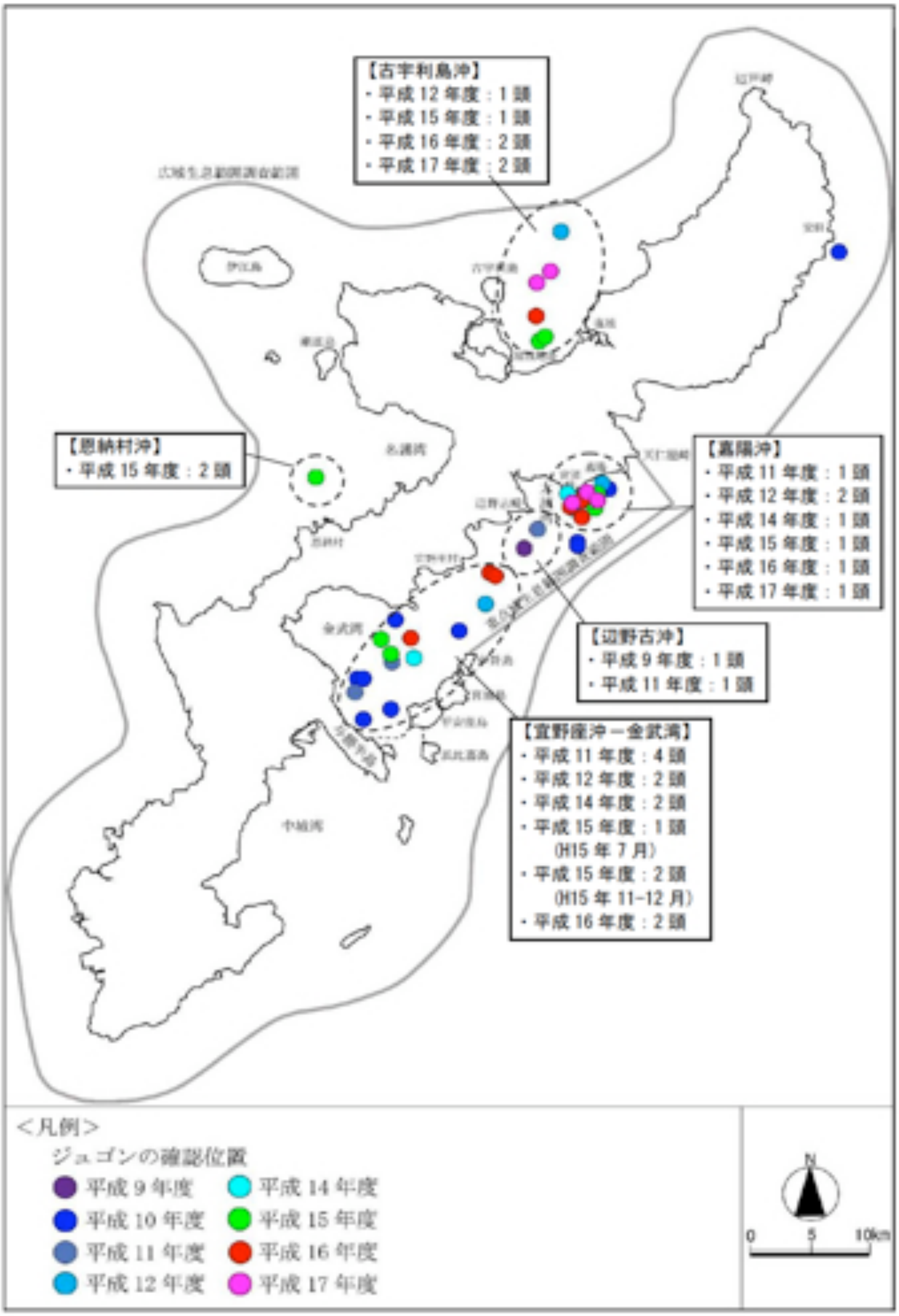


Figure 2-3. Dugong sighting locations in past surveys around Okinawa Island, and minimum discovered populations in each survey period (from Figure 6.16.1.71 of Reference 21).

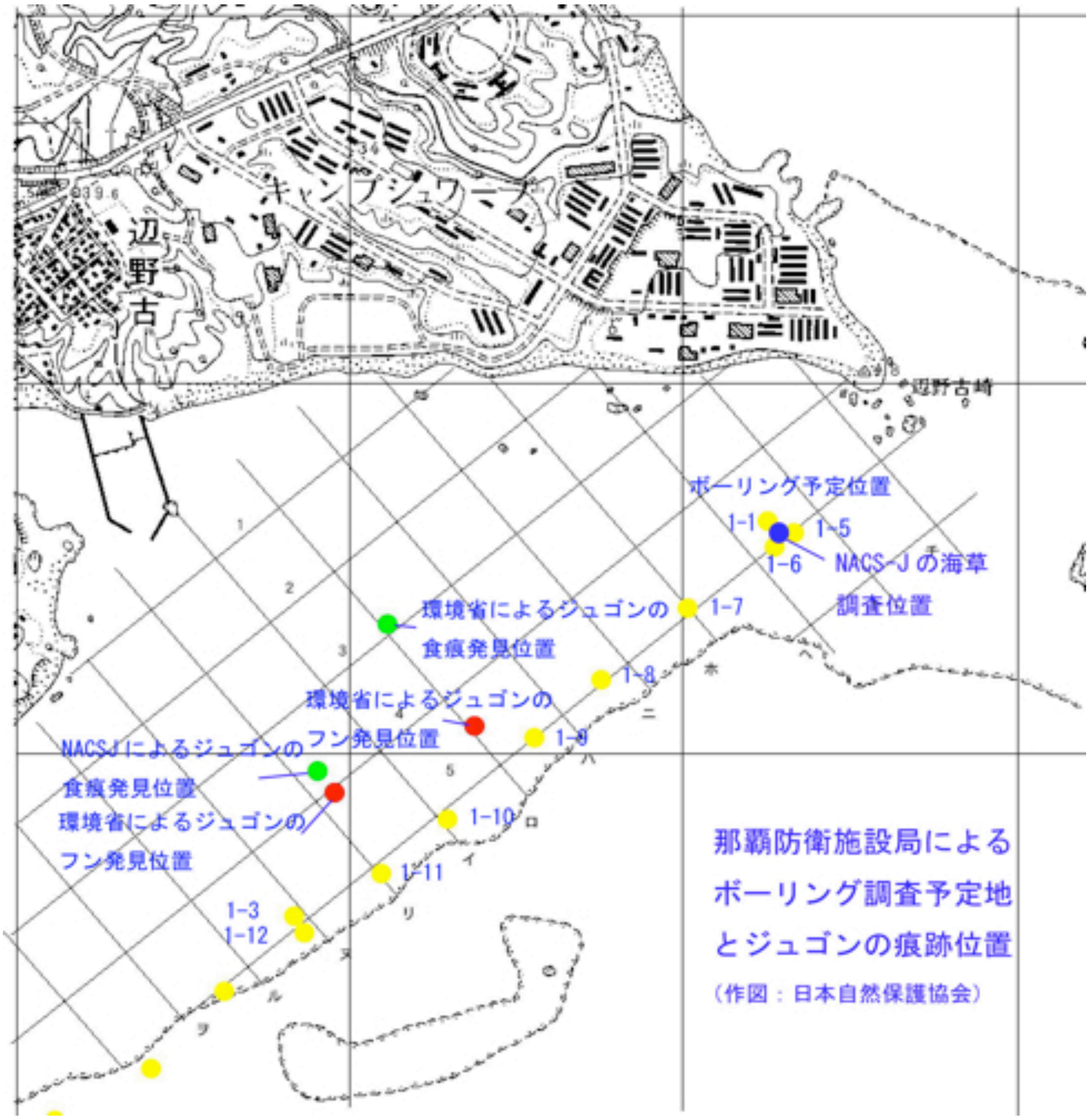


Figure 2-4. Locations offshore from Camp Schwab where dugong feeding trails and droppings were found (from Reference 11).

2.5 Movement of Dugongs and Its Significance

Much information on movement of dugongs in Okinawa waters has been obtained from the Ministry of the Environment (Reference 7) and the Okinawa Defense Bureau (Reference 1 and Reference 2). Both organizations concentrated their surveys in the vicinity of Kouri Island on the west coast, and in the Kayo/Henoko marine area on the east coast, while in other areas the amount of observation effort and the number of individuals observed were both small. This must be taken into account when analyzing the data. It is obvious from these results that dugongs living around Okinawa Island tend to use certain seagrass meadows over multiple years. For example, Individual A, which lives offshore from Kayo (Reference 1 and Reference 2), was always sighted in that place from fiscal 2007 to fiscal 2011. Although these were all daytime sightings, its movement ranged from the shore to approximately 1 km offshore, outside the reef margin, and 10-odd km along the coast from the north shore of Oura Bay's inner recess to Cape Ban. But the data in the Final EIS also indicate that dugongs do not live their entire lives in the same areas while staying with certain seagrass meadows. Some examples which support this are: (1) A dugong identified as Individual C was observed in both the Kouri Island area on the west coast and the Kayo area on the east coast; (2) in a daytime tracking survey, an unidentified individual traveled from the Kayo area to the vicinity of Ada, 70 km north; and (3) also in daytime observation, another individual traveled from the vicinity of Ada to near Cape Hedo at the northern tip of Okinawa Island (Reference 2). The reports by the Ministry of the Environment (Reference 7) provides similar information. Especially interesting in terms of assessing the impacts of the FRF construction and operation on dugong movements is a case in which an individual discovered at the mouth of Kin Bay traveled outside the reef margin north to the vicinity of Cape Henoko.

These survey results indicate that although these Okinawa dugongs tend to continuously use certain seagrass meadows, they frequently move between adjacent seagrass meadows, and sometimes travel to the vicinity of distant meadows several tens of km away. This behavior can be understood as a strategy to avoid excessively exhausting particular meadows by feeding, while searching for and using good feeding meadows (Reference 10; Chapter 5). And this likely makes sense in terms of mixing with other dugongs for propagation as well. Similar cases from Australia were described above.

3. Overview of the FRF and Problems with EIA Procedures

3.1 The Futenma Replacement Facility (FRF)

The Japanese government's plan for the FRF project involves construction of the Henoko Airfiled and its related facilities, as well as land reclamation of public waters at Cape Henoko and Oura Bay prior to airfield construction (Reference 2). The Henoko Airfield will have two runways (1,200m) in a V-shape with the overall length of 1,800m including overruns and exclusive of seawalls. Approximately 160 ha (150ha for the main body of the FRF, 5ha for the seawall section, and 5ha for the work yard near Henoko) of public waters will be reclaimed. After its completion, the FRF will be operated by the US military. The types of aircraft that will be operated at the FRF include the rotorcrafts of CH-53, UH-1 and AH-1 and the tilt-rotor aircraft of MV-22.

These aircrafts are currently in use at the US Marine Corps Air Station Futenma.

3.2 Late Revelation of Project Specifics and Related Problems

The ODB's EIA procedures for the FRF was marred with the problem of late revelation of specifics. Some important information, especially regarding military functions, was provided only after the necessary documents had been submitted to the Okinawa Prefectural Government and for public viewing (Figure 3-1 and Figure 3-2). This made it difficult for the Okinawa Prefectural Government Environmental Impact Assessment Council and the public to examine the documents in a properly and timely manner. It appears that more and more functions were added to the FRF during the EIA process, thereby imposing an increasing burden on dugong habitat.

Figure 3-1 Diagram of FRF in the Scoping Document (Reference 18)

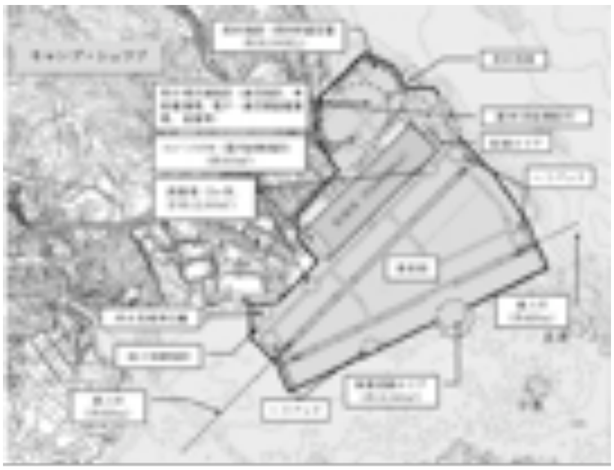


Figure 3-2 Diagram of FRF in the Draft EIS (Reference 8)

One of such late revelation was that of deployment of the MV-22 Osprey aircraft to the FRF. While it is now apparent the MV-22 Osprey will be important part of the operation of the FRF, neither the scoping document (Reference 18) nor the draft EIS (Reference 8) included the MV-22 Osprey among the types of aircraft expected to be used. It was only in the EIS that deployment of the Osprey was revealed and results of EIA regarding the MV-22 Osprey were presented. However, the scope and extent of the EIA regarding impacts of the MV-22 Osprey operation on dugongs were extremely limited because the basic data was obtained from the OBD's tests conducted on a US military base in Atlantic, North Carolina, a much different environment from the Henoko area (Reference 1 and Reference 2).

3.3 Functions Added in the Application for Approval of Reclamation in Public Waters

In March 2013 the ODB submitted an "Application for Approval of Reclamation in Public Waters" (Reference 21) to the Okinawa Prefectural Government. The document provided new details on the reclamation work especially regarding the sites of sand and soil sources (see 4.2 and 4.3 below), and show added functions to the FRF. Page 53 of the "Reason for Reclamation Necessity" has a diagram (Figure 3-3) of a seawall that can moor ships. The location is the inset enclosed by a dotted line in the overall view. The seawall's length, which was said to be about 200 m during the EIA process, lengthened to 271.8 m. This length enables docking of the US Navy's amphibious assault ship *USS Bonhomme Richard* (257 m). Additionally, a slope toward the sea adjoins the seawall. This newly shown slope points to the FRF's ability to land assault amphibious vehicles, and the landing craft air cushion (LCAC) vehicle carried on the *Bonhomme Richard*, after navigating Oura Bay (Figure 3-4) (Reference 22). The Final EIS did not discuss these functions at all. The Application for Approval of Reclamation in Public Waters casts down on the draft EIS statement that: "Part of the seawall (about 200 m) will be structured so that ships can dock, but there is no intent to build what might be called a military port which would be regularly garrisoned and constantly function to load and unload cargo" (Reference 8).

There are concerns about the impacts of such large warships, amphibious fighting vehicles, and the like on dugong habitation and feeding activities, but no discussion of this is found anywhere in the section "Documents Describing Environmental Measures to Be Taken" of the Okinawa Defense Bureau's Application for Approval of Reclamation in Public Waters.

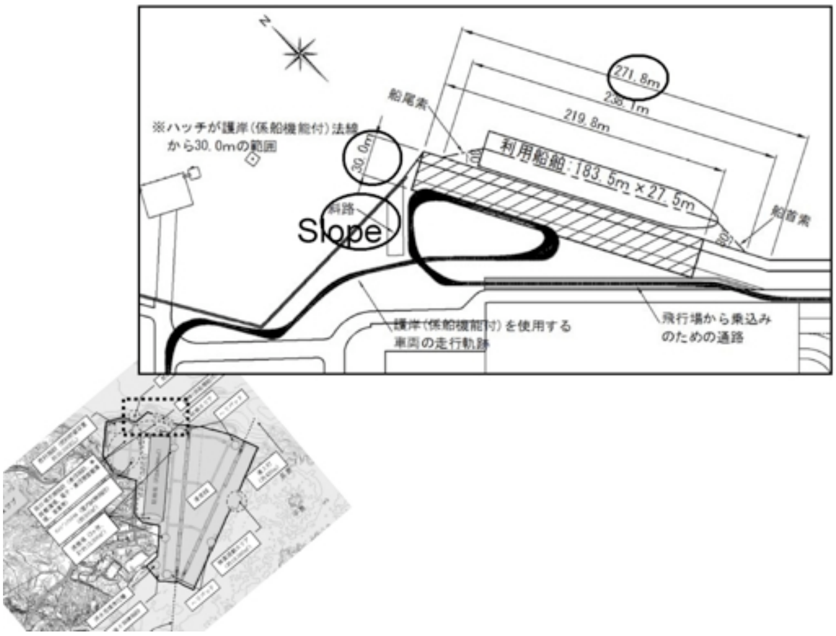


Figure 3-3 Added Functions of FRF after Completion of EIA (from Reference 21)

Figure 3-4 photos of US Navy's amphibious assault ship *USS Bonhomme Richard* and landing craft air cushion (LCAC) vehicle (from Reference 22).

4. Impacts of Construction Work on Dugongs and Proposed Mitigation Measures

4.1 Disappearance of Seagrass Meadows and Mitigation Measures

The seagrass meadow near the area to be reclaimed is at most 3 km long and 1.5 km wide. The meadow's extent and its seagrass coverage undergo large yearly changes probably owing to natural factors, but it is the largest (173 ha) seagrass meadow around Okinawa Island, and far larger than that of Kayo (8 ha). The Final EIS predicts that, with reclamation of 160 ha of public waters, about 30% of this meadow would be buried by reclamation while the parts of the seagrass meadow which escape destruction from reclamation will survive in the same form as before (Reference 2). This prediction seems too optimistic. This is because, at the current time when we lack understanding of the mechanism by which the meadows has undergone the annual changes, it is impossible to incorporate reclamation-caused changes in tidal currents and waves into simulations of what will happen to seagrass meadows in the future. Even assuming that such expansive seagrass meadows are not needed by the current dugong population, in the event of a future Okinawan dugong population recovery, those meadows would no doubt be used. As already stated, population recovery is essential for preservation of the Okinawa dugong. Even if there are good seagrass meadows away from Okinawa Island, that habitat became for some reason unsuitable for dugong use, and was abandoned. As such, one should not have expectations for its use by dugongs.

The Final EIS proposes transplanting seagrass to different locations as a mitigation and conservation measure regarding the seagrass meadow that would be lost by reclamation work, and as precedents it cites cases at Nakagusuku Port (Awase District) and an example from the Fisheries Agency's Fisheries Research Agency (Reference 2). However, as shown by the NACS-J (Reference 23), the former ended in failure, and the latter was not rigorously examined. Moreover, the seagrass transplant candidate sites offshore Toyohara and Kushi given in the Final EIS (Reference 2, Figure 6-15-231) cannot be considered appropriate for the purpose (Reference 23). Red soil runoff is observed in these places and seagrass species resistant to red soil grow there, meaning that they cannot compensate for the seagrass loss in the Camp Schwab offshore area, which has high seagrass species diversity (Reference 23). The impossibility of guaranteeing the preservation of seagrass meadows where dugongs feed is a major problem.

4.2 Impacts of Reclamation Work, Related Ship Movements, and Mitigation Measures

The OBD's Application for Approval of Reclamation in Public Waters shows that a total of 21,000,000 m^3 soil is required for the land reclamation (Reference 21). A rough approximation of the sources of soil needed for the reclamation work calls for about 580,000 m^3 of sea sand, about 16,440,000 m^3 of crushed rock, and 3,600,000 m^3 of mountain soil. The 580,000 m^3 of sea sand are to be extracted from six locations around Okinawa Island, while the remaining 16,400,000 m^3 are to be obtained from outside of Okinawa (including Amami, Tokunoshima, Goto Islands, and Amakusa Islands). There is however only a very general note on where the materials will be obtained, and nothing on matters such as how much will be extracted in each location, or about the environment. Assuming that this amount is hauled by six soil transport vessels (each with a capacity of 2,000 m^3), a total of 8,500 shiploads would be required (Reference 1 and Reference 2). It is also indicated that 10 bucket dredgers having the same capacity will be used (Reference 1 and Reference 2). It is possible that dugongs will flee the Kayo/Henoko area because of the noise from these vessels (Reference 10; Chapter 7).

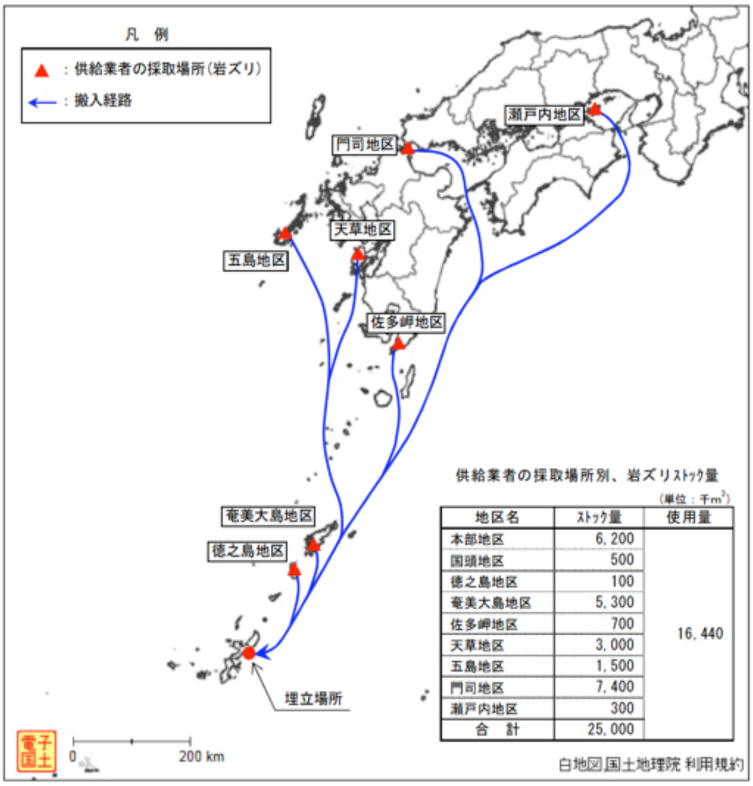
The Final EIS proposes, as mitigation measures, posting lookouts on ships and setting up a dugong monitoring system to avoid collisions with dugongs (Reference 2). However, owing to the difficulty of predicting dugong behavior, the limits to the ability of people to spot dugongs, and the limits of ship maneuvering capabilities, the effectiveness of such lookouts would likely be virtually zero. It is common knowledge among dugong researchers that spotting dugongs from ships is extremely difficult (Reference 24). This is because dugongs will dive in response to ship sounds before scientists on board spot them. The effectiveness of the proposed monitoring and warning system is also unproven proven and questionable especially given the intensity of vessel movements during the construction period (Reference 23).

Further, in response to inquiries by the Okinawa Prefectural Government, the Okinaw Defense Bureau stated in their response documents (Reference 25): "Because the activity range of dugongs is within 10 km of the coast, in order to avoid dugongs, vessels will keep 10 km or farther away from the coast when sailing in the coastal waters of Okinawa Island." Reconsideration is needed on whether this measure is appropriate.

4.3 Sand Extraction Work

The land reclamation work calls for extracting 580,000 m^3 of sea sand from six locations around Okinawa Island (Reference 21). For the following reasons, extraction from the four locations near the northern part of Okinawa Island (Figure 4-2), which are especially close to dugong travel routes and feeding areas, would likely have extremely heavy impacts on survival of the dugong population. There are two problems with sea sand extraction. One is topographical change in the sea bed by digging, leading to change in benthic biota owing to change in the grain size distribution of bottom material (Reference 26), and change in flow regime induced by change in sea bed topography (Reference 27). The other problem is the impact of spreading turbid water on the local marine environment. Observed consequences are decreased transparency (Reference 28) and the attendant decrease of seagrass meadows (Reference 26).

One of the four sea sand extraction sites is the Kayo offshore area. The adjacent Kayo seagrass meadow is an important meadow where dugongs often feed (Reference 2). One of the authors (Mariko Abe) has visited this location several times and observed alteration of bottom topography around this seagrass meadow due to migration of sediment caused by sea sand extraction currently in progress offshore Kayo, and there are concerns about impacts on the seagrass meadow. Further sand extraction from this location for the FRF construction will certainly threat maintenance of the seagrass meadow and survival of the endangered dugongs and the sea turtles that feed in the seagrass meadows. A survey by the Okinawa Defense Bureau found that the other three sites likewise are located on travel routes used daily by the dugongs (Figure 4-3) (Reference 21).



供給業者の採取場所別、岩ズリｽﾄｯｸ量

(単位：千m³)

地区名	ｽﾄｯｸ量	使用量
本部地区	6, 200	16, 440
国頭地区	500	
徳之島地区	100	
奄美大島地区	5, 300	
佐多岬地区	700	
天草地区	3, 000	
五島地区	1, 500	
門司地区	7, 400	
瀬戸内地区	300	
合　計	25, 000	

Figure 4-1. Planned extraction sites and transport routes for landfill soil and sea sand to be obtained from outside Okinawa Prefecture (from Reference 21).

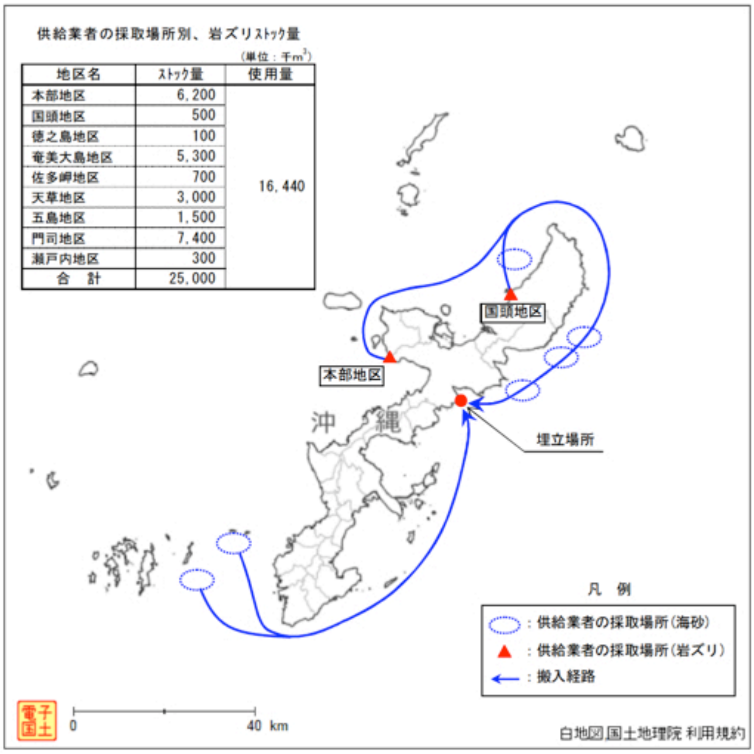


Figure 4-2. Planned extraction sites and transport routes for landfill soil and sea sand to be obtained from inside Okinawa Prefecture (from Reference 21).

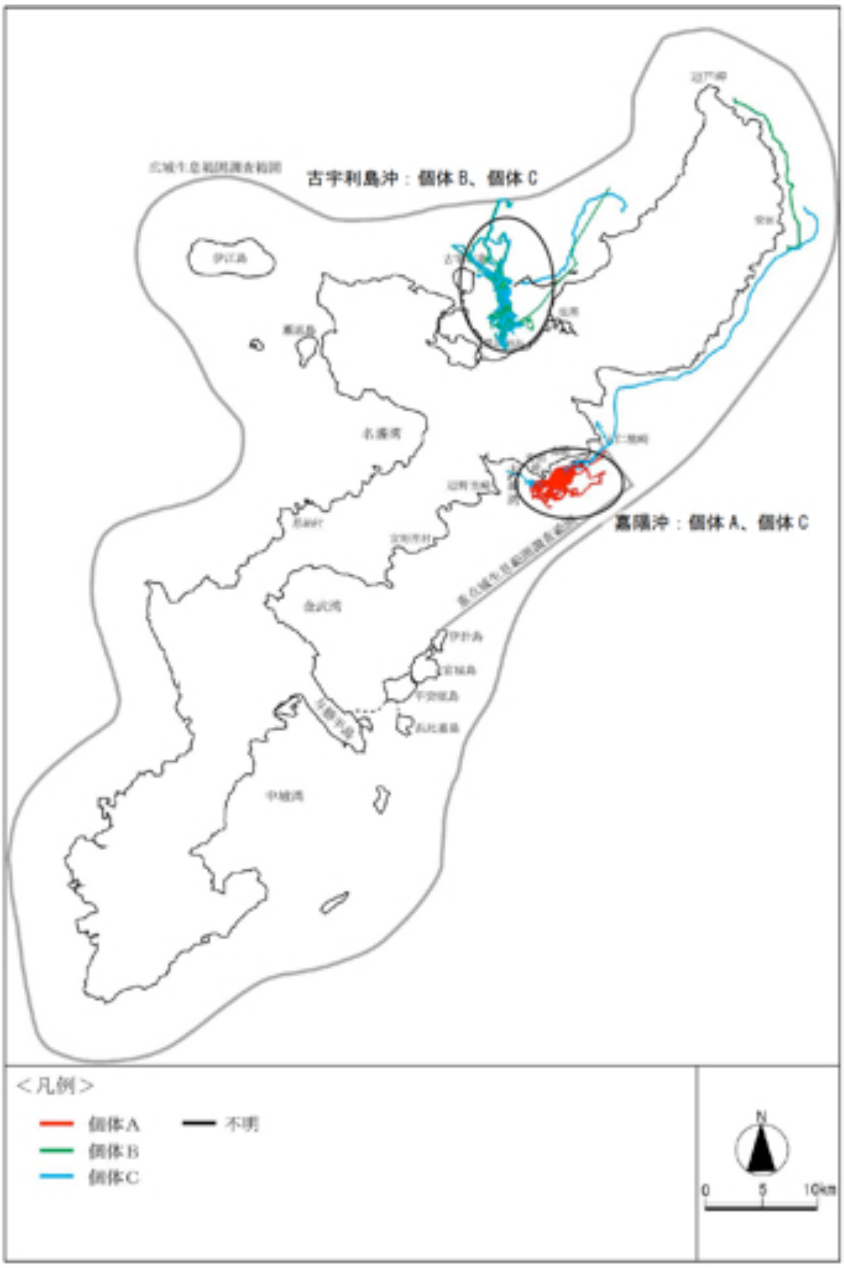


Figure 4-3. Example of travel routes followed by three dugongs (individuals A, B, and C) (from Reference 21).

4.3 Impacts of Construction Noise

Currently there is little knowledge about the reactions of dugongs to underwater noise. Views expressed in the EIA are therefore limited to hypotheses. It is perhaps insufficient to assess the sounds which cause escape behavior in dugongs in terms of sound source and acoustic pressure alone as it was done in the EIA. It is necessary to assess attributes including frequency, sound production regularity, and the physical extent of the sound source. Also, while the Final EIA refers to studies on the impact of the sound emitted from pingers on dugongs (Reference 2), it is insufficient to make assessment for the impact of the acoustic pressure from construction noise based upon the knowledge of regularly emitted sound of pingers. Even if acoustic pressure is of the extent that does not cause escape behavior, it is clear that it would interfere with the dugongs' use of underwater acoustics (Reference 10; Chapter 5). For example, when listening to the sound from other dugongs in a distance, even comparatively low-level noise would present a hindrance. Ignoring atmospheric acoustics would also be problematic. It is said that dolphins dive in response to the sound of helicopters.

The Final EIS proposes using "low noise" construction methods and equipment as mitigation measures for the impact of construction noise on dugongs (Reference 2). The effectiveness of such methods and equipment is unproven and questionable (Reference 23). It also proposes as mitigation measures posting up lookouts on ships and setting up a dugong monitoring and warning system so that construction works can be stopped when a dugong is found near the construction area (Reference 2). The effectiveness and even the feasibility of the proposed monitoring and warning system is in question (Reference 23).

4.4 Other Factors

Other factors that would be a potential threat to the dugongs during the construction period include the possibility of alien species being introduced with the landfill soil (Reference 28) and the contamination of the seawater by pollution from landfill soil and chemical discharges from construction ships and equipment. Even though all these factors would affect dugong habitat, the EIA makes no predictions about the impacts on dugong habitation (Reference 2 and Reference 21).

5. Impacts of Airfield Operation and Mitigation Measures

5.1 Aircraft Noise

Regarding aircraft noise, the Final EIS estimates underwater acoustic pressure under the assumption that an AS-350 helicopter flies while maintaining the lowest level flight altitude of 150 m, and claims that this is below the 122 dB estimated to cause escape behavior in dugongs (Reference 2). However, problems here are that it is possible this altitude restriction will not be observed during takeoff and landing, and that aircraft which use this airfield will not be limited to one type. The Final EIA also states that, in assessing the impact of low-frequency sounds, under the assumption that MV-22 aircraft will fly at an altitude of 150 m, the maximum underwater acoustic pressure at 1 m below sea level would be 135.9 dB, which is lower than the 150 dB level that damages acoustic organs, and is therefore allowable. The assessment lacks uniformity because it uses both the acoustic pressure level which causes escape behavior and the acoustic pressure level which damages acoustic organs. And as stated above, it is improper to deem sounds harmless to dugongs if acoustic pressure is below the 122 dB level causing escape behavior or the 150 dB level causing damage of acoustic organs.

The Final EIS does not present concrete mitigation measures for the possible impact of aircraft noise, except for stating that necessary measures will be taken based upon survey results in order to avoid the impacts (Reference 2).

It is quite possible that such noises would drive dugongs away from the Henoko area, and noise might create conditions which hamper north-south dugong movement, which cuts through the base construction area. It is presumed that this situation would hinder dugongs' efficient use of seagrass productive capacity and have detrimental impacts on the survival of the dugong population and recovery of the dugong population.

5.2 Ship Movements

It is possible that large military ships would also dock at the Henoko Airfield (Reference 21 and 22). The proposed mitigation measure is to avoid collisions with dugongs by posting a lookout on ships (Reference 1 and Reference 2). However, even if ships intend to avoid collisions, it is impossible to expect that posting lookouts will be effective (as point out previously, it is difficult to spot dugongs from ships) (Reference 23). If collisions with ships result in dugong deaths, that would of course hobble efforts for the Okinawa dugong population recovery, and jeopardize the population's future. It should be recognized that detecting such collision accidents is nearly impossible. Even if collisions with vessels could be avoided, it is expected that fragmentation of the dugong distribution into north and south would interfere with the dugongs' efficient resource use, and reduce opportunities for their population recovery.

5.3 Other Factors

Other factors that would be a potential threat to the dugongs during the operation of the FRF include the contamination of the seawater by the effluent from aircraft washing and illumination emitted from the FRF (Reference 1 and Reference 2). However, the Final EIS does not take into consideration the content of the effluent (Reference 23) and while it proposes, as a mitigation measure for the latter, that the "US military will be notified by preparing and showing manuals." Reconsideration is needed on whether this measure is appropriate.

6. Problems with Population Viability Analysis for Dugongs in the Final EIS and the Application for Approval of Reclamation in Public Waters

6.1 Population Viability Analysis for Dugongs

The Final EIS presents a population viability analysis (PVA) for the Okinawa dugong (Reference 2), but the reproduction rate and other values used by this analysis for the dugongs are those for areas such as the Torres Strait between Australia and New Guinea, which have extremely good breeding conditions. Applying these to the Okinawa dugong population could result in overestimating the population viability. For example, while the Final EIS's analysis assumes that nine years is the mature age for dugongs, according to UNEP (2002) (Reference 29) and Marsh et al. (2012) (Reference 10), Kwan (2002) (Reference 30), who studied the dugong population in the tropical

Torres Strait, says the age is six to 11 years, and Marsh et al. (1984) (Reference 31), who studied Australia's dugong population, says the age is 10–17 years . As these studies show, the mature age of dugongs is greatly influenced by the environment. Marsh et al. (2012) states that dugongs have the flexibility to change their life history in accordance with food conditions and other environmental factors (Reference 10). It should also be recognized, even within the ranges of mature age given just above, sexual maturity and calving interval are influenced by population density and food availability and other environmental stresses. It can be surmised that the dugongs of Okinawa, which is subtropical, are closer to the dugong population of Australia than to that of the Torres Strait. Accordingly, a mature age of nine years is not a sound assumption.

In calculating environmental carrying capacity for the Okinawa dugongs in its PVA analysis, the Final EIS (Reference 2) uses the total area of seagrass meadows of Okinawa Island and the total area of seagrass meadows of Okinawa Prefecture including the Sakishima Islands as base values, and regards the area of seagrass meadows that would be lost by the FRF as percentages of the total areas of seagrass meadows. However, especially in recent years the place where dugongs and their feeding trails have been found are limited to the coastal waters of the northern part of Okinawa Island. No quantitative predictions or assessments taking this into account have been performed. Additionally, as pointed out by the Nature Conservation Society of Japan (NACS-J) (Reference 23) in accordance with results of their Jangusa-Watch Program (Reference 11), the Final EIA should have considered not just the size of seagrass meadows, but also the seagrass species in the meadows. Many of the seagrass meadows around Okinawa Island are resistant to red soil runoff and the dominant species are the seagrasses *Syringodium isoetifolium* and *Thalassia hemprichii*, which have densely growing rhizomes. It is inappropriate to calculate environmental carrying capacity with no consideration at all of seagrass species composition.

Further, as the Governor's Opinion (Reference 32) states, in predicting the habitation state of dugongs, the EIA should have made use of a habitat evaluation procedure (HEP).

7. Conclusion

The distribution of dugongs in Japan has grown smaller since the 19th century, and currently a few dugongs live in certain marine areas off the central and northern parts of the east and west coasts of Okinawa Island, while contacting with one another through occasional movements. Although there is no reliable estimate of the population size, one view is the lowest value of three, which is the lower limit of the estimate and is the most pessimistic, and possibly an underestimate. There is no estimate of the upper limit of the range.

If the FRF is built at Henoko, it is possible that the noise of construction work, aircraft noise, and increased ship traffic would drive the two individuals living near Kayo from the good feeding ground off the Kayo coast. Just as with the partial loss of the seagrass meadow by landfilling, the airfield could degrade the habitat of Okinawa dugongs and lower the possibility of population recovery, thereby raising the possibility of extinction.

Additionally, we believe that if dugongs are killed in collisions with airfield-related ships, it would be a fatal blow to dugong population recovery, and greatly increase the possibility of extinction.

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Appendix

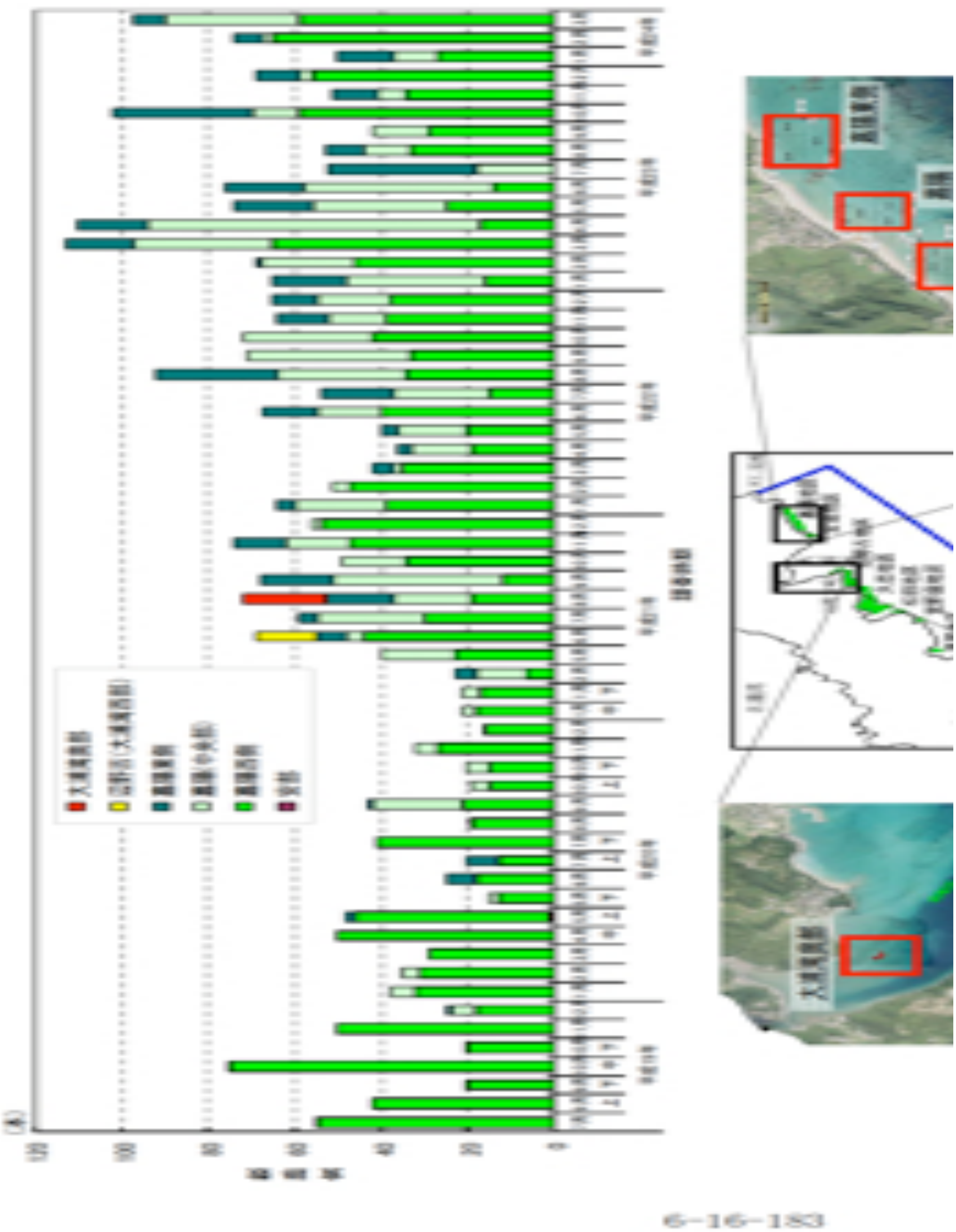

Figure A-1. Numbers of feeding trails in each survey zone according to surveys from fiscal 2007 to fiscal 2011 (from Reference).

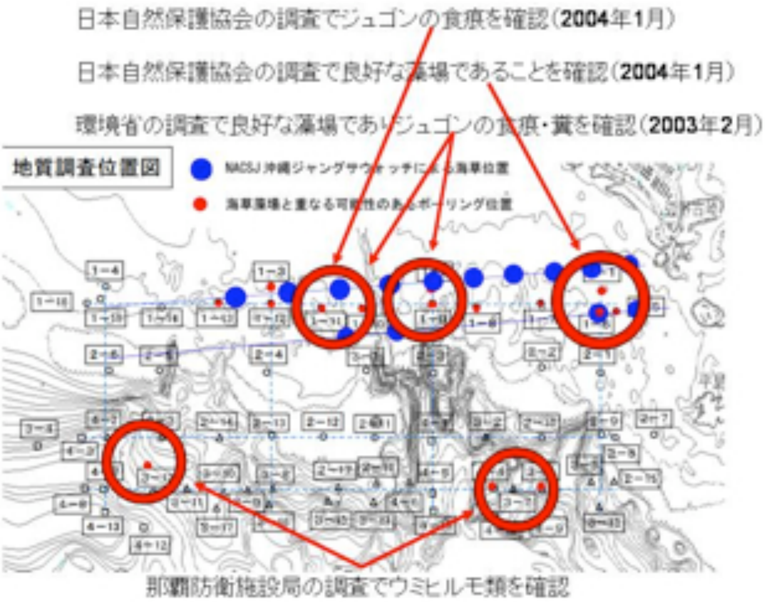

Figure A-2. Locations of dugong feeding trails and droppings, 2003–2004 (from Reference).

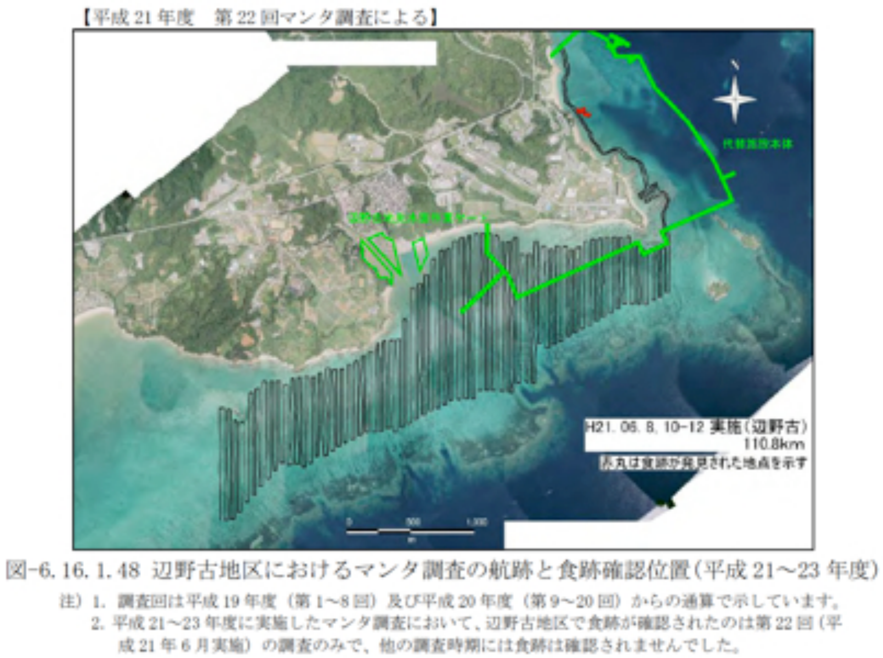

Figure A-3. Ship routes for manta survey and locations of dugong feeding trails, fiscal 2009-fiscal 2011 (from Reference)

【平成21年度　海域生態系に関する調査による】

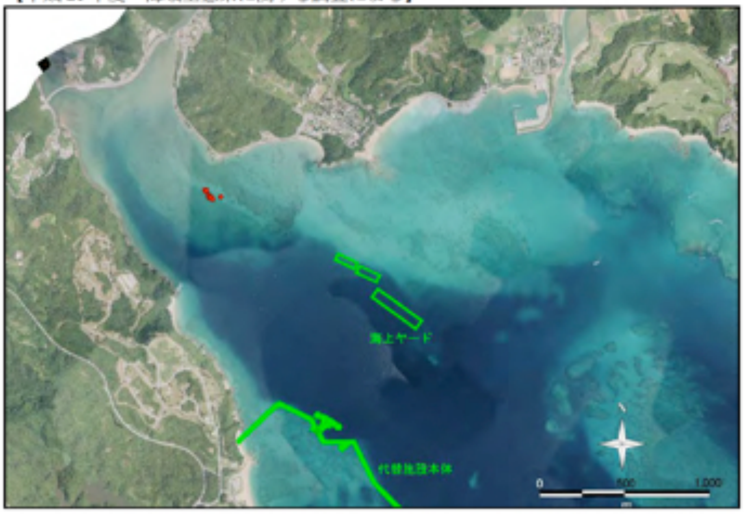

図-6. 16. 1. 49　大浦湾奥部におけるジュゴンの食跡確認位置

注）平成21年8月18日に実施した海域生態系に関する現況調査時において、調査地点近傍の藻場にジュゴンの食跡である可能性のある痕跡を発見したため、同年8月19、20日に詳細観察を行った結果、図中の赤丸(●)で示す位置にジュゴンの食跡があることを確認しました。

Figure A-4. Locations of dugong feeding trails in the inner part of Oura Bay on August 19 and 20, 2009.

Figure A-5. Dugong travel routes according to year from fiscal 2007 to fiscal 2011.