Utilization of ALOS Data for Conserving Coastal Ecosystems and Managing Fisheries Activities – Example of Seagrass Beds in Akkeshi Lake, Hokkaido, and Aquaculture Facilities in Yamada Bay, Sanriku Coast, Japan

Teruhisa Komatsu(1), Tatsuyuki Sagawa(2), Etienne Boisnier(3), Kenichi Ishida(4), Haifa Ben Rhomdhane(5), Thomas Belsher(6), Yoshihiko Sakanishi(7), Mohd Ibrahim Seeni Mohd(8)

(1) Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan, komatsu@ori.u-tokyo.ac.jp
(2) Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan, tatsuyuki@nenv.k.u-tokyo.ac.jp
(3) Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan, etienne@nenv.k.u-tokyo.ac.jp
(4) Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan, ishidak@ori.u-tokyo.ac.jp
(5) Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan, haifa@ori.u-tokyo.ac.jp
(6) IFREMER, Avenue Jean Monnet, BP 171, 34203 Sète, France, belsher@ifremer.fr
(7) Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116, Katsurakoi, Kushiro, Hokkaido 085-0802, Japan, sakani@affrc.go.jp
(8) Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia, mism@fksg.utm.my

Abstract
Sound coastal ecosystems provide important services such as habitats for animals and plants, and stabilizing effects of environments. However, human impacts such as fisheries or reclamation destroy coastal environments and ecosystems. Thus it is necessary to know present situation of coastal areas to conserve or restore sound coastal ecosystems. This study examines possibility of ALOS imagery for mapping different types of costal ecosystems and fisheries facilities. For the first step, we selected seagrass beds in Akkeshi Lake and aquaculture rafts in Yamada Bay, Japan. Supervised classification of AVNIR2 multispectral imagery of Akkeshi Lake could detect broad distribution of seagrass, Zostera marina, in shallow area in the lake. AVNIR2 imagery pansharpened with PRISM panchromatic imagery of Yamada Bay successfully identified aquaculture facilities of wood rafts (12x4 m) and buoy and rope types. These results indicate that ALOS imagery is practical tool to map coastal ecosystems and aquaculture facilities.

Keywords: ALOS, Remote Sensing, AVNIR2, PRISM, Seagrass, *Zostera marina*, Mapping, Coastal Ecosystem, Coastal Management, Conservation

1. INTRODUCTION

In coastal waters, sound ecosystems provide important services such as habitats for animals and plants, and stabilizing effects of environments such as seagrass beds and seaweed beds. They have been destroyed due to human impacts such as fisheries, reclamation and pollution during economic development [1]. Aquaculture (e.g. shrimp farming) has been developed in the world since 1980s. It has sometimes destroyed natural ecosystems. For example, it is well known that shrimp aquaculture has caused deforestation of mangrove [2]. Coastal ecosystems, however, have to be conserved and maintained for sustainable development of fisheries and society. Thus it is necessary to monitor present coastal ecosystems and fishing activities, and to establish databases and information networks to share and disseminate their data to manage them for their sustainable development [3].
ALOS launched on by JAXA has a multispectral sensor, AVNIR2, with 10 m spatial resolution and a panchromatic sensor, PRISM, with 2.5 m spatial resolution. These sensors that have spatially more precise than those of LANDSAT 7 ETM permit us to map coastal areas with various ecosystems and fishing activities. Therefore we applied ALOS imagery to use data for remote sensing of coastal areas to map and monitor them.
In this report, we selected seagrass beds that are distributed in Akkeshi Lake, Hokkaido and aquaculture rafts in Yamada Bay, Sanriku Coast, where aquaculture are highly developed, to examine possibility of utilization of ALOS imagery for the above-mentioned objectives.

2. MATERIALS AND METHODS

2.1.Seagrass beds

2.1.1. Study area

Akkeshi Lake is located in Hokkaido Island northern part of Japan facing the Pacific Ocean (Fig. 1). The maximum bottom depth was 9 m. The seawater comes into the lake by tidal current through the narrow bay mouth (400m). Since Environmental Agency of Japan (1994) reported that broad seagrass, *Zostera marina* L., was distributed in this lake, it is suitable for examining possibility of AVNIR2 imagery to map seagrass beds in shallow waters. Inside the lake, aquaculture of oysters has been developed since 1930. Seagrass beds are an important source of particulate organic matter as foods for oysters. Therefore conservation of seagrass beds is needed for sustainable aquaculture.

2.1.2. Satellite imagery and its analysis

An imagery of ALOS AVNIR2 sensor taken on 29 September 2006 was analyzed with image processing software, TNT mips (Microimage Inc., USA). Pixels inside the lake were classified into seagrass bed, sand bed, turbid water and tidal flat with supervised classification (maximum likelihood method) after masking land area. Ground truth of sand and seagrass beds was conducted on August 2007. A researcher observed bottom feature from the boat localizing survey points with a portable GPS.

2.2. Aquaculture facilities

2.2.1. Study site and field survey

Yamada Bay is located in Sanriku Coast. The bay is one of the rias-type ones in Sanriku Coast facing the Pacific Ocean (Fig.1). There are a lot of aquaculture facilities in the bay. Thus the bay is suitable for the study site.

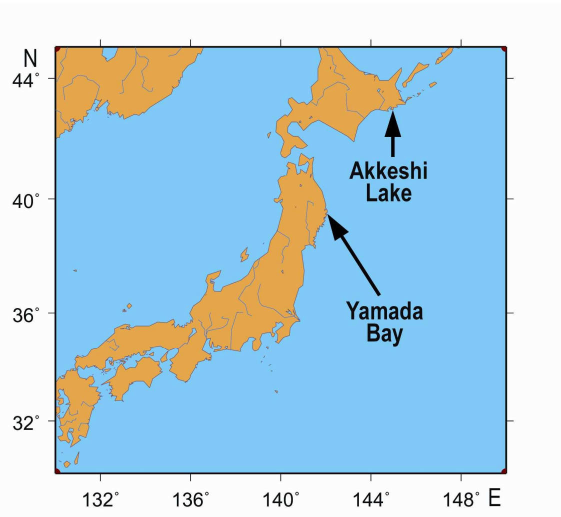

Figure 1. Map showing locations of Akkeshi Lake and Yamada Bay

2.2.2. Satellite imagery and its analysis

Imageries of ALOS and PRISM taken on 10 September 2006, respectively, were used for producing pansharpened RGB imagery with the image processing software (TNT mips, Microimage Inc.). Enhanced pansharpened imagery was used to detect aquaculture facilities.

2. 2.3. Field survey of aquaculture facilities

Fishing right territory in Yamada Bay was divided by four fishermen's cooperatives, Yamada, Orikasa, Ohsawa and Oura. Aquaculture facilities were classified into two types: wood-raft type and buoy-and-rope type. Fishermen used two types of facilities for scallop and oyster aquaculture. Aquaculture license of the former type by Iwate Prefecture stipulated for the size of the raft; it was rectangular and its length and width were 12 m and 4 m, respectively. On the other hand, aquaculture license of the latter type stipulated not for size and color of buoys but for rope length. Clusters of oysters or scallops were attached to vertical rope, which was suspended from the raft or buoy-and-rope facilities. The length of horizontal rope ranged between 50 and 100 m. Number, size and color of buoys depended on a facility.

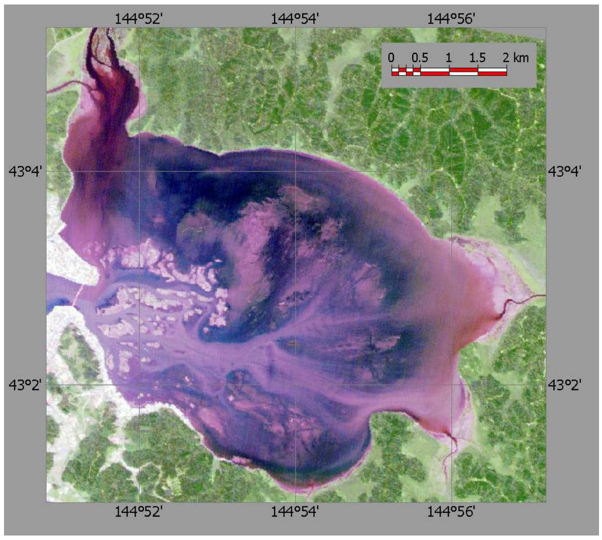

Figure 2. Enhanced AVNIR2 imagery of Akkeshi Lake

3. RESULTS AND DISCUSSION

3.1. Seagrass beds

Enhanced imagery of AVNIR2 was shown in Fig. 2. Bands of NIR, R and G were allocated to red, green and blue colors. Field survey revealed that the seagrass beds were distributed in the areas of dark blue (seagrass) and grey colors (dense seagrass). Turbid water, tidal flats and sand beds were reddish, brighter grey and purple, respectively. Using the distribution information, supervised classification was conducted. The result demonstrated that classification well corresponded to ground truth data (Fig. 3). Overall accuracy of seagrass and sand beds was about 95%. ALOS AVNIR2 could detect seagrass beds in Akkeshi Bay. Shallow water depth, clear water in the lake and healthy seagrass leaves with less epiphytic algae lead successful classification in the lake.

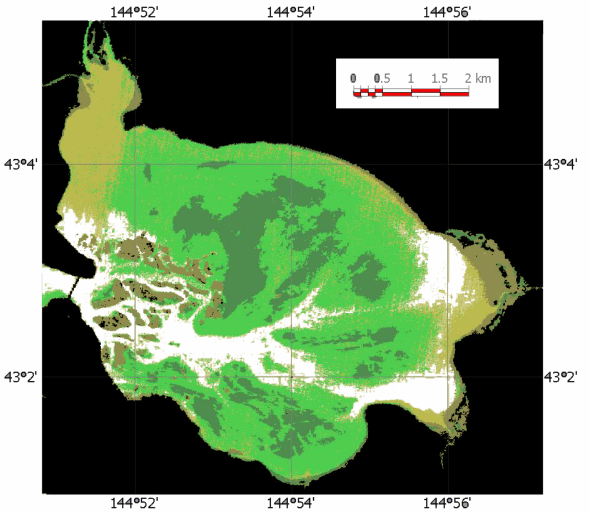

Figure 3. Supervised classification result of Akkeshi Lake. Dark green, green, ocher, brown, white and black were dense seagrass, seagrass, turbid water, tidal flat, sand bed and land, respectively

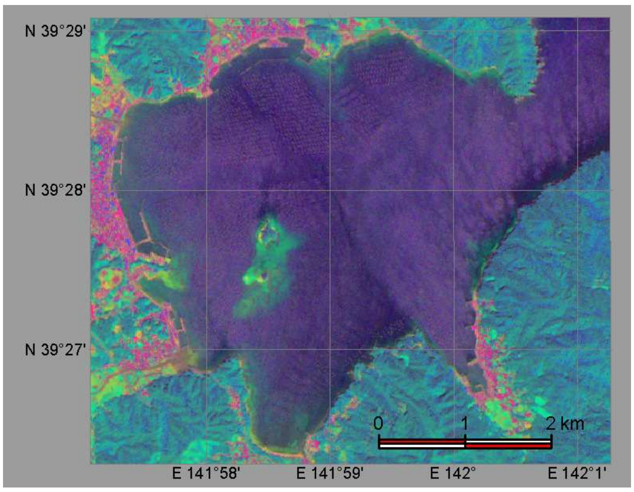

Figure 4. Enhanced pansharpened true color AVNIR2 imagery of Yamada Bay

3.2 Aquaculture facilities

3.2.1. Distribution of wood-raft type facilities

Pansharpened AVNIR2 true color imagery couldn't distinguish wood-raft type aquaculture facilities from the sea. However, enhanced imagery could show rafts distributions around north and west sides of the bay (Fig. 4). Cloud like pattern from north-northwest to south-southeast was distributed on the seasurface in the east side of the bay. Since radiance of this pattern was similar to those of rafts, it was impossible to process the imagery of the whole bay to extract rafts from the seasurface at once. Then we divided the imagery of the bay into several sections with similar radiance of rafts. The sections were enhanced to examine rafts distributions. One of example was shown in Fig. 5. Radiance of wood rafts was greater than those of the seasurface because the rafts were completely exposed on the sea surface. Then they were extracted from the imagery (Fig. 6). All the wood rafts in the bay were shown in Fig. 8. Iwate Prefecture licensed 179, 313, 825 and 1625 wood-type rafts to Oura, Orikasa, Yamada and Ohsawa Fishermen's Cooperatives, respectively (FY2006, Iwate prefecture). From Fig. 8, 189, 311, 811, and 1525 rafts belonged to waters of above-mentioned cooperatives, respectively. Only rafts number of Ohsawa Fishermen's cooperative between licensed and counted numbers was different by 100 wood-type rafts. However, percent of counted number to the licensed number was 96.4%. The result obtained by image analysis of ALOS imagery is enough accurate for practical use.

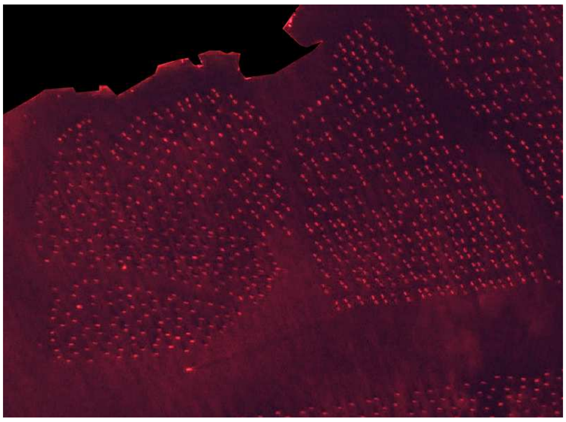

Figure 5. Pansharpened imagery of the northwest area of Yamada Bay of which red color was enhanced

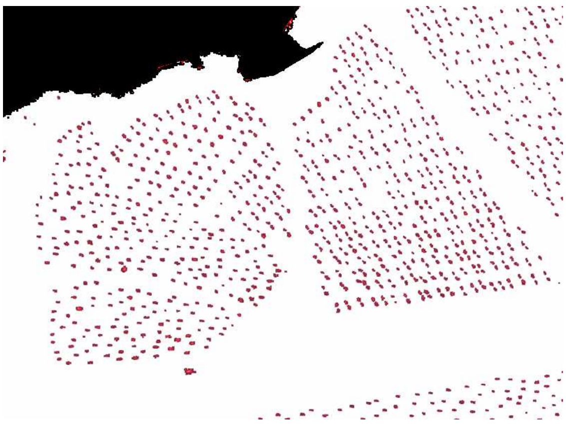

Figure 6. Extracted rafts in northwest area of Yamada Bay

The license of Iwate Prefecture determined the size of raft was 48 m^2 (12m x 4m). Since the resolution of one pixel of ALOS pansharpened imagery is 2.5x2.5 m^2, one raft is consisted of about 2 x 6 pixels. In reality, wood rafts on the imagery were consisted more than 12 pixels. It is known that image analysis of satellite imagery overestimates a plane area of object with strong reflectance due to light diffusion. It is also true for rafts in Yamada Bay because they had relatively strong reflectance.

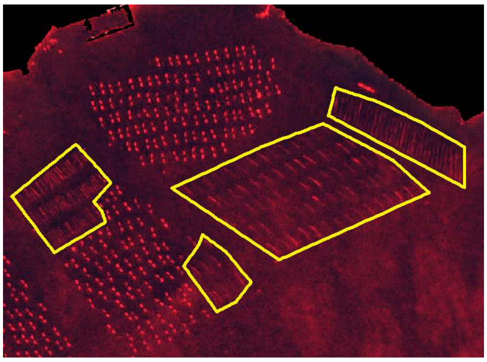

Figure 7. Pansharpened imagery of the north area of Yamada Bay of which red color was enhanced

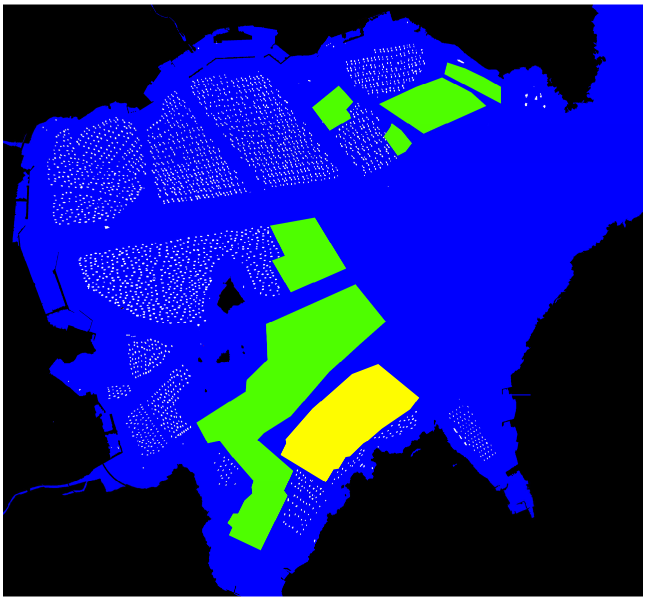

Figure 8. Distribution of wood-raft type aquaculture facilities (white points) and buoy-and-rope ones. Green and yellow areas were occupied by measurable and non-measurable facilities, respectively.

3.2.2. Distribution of buoy-and-rope type aquaculture facilities

Buoy-and-rope type aquaculture facilities in Fig. 7 were clearer than those in Fig. 4 due to enhancement of image characteristics through adjustment of color tone levels. They were distributed east and south of the island in the center of Yamada Bay (green area in Fig. 8). The other buoy-and-rope facilities were distributed in southeast area of the bay. Although a buoy-and-rope type aquaculture facility had many buoys for getting buoyancy, it was difficult to identify the length of this type with image analysis. Field observation showed that this kind of facilities was composed of black buoys and their diameters between 0.4 and 1 m. Since the buoys were smaller than 1 m below the resolution of ALOS PRISM sensor, image analysis couldn't distinguish them. In some cases, suspended clusters of scallops or oysters were so heavy that buoys were submerged under the sea. It is very difficult to measure the surface area occupied by this type facilities due to pixels with low radiance (yellow area in Fig. 8). Surface area occupied by the buoy-and-rope type aquaculture facilities were summarized in Fig. 8.

The results above-shown well corresponds to those of image analysis of IKONOS pansharpened multispectral imagery with 1 m spatial resolution [4]. Therefore this method mapping aquaculture facilities in Yamada Bay using ALOS imagery is very practical and useful for management of coastal aquaculture activity like as IKONOS imagery.

4. CONCLUSIONS

ALOS optical sensors, AVNIR2 and PRISM, are very practical tool for mapping coastal ecosystem such as seagrass beds in shallow waters and aquaculture facilities on the seasurafce. We will use ALOS optical sensors to coastal waters in southeast Asia and north Africa with SAR (PALSAR) in the near future.

Acknowledgement

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