1. PROJECT INFORMATION

Title:	Webcam monitoring of marine/tsunami debris
Award period	October 1, 2014-March, 31, 2015
Amount of funding	94,599 Canadian dollars
Report submission date	30 April 2015
Lead Author of Report*	Atsuhiko Isobe

**Although there may be only one lead author of the report, all PIs and co-PIs of the project, as identified in the approved statement of work and listed below, are responsible for the content of the Final Report in terms of completeness and accuracy.*

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Collaborators in Canada: Dr. Cathryn Clarke Murray (PICES)

2. EXECUTIVE SUMMARY

Describe both the research purpose, objectives, methods, results, achievements and challenges, timelines and milestones (2-3 pages)

To date, there are few published studies that have investigated variations in the quantities of long-term beach litter for intervals shorter than one month. Consequently, there is no way of knowing the ''true'' temporal scale of the variations in the quantity of litter on beaches, or the factors responsible for them. Furthermore, there is no way of knowing the appropriate time scales for beach surveys and/or cleaning services. Thus in this study, for monitoring tsunami debris, photographs of beach littering were taken automatically every 60 min over a one and half year period using webcams, with the aim of elucidating the temporal variations of litter quantities and the possible factors responsible for these changes. To provide quantities of marine debris littered on beaches, monitoring using webcams is adopted in line with Kako et al. (2010) and Kataoka et al. (2012). Photographs of beaches are taken every 1-hour during 1-2 years sequentially, and are converted to time series of areas (in the unit of m^2) covered by marine debris after an image processing. The projection transformation method is used for this geo-referencing (Kako et al., 2010), and extraction of anthropogenic objects from the beaches is conducted on a CIELUV color space (Kataoka et al., 2012). T he photographs are sent via the Internet to laboratories, and are also opened publicly. In the above experiment, we examine the efficiency of the above system for automatically monitoring tsunami debris, and elucidate relationships between the quantities of marine debris on beaches and atmospheric/oceanic conditions.

Also investigated is the efficiency of a near-infrared camera to monitor lumbers that are potentially carrying invasive species onto beaches. The near-infrared monitoring experiments are conducted on beaches in Japan this year.

The webcam data are provided to the research project “Effect of Marine Debris Caused by the Great Tsunami of 2011” to combine with data obtained by other research groups (aerial photography and beach severance). This potentially provided us with a quantitative estimate of invasive species washed ashore onto western US and Canada coasts along with tsunami debris.

The timetable this year is as follows.

- January 15-21, 2015
  Seeking the webcam-monitoring site around Newport OR
- By the mid-February
  Purchase of equipment required for webcam monitoring
  Shipping them to the webcam site
- February 15-21, 2015
  Installing the webcam monitoring site
  Operating test for the webcam monitoring
  Near infra-red camera experiments

The details of the webcam system are as follows. The VIVOTEK IP8362 network camera is driven by two solar panels, and takes a photo every one-hour during the daytime (0900-1800 EST). The photo data are sent using the AT&T mobile communication service, and using Verizon 4D LTE USB Modem (UML295) and the CradlePoint MBR1400 Mission Critical Broadband Router to establish the Internet communication. All photos taken by the camera are now opened publicly on the website http://mepl1.riam.kyushu-u.ac.jp/home/works/gomi/webcam.html.

Webcam monitoring

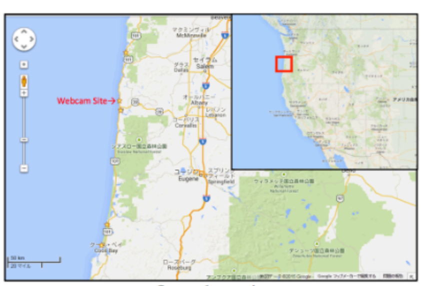
PICES project on "Effects of marine debris caused by the great tsunami of 2011"

TOP	Webcam images	Research

About webcam monitoring

Thank you for visiting our website and your interest in our research

We are monitoring tsunami debris using a webcam installed on a beach in the Oregon Coast. We will provide quantities of marine debris litterd on beaches using the webcam data (Kako et al., *Mar. Pol. Bull.*, 2010; Kataoka et al., *Mar. Pol. Bull.*, 2012). The webcam is oparated every one hour for 9:00 to 18:00 (PST), and the webcam data is sent to our server via the Internet. We will put the last webcam data on this website.



Our webcam site

Our webcam system

The webcam monitoring is supported by the reserch project "Effect of Marine Debris Caused by the Great Tsunami of 2011" funded by the Ministry of the Environment of Japan through the North Pacific Marine Science Organization (PICES). The website of the research project is here.

This webcam monitoring project is done by Prof. Atsuhiko Isobe (Kyushu University, Japan), Prof. Hirofumi Hinata (Ehime University, Japan), Dr. Shin'ichiro Kako (Kagoshima University, Japan) and Dr. Tomoya Kataoka (National Institute for Land and Infrastructure Management, Japan),
collaborated with Mr. Charlie Plybon (Surfrider Foundation, Oregon Region), Dr. Nir Barnea and Dr. Nancy Wallace (NOAA),
and special thanks to Lincoln County, OR, for providing the webcam site, Ms. Catherine Pruett (Salmon Drift Creek Watershed Council, OR) for seeking the webcam site and AT&T (Corvallis, OR) for Internet contract.

3. PROGRESS SUMMARY

a. Describe original proposed research and planned outputs

As mentioned above, photographs of beach littering were taken automatically every 60 min over a one and half year period using webcams, with the aim of elucidating the temporal variations of litter quantities and the possible factors responsible for these changes. Thus, we had to complete to the install the webcam this year, and this has done successfully. All image data are sent our laboratory through the Internet. The image processing is now ongoing, and will provide the time series of marine debris during the next year.

b. Describe progress

The most telling on our accomplishments is our website. This provides us photos of the OR beach littered by marine debris every one hour during the daytime (0900-1800 EST). The photos are processes by the projective transformation to convert images on the Cartesian coordinate in order to measure the areas covered by marine debris. Part of the processed images is shown in the next section.

c. Describe results

(1) Choice of webcam site at Newport OR

Candidates suitable for the webcam site were investigated along Oregon coasts close to Newport during the period 11th through 15th January 2015 (Fig. 1). The bottom lines to be satisfied for monitoring are capability of the mobile communication, soil condition, areas sufficiently large for setting a webcam equipment, accessibility from major roads, and surroundings without vandalism. The results of the in situ examination are listed on check sheets for each candidate.

As a result, we chose the site#2 (Fig. 1) for the webcam monitoring of marine debris at the west coast in US. This is because this site is located on the place higher than other sites (see photos in the check sheet), and because higher places always have an advantage in watching the debris littered on beaches. Also, the site#2 seems to be free from vandalism compared to other sites because of a careful management by county officials. In addition, the capability of the AT&T mobile service, the soil condition suitable for setting the webcam system, and accessibility from the major road all meet our criteria.

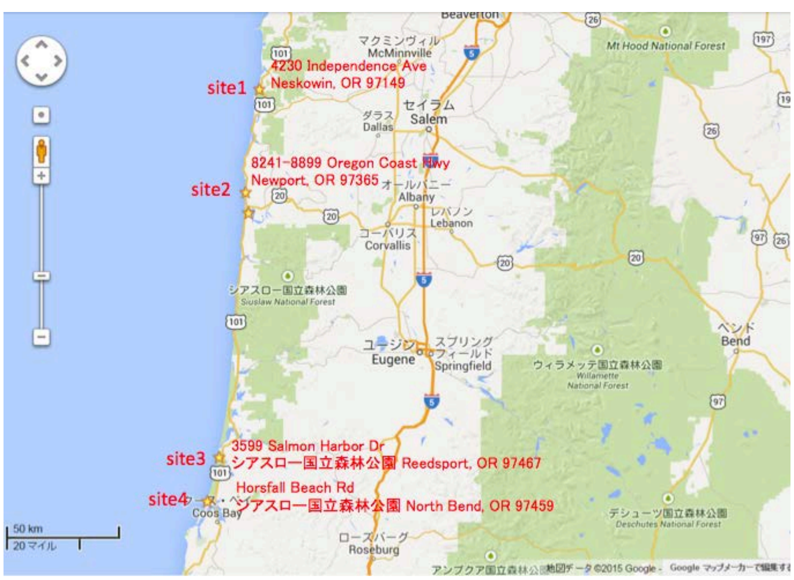


Fig. 1 Four candidates of the webcam site investigated in January 2015

(2) Installing a webcam at the Oregon coast

We stayed at Newport to install a webcam system at the site#2 during the period 15 through 21 February 2015. Figure 2 shows the webcam system that we have a plan to set at the site#2. The electricity for driving the camera is provided using solar panels. The area of 2.5 m x 2.5 m at least is required for the webcam system to set stably, and the site#2 well meets this criterion. By the end of February 2015, photo images taken by the camera was opened publicly via the Internet using the Verizon 4D LTE USB Modem (UML295) and the CradlePoint MBR1400 Mission Critical Broadband Router.

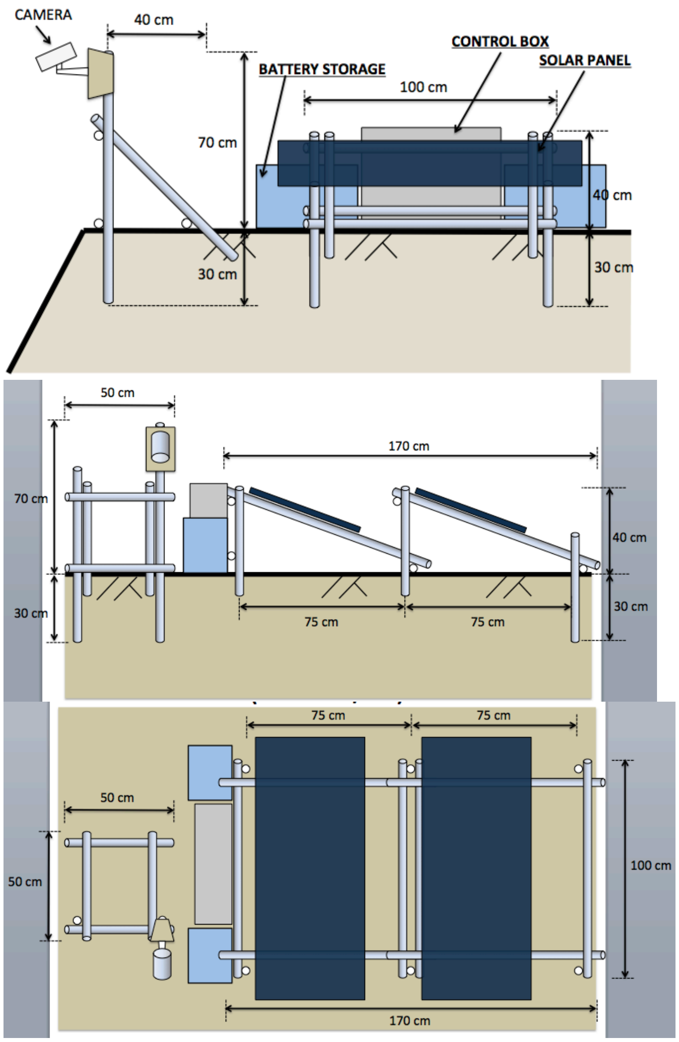


Fig. 2 Overview of the webcam system looking offshore-ward (westward) at the Oregon coast near Newport. The side views from south (upper panel) and west (middle panel), and plane view (lower panel) are shown in the figure.

(3) Providing webcam images through the Internet

The webcam images are first sent from the Oregon coast onto a FTP site at Kagoshima University, Japan. Thereafter, the images are opened publicly on the website http://mepl1.riam.kyushu-u.ac.jp/home/works/gomi/webcam.html. When installing the webcam at the OR coast, the reference points for georeferencing were chosen in the area taken by the camera. The webcam images (Fig. 3a) are rotated to the images (Fig. 3b) on the Cartesian coordinate using the positions measured by GPS on the coast.

Fig. 3 Photo taken by the webcam at 1000EST on 4 April 2015 (a: left) and processed images by rotating the same photo onto the Cartesian coordinate with the projective transformation technique (b: righrt).

(4) Collaboration with aerial photography

The webcam monitoring has an advantage in monitoring marine debris continuously in time. The webcam however has a disadvantage that this monitoring provides us with quantities of marine debris only at a local site. On the other hand, aerial photography can synoptically monitor the accumulation of marine debris over areas broader than webcam monitoring. Nonetheless, the aerial photography also has a disadvantage that the surveys are conducted sporadically, so difficulty arises in considering the temporal variability of the quantities of marine debris with a fine resolution. Probably, the most reasonable method to monitor the marine debris with a high spatio-temporal resolution is a combination between webcam monitoring and aerial photography. In this year, as the first step of the combination, we attempt to quantify the marine debris on aerial photographs using the same image processing method as we applied to webcam images.

To investigate the accumulation of marine debris in the British Columbia and Alaska coasts, PICES and NOAA have been conducting aerial photographic surveys. We attempted to estimate a ratio of areas covered by marine debris to areas of entire beach (hereinafter, “percent cover”) by applying the image processing established by Kataoka et al. (2012) to the aerial photographs.

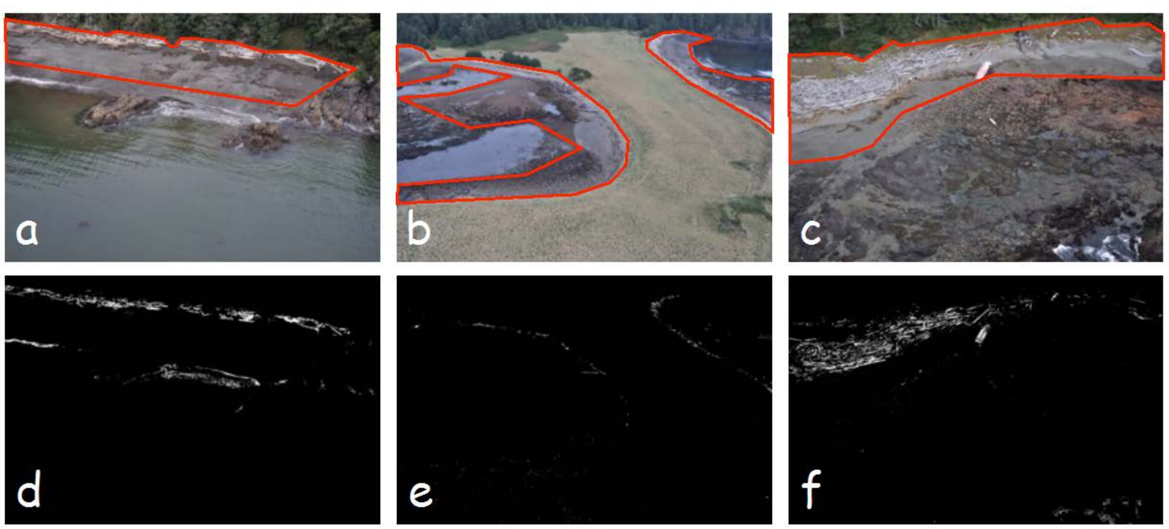


Fig. 4 Comparison between original aerial photographs (a-c) and images that are extracted debris pixels by image processing (d-f). The red curves denote the beach area for calculating the percent cover.

Driftwoods are the most remarkable marine debris along the British Columbia coasts (Fig. 4, upper panels). In the present analyses, we chose driftwoods and anthropogenic debris as target objects, and extract their pixels (hereinafter, “debris pixel”) from aerial photographs using the difference of their colors. The lower panels of Fig. 4 show the images in which we extracted debris pixels from the three sample photos by the image processing. Most of debris pixels are likely to be successfully extracted although the whitecaps along the shoreline are erroneously extracted. Next, to calculate the percent cover of marine debris, we define the area of the beach every sample photographs (areas surrounded by red curves in Fig. 4 (a)-(c)). The percent covers were estimated for panels (a), (b) and (c) in Fig.4 as 4.8%, 0.1% and 6.0%, respectively.

At the present time, we have to override two technical issues to enhance the accuracy of the percent cover as follows:

i. The geo-referencing process is needed. The percent cover remains uncertainty because of the geometric distortion of the photographs. Hence, we have to convert the photos to those on a geographic coordinate using several references (more than four positions should be measured by GPS). Applying a projective transformation technique to the aerial photographs is thereafter required (e.g., Kako et al., 2012 and Kataoka et al., 2012).
ii. The areas littered by marine debris should be identified automatically. In the present analysis, we had to compute the percent covers from many photographs by eyes because the beach areas were defined by each photograph. In Year 2 (April, 2015 to March, 2016), we will establish the method for extracting the pixels of the beach from aerial photographs based on their colors

(5) Experiments of near-infrared monitoring

The accuracy in monitoring marine debris with invasive species should be validated using alternative methods different from webcams; otherwise we cannot justify the estimate of the marine-debris amount. We attempt to identify driftwoods and anthropogenic debris covered partly by biological things (e.g., shells) using a near-infrared camera (Hyperspectral Camera; NH-7, EBA Japan Co. Ltd.). The camera has ability to distinguish the marine debris, driftwood, and other biological things from sands using reflectance spectra (Fig. 5) backscattered from objects on images. The comparison between images of near-infrared camera and webcam is conducted to investigate if the webcam images accurately capture marine debris with invasive species.

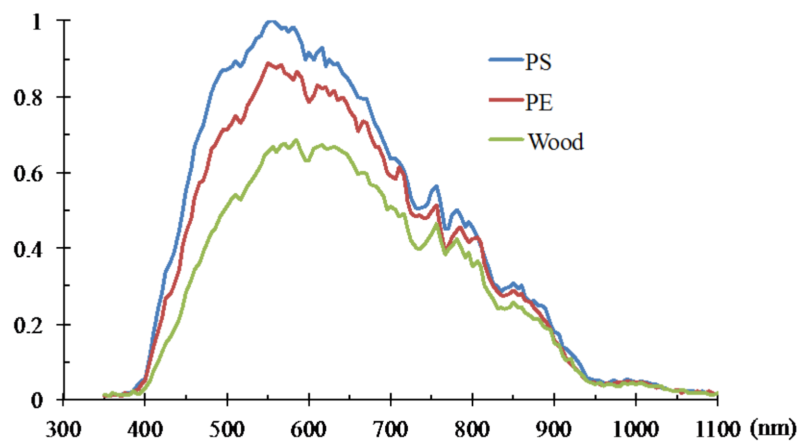


Fig. 5 Normalized reflectance spectra of polystyrene (PS), polyethylene (PE) and wood measured by NH-7.

(6) Potential research to be carried out in Year 2.

(6)-1 Comparison among webcam monitoring data, aerial photography, near-infrared images, and results of particle-tracking model

The photo image data are dumped every one or two hours into a data server via the Internet, and the areas covered by marine debris littered on the beach are computed using pixel numbers after geo-referencing (Kako et al., 2010; Kataoka et al. 2012). The time series of the area is regarded as that of the amount of marine debris washed ashore on the beach over the entire project period. The accuracy of the debris estimate will be validated using near infrared images as mentioned above. In addition, the spatial-temporal variability of marine debris washed ashore on the US and Canadian coasts will be deduced by the combination with aerial photography. The cause(s) of the temporal variation of the debris amount will be investigated using a particle-tracking model into which ocean currents and winds are given. The model details are described below.

The gridded ocean surface current data from National Oceanic and Atmospheric Administration/Ocean surface Current Analyses – Real time (NOAA/OSCAR) is used for the ocean currents in this study (Fig. 6). The surface currents are computed directly from the gridded surface topography and surface wind analyses data derived from the various types of satellite observations such as TOPEX/Poseison, Jason-1, Geosat Fllow-On, European Remote Sensing 1/2, Environmental satellite, QuikSCAT, and so forth. The data derived from these satellites are interpolated into 1˚ by 1˚ grid box for every 5 days by using objective analysis method proposed by Lagerloef et al., (1999). This employs a straightforward linear combination of geostrophic and wind-driven (Ekman) motion. The technique is tuned to best represent the ageostrophic motion of the WOCE/TOGA 15 m drogue drifters relative to the surface wind stress. Geostrophic velocities are computed with sea level gradients derived from satellite sea surface height analyses. The mean altimeter surface height field is also subtracted and replaced by the mean annual 0-1000 dbar dynamic height derived from the NOAA/NODC (Levitus et al., 1994a,b) to preclude the influence of marine geoid errors on the altimeter data.

The difficulty of computing near equatorial geostrophic currents was treated by devising a weighted blend of the equatorial beta-plane and conventional f-plane geostrophic equations (Lagerloef et al., 1999). Ekman currents were derived from a two-parameter linear model fitted to drifter data. This provided a formulation that allowed smooth transitions across the equator without the problem of the equatorial singularity where the Coriolis acceleration crosses zero. The gridded surface current and sea surface height datasets for global oceans have been opened on NOAA website: http://www.oscar.noaa.gov/index.html. The period for which NOAA/OSCAR datasets are available is from 15 October 1992 to present.

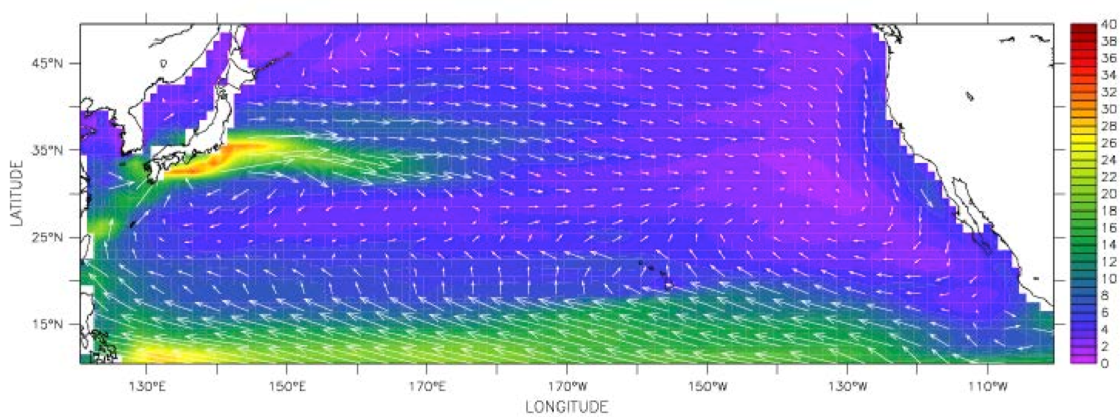


Fig. 6 Horizontal distribution of long-term averaged (1993-2014) ocean surface currents in the North Pacific derived from NOAA/OSCAR. The unit is cm/s.

(6)-2 Additional webcam monitoring

We have a plan to install an additional webcam site in Year 2. Two candidates are now considered to monitor marine debris effectively, and we will choose one of two because of limitations of financial and human resources. The OR coast where we are installing the webcam is located at the boundary between subtropical and subarctic gyres of ocean currents in the North Pacific. A new site should be located in either subtropical gyre or subarctic gyre. The webcam data on the beaches provide us with an amount of debris “integrated” in time, and so it will be useful to compare with results of the particle-tracking model of the subsection (6)-1 and the models used by MoE/PICES project researchers. In addition, the comparison with winds and ocean currents with webcam data should be conducted in various places to draw the firm conclusions.

One candidate is Pacific Islands such as Hawaiian Islands in the subtropical gyre. The other is Alaskan coast in the subarctic gyre. Both places are littered intensely by marine debris, and NPOs' activities are anticipated to help us seek and maintain the webcam monitoring site.

References

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Levitus, S., R. Burgett and T. Boyer, World Ocean Atlas 1994, Vol. 3: Salinity, NOAA Atlas NESDIS 3, NOAA, Washington, DC , 99pp, 1994a.

Levitus, S. and T. Boyer, World Ocean Atlas 1994, Vol. 4: Temperature, NOAA Atlas NESDIS 4, NOAA, Washington, DC , 117pp, 1994b.

d. Describe any concerns you may have about your project's progress

We met some difficulties in making a contract of the Internet connection because of the limitation due to non-US inhabitants (without social security numbers, and without residential address in US). Our collaborators in US (Dr. Nir Barne) provided us with great helps to make the contract. We will need a counterpart in installing the webcam at additional places except in Japan.

e. Completed and planned publications

We just installed the webcam one month before, so that much more times are needed to process the images for preparing publications.

f. Poster and oral presentations at scientific conferences or seminars

We just installed the webcam one month before, so that much more times are needed to process the images for preparing presentations.

g. Education and outreach

All photos taken by the camera are now opened publicly on the website http://mepl1.riam.kyushu-u.ac.jp/home/works/gomi/webcam.html.

4. PROGRESS STATUS

Overall, In Year 1 the webcam project progressed on schedule. The webcam was installed by March 2015 and is now providing images through the Internet. Image processing has already started and will continue in Year 2 as suggested in the proposal submitted to PICES.