Seagrass beds and its ground truthing

Teruhisa Komatsu
Japan Fisheries Resource Conservation Association

Who is Teruhisa Komatsu?

- graduated Department of Fisheries, Kyoto University in 1976.
- graduated doctor course of Department of Fisheries, Kyoto University in 1981.
- Research associate, Faculty of Agriculture, Kyoto University from 1982 to 1988
- Assistant Professor, Faculty of Agriculture, Kyoto University from 1988 to 1990
- Assistant Professor, Ocean Research Institute, the University of Tokyo from 1990 to 1997
- Associate Professor, Ocean Research Institute, the University of Tokyo from 1997 to 2010
- Associate Professor, Atmosphere and Ocean Research Institute, the University of Tokyo from 2010 to 2017
- Professor, Faculty of Commerce, Yokohama College of Commerce, from 2017 to 2020
- Expert Advisor, Japan Fisheries Resource Conservation Association under the Ministry of Agriculture, Forestry and Fisheries from 2020

Research Field

Doctor thesis: Marine environments in a *Sargassum* forest

Ecology of seagrass and seaweed species

Ecology of floating seaweeds of *Sargassum* species in East Asia

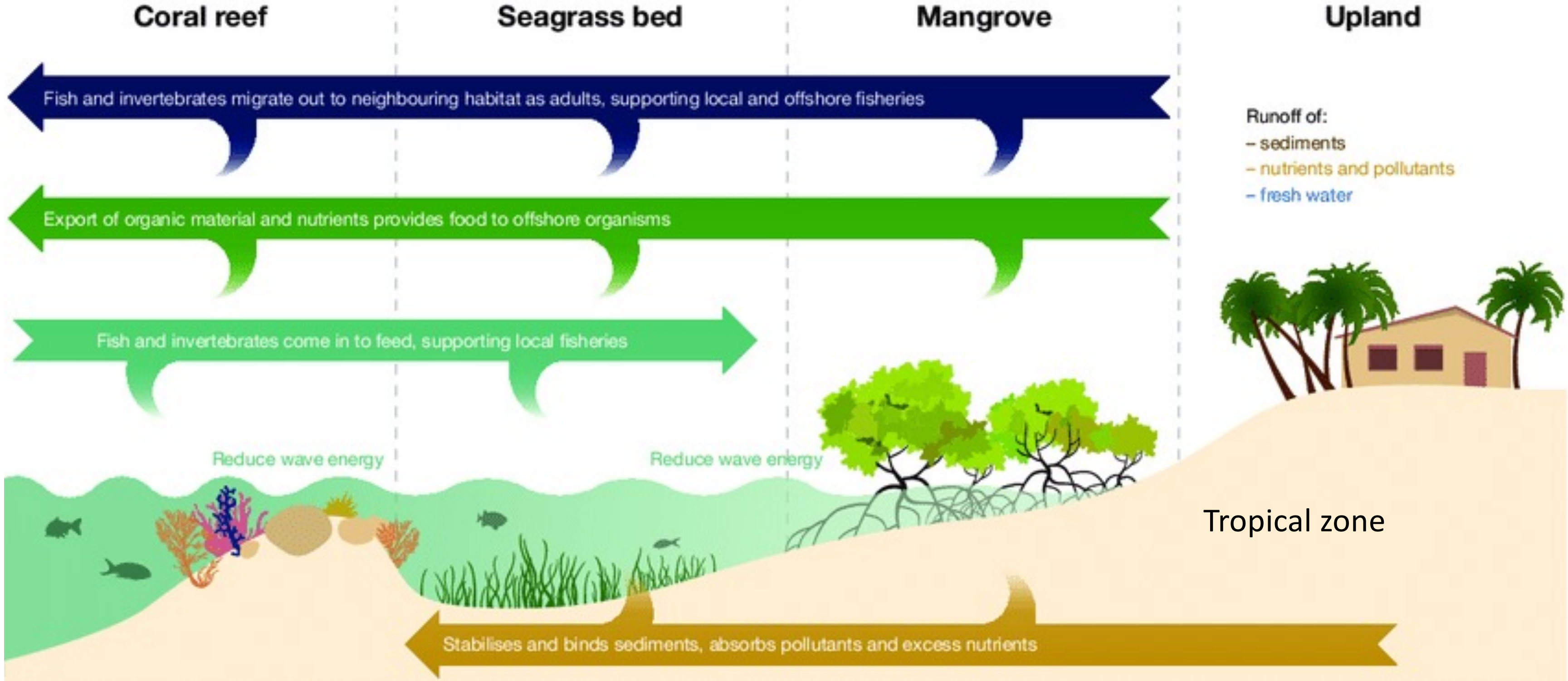
Coastal habitat mapping using optical and acoustic methods

Social activity

Leader of IOC-WESTPAC Ocean Remote Sensing for ICAM from 2011

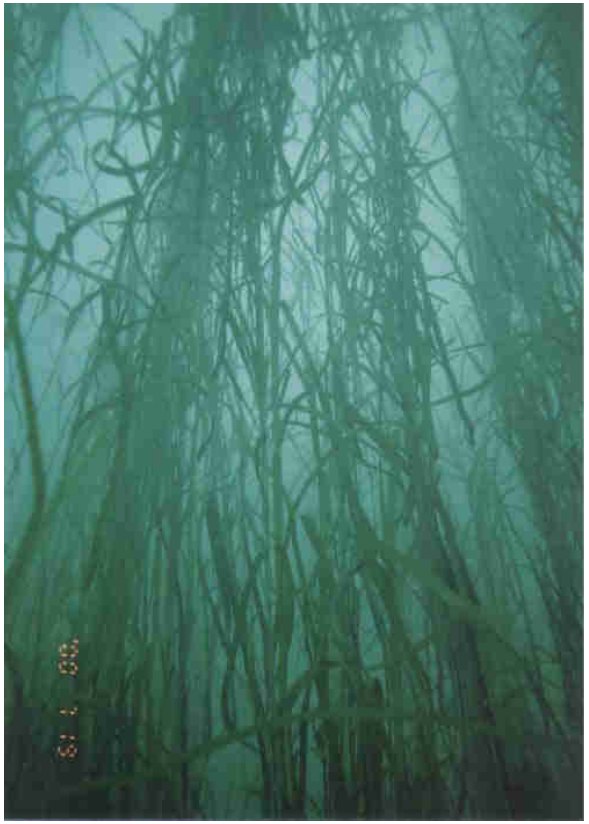
President of French-Japanese Society of Oceanography from 2013

Coastal ecosystem as an ecotone between land and the sea



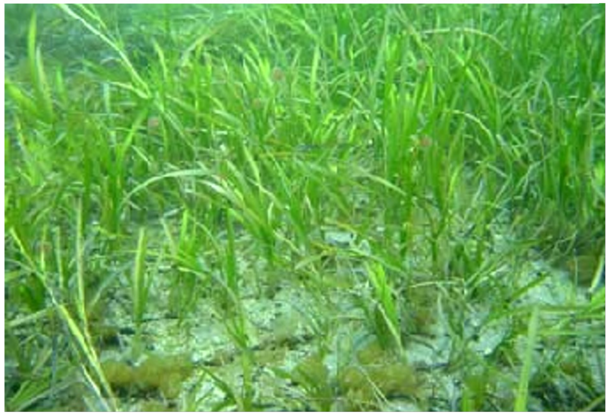
Ecotone, a transitional area of vegetation between two different plant (ecosystem engineers') communities, such as forest and grassland on land and mangrove, seagrass and coral reef in the coast. It has some of the characteristics of each bordering biological community and often contains species not found in the overlapping communities.

Seagrass beds



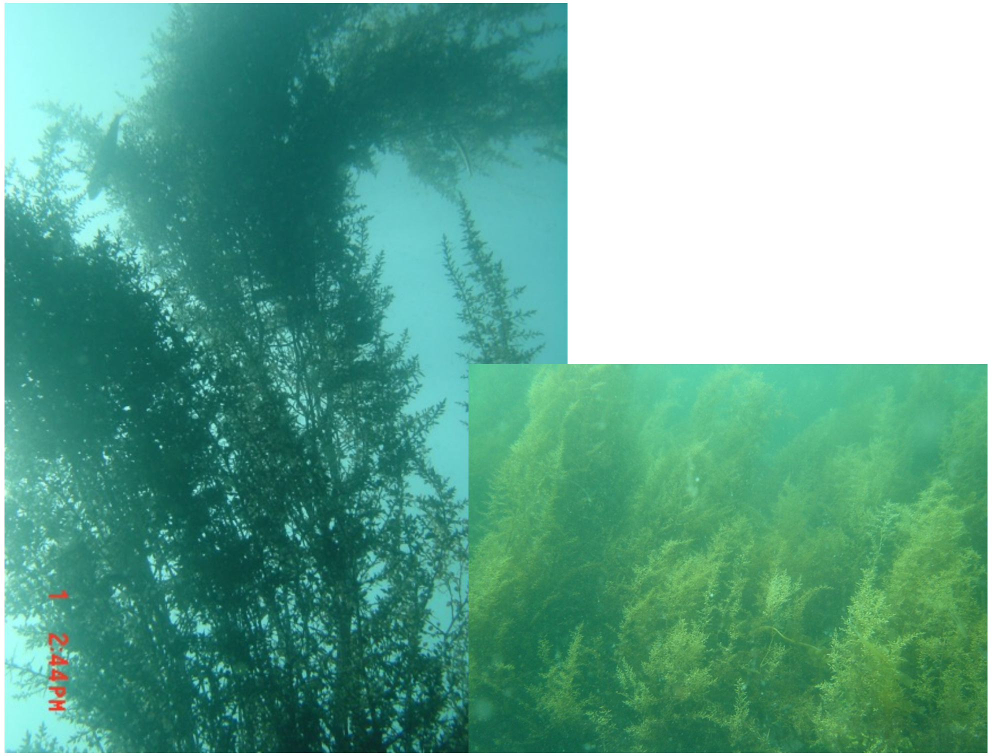
Zostera caulescens

Posidonia oceanica



Zostera marina

Seaweed beds

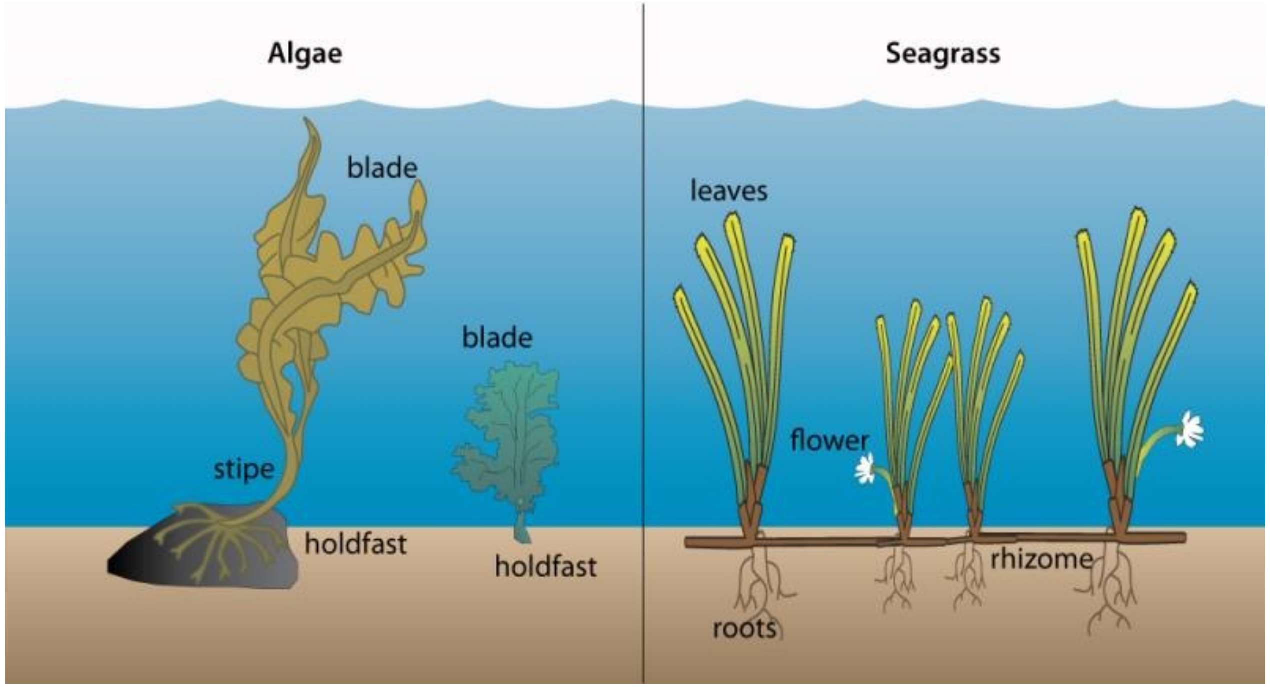


Sargassum horneri in Otsuchi Bay, Japan (T. Komatsu)

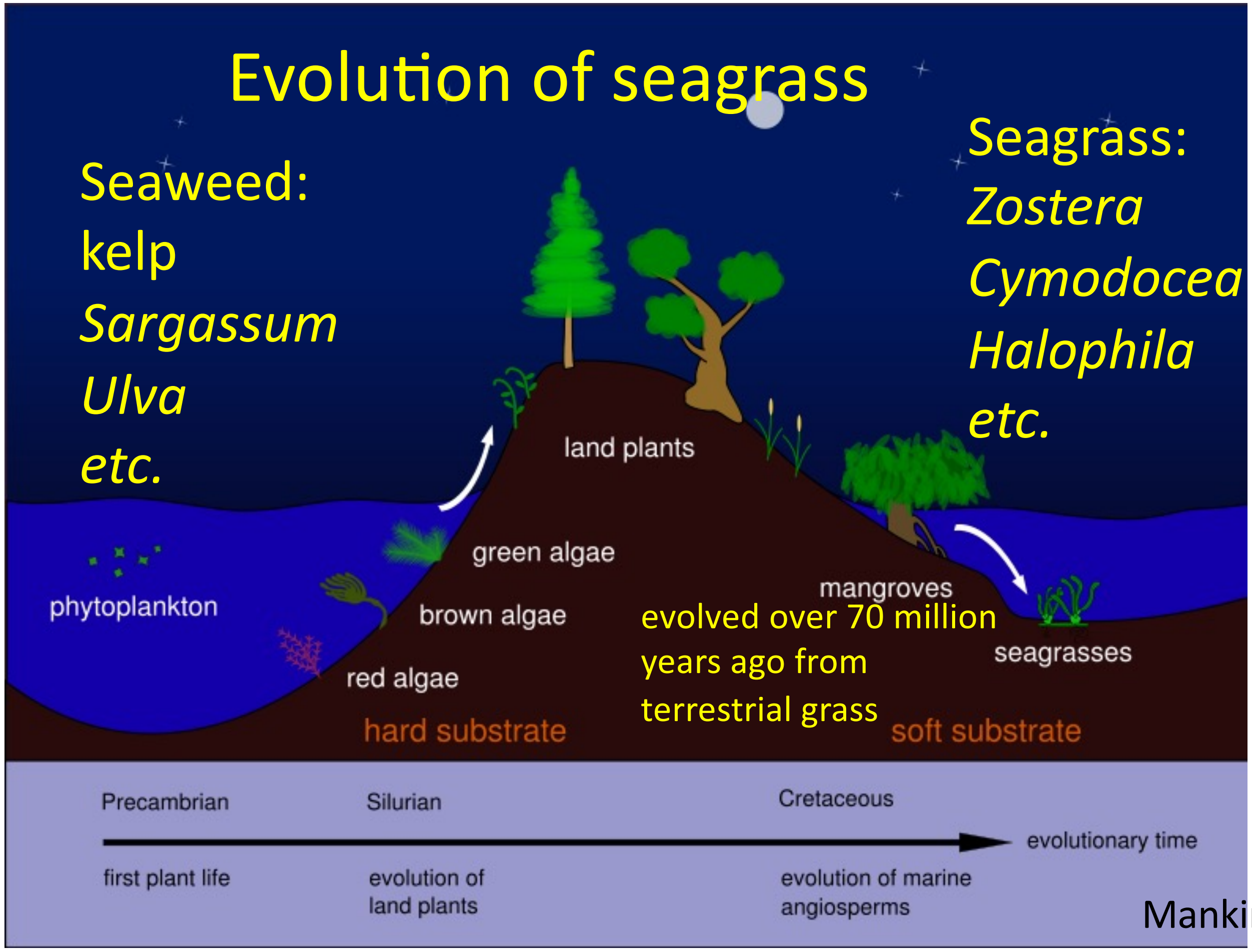
Giant kelp (*Macrocystis pyrifera*) in California's coast

https://news.virginia.edu/content/study-finds-kelp-key-californias-coastal-ecosystems

Difference between seaweed and seagrass



https://ocean.si.edu/ocean-life/plants-algae/seagrass-and-seagrass-beds

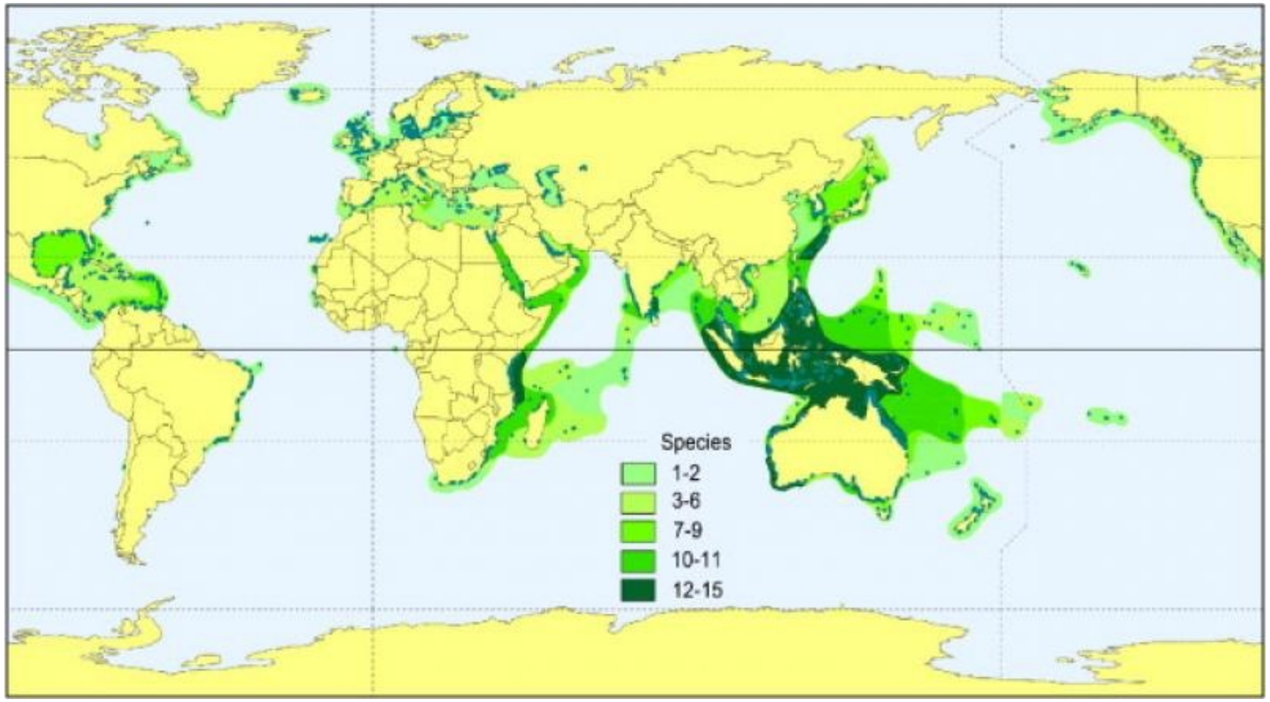


Mankind

540-490 million yrs ago | 440-410 million yrs ago | 140-60 million yrs ago | 7-5 million yrs ago

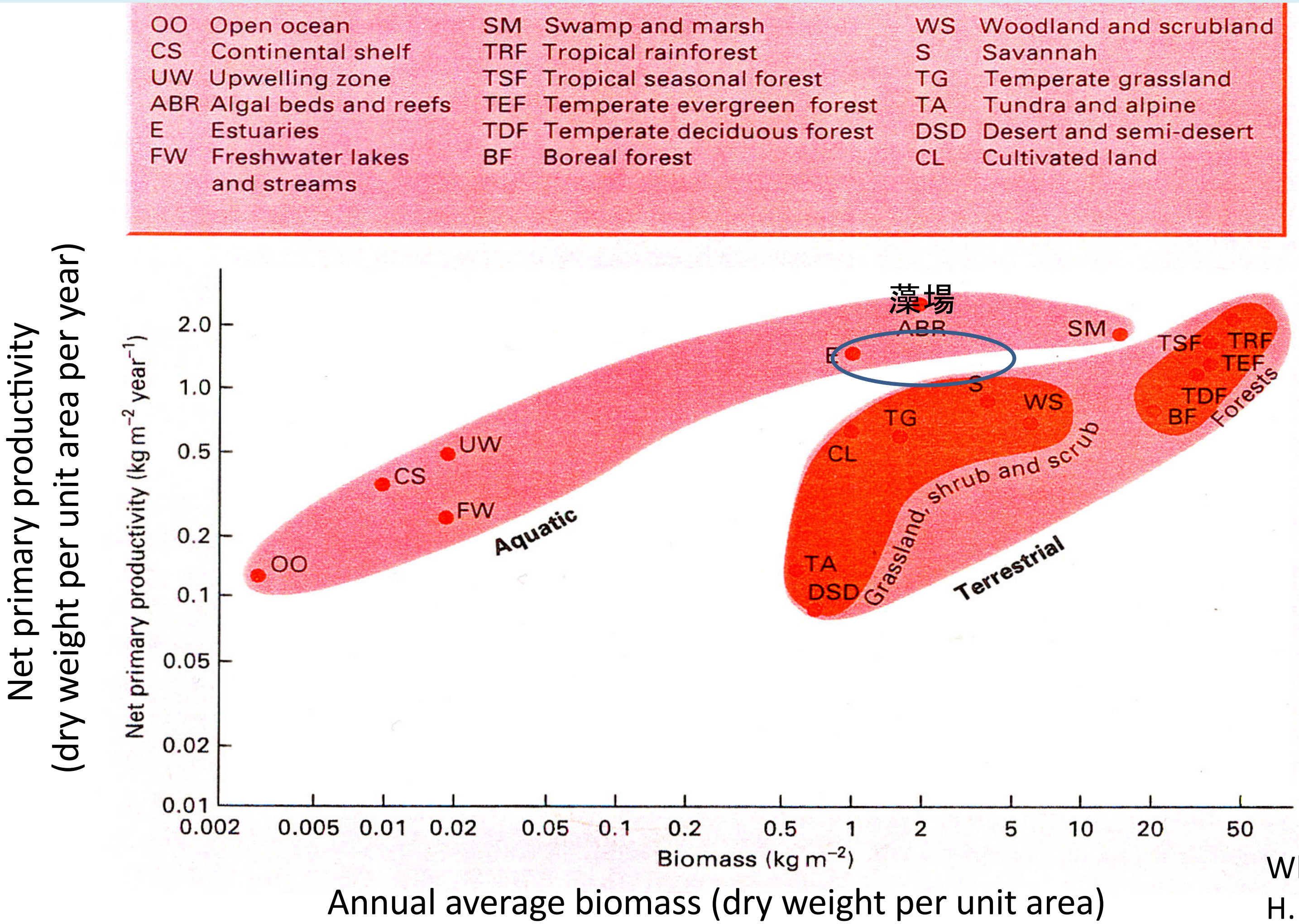
https://commons.wikimedia.org/wiki/File:Evolution_of_seagrasses_Pengo.svg

Distribution of the number of seagrass species



Approximately 72 seagrass species have been identified around the world. Seagrasses are found across the world, from the tropics to the Arctic. Shades of green indicate the number of species reported for a given area. The darker shades of green indicate more species are present. (Short, F. et al. 2007).

Primary production of seagrass and seaweed beds



Whittaker, R. H. and G. H. Likens (1975)

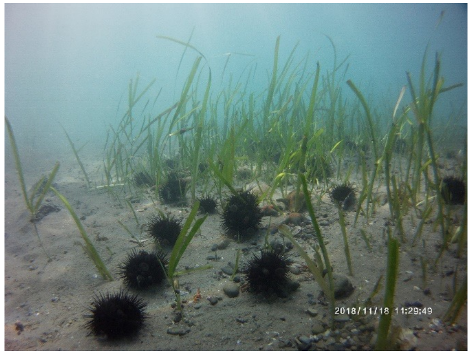
Important ecological roles of seagrass beds

Eggs spawn on seagrass leaves by herring

https://www.hro.or.jp/list/fisheries/research/central/section/zoushoku/img/j12s22 0000000o3y.jpg

Habitat of many organisms including rockfish

https://www.hro.or.jp/list/fisheries/research/central/section/zoushoku/img/j12s22 0000000o3y.jpg



Prey of many marine animals (e.g. sea urchins)

https://www.facebook.com/921771297863676/posts/2463139270393530/

Feeding place for dugongs

https://www.facebook.com/921771297863676/posts/2463139270393530/

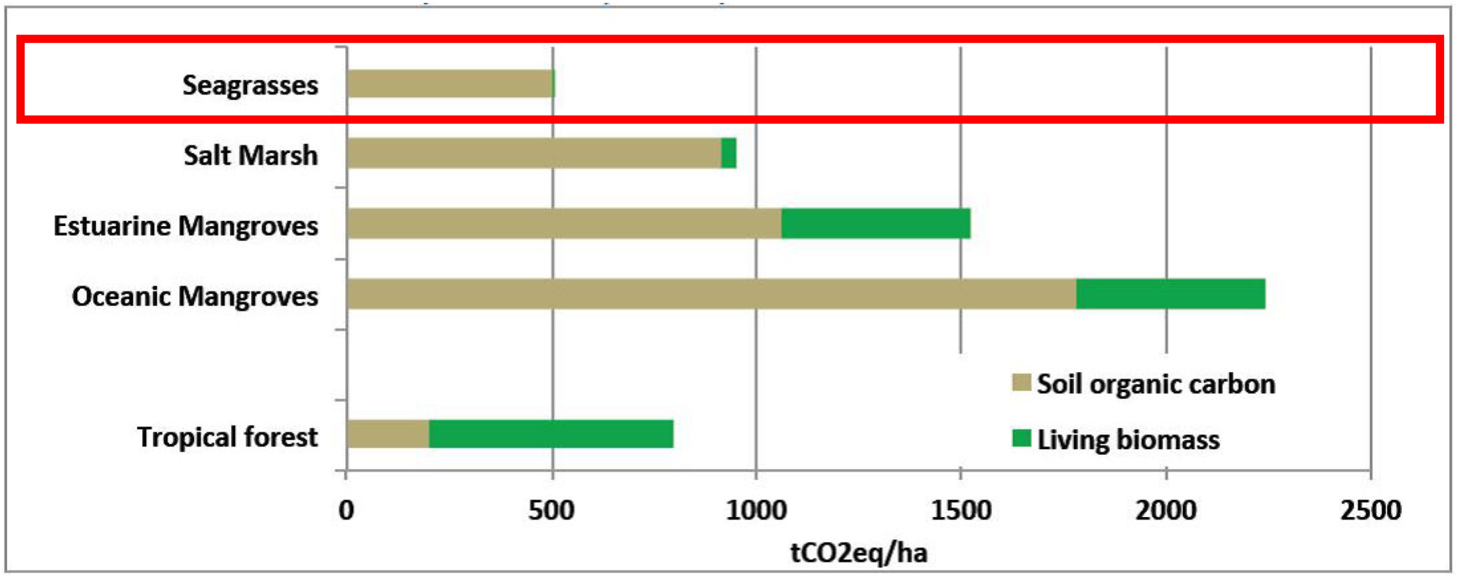
Biodiversity and fisheries resources

Blue carbon of seagrasses

Mitigation for global warming

(tCO2eq/ha: tonne of CO_2 equivalent)

Seagrass meadows

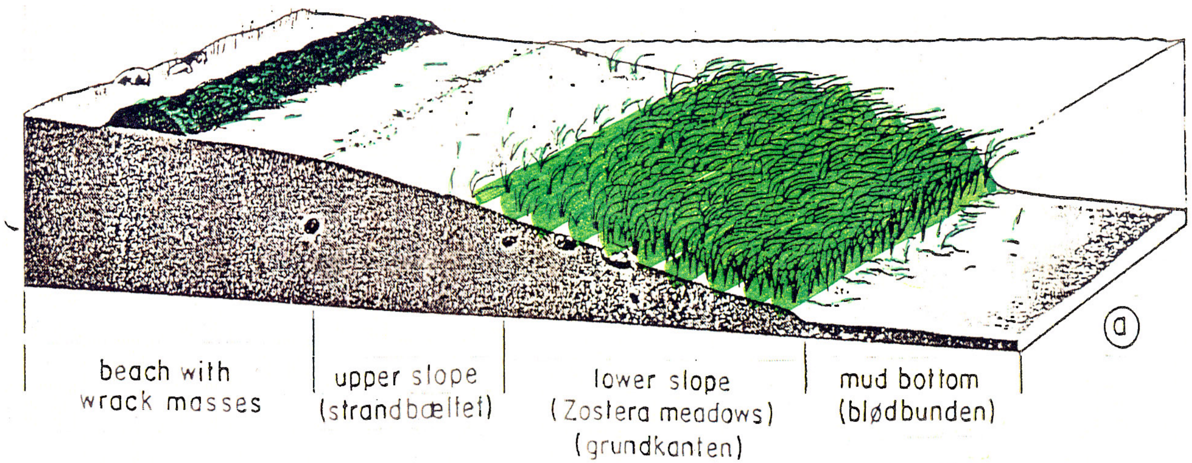


*Data is per unit area, where tCO2eq/ha is tons of carbon dioxide equivalents per hectare

Source: Murray, Brian, Linwood Pendleton, W. Aaron Jenkins, and Samantha Sifleet. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NI R 11-04

https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/322/original/AbidjanBlueCarbon_screen.pdf?1491297406

Buffering effect against waves and currents



The disappearance of seaweed beds due to a disease called Wasting disease of eelgrass

Erosion of coastline and seabed

Protection of coastline and sea bottom

Rassmussen, E. (1973)

Ecosystem service values of coastal and land habitats

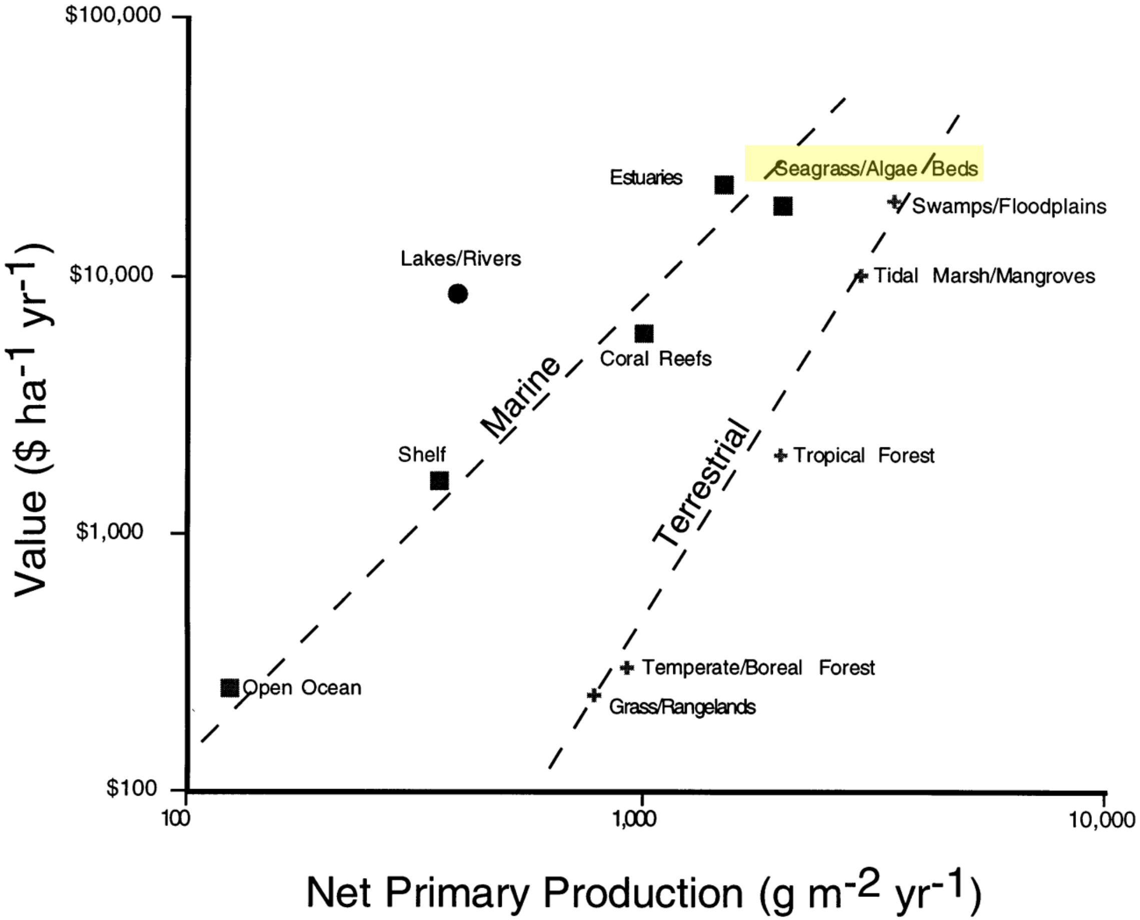


Fig. 1. Plots of NPP vs. value for terrestrial and marine systems.

Costanza et al. (1998)

Ecosystem services of seagrass/algae meadows

Blue forest type	Supporting services	Provisioning services	Regulating services	Cultural services
Seagrass meadows	Primary production Reservoirs of high biodiversity		Food basket Hide and breeding area Water purification	Cultural values Recreation & tourism

Biome	Area (e6 ha)	NPP* (g m^{-2} year^{-1})	Value ($ ha^{-1} year^{-1})
Open ocean	33 200	125	$252
Estuaries	180	1500	$22 832
Seagrass/algae beds	200	2000	$19 004
Coral reefs	62	1000	$6075
Shelf	2660	360	$1610
Lakes/rivers	200	400	$8498
Tropical forest	1900	2000	$2007
Temperate/boreal forest	2955	1000	$302
Grass/rangelands	3898	800	$232
Tidal marsh/mangroves	165	3000	$9990
Swamps/floodplains	165	3500	$19 580

* NPP from Bolin et al. (1977), pp. 25 and 132. All other data from Costanza et al. (1997a).

Costanza et al. (1998)

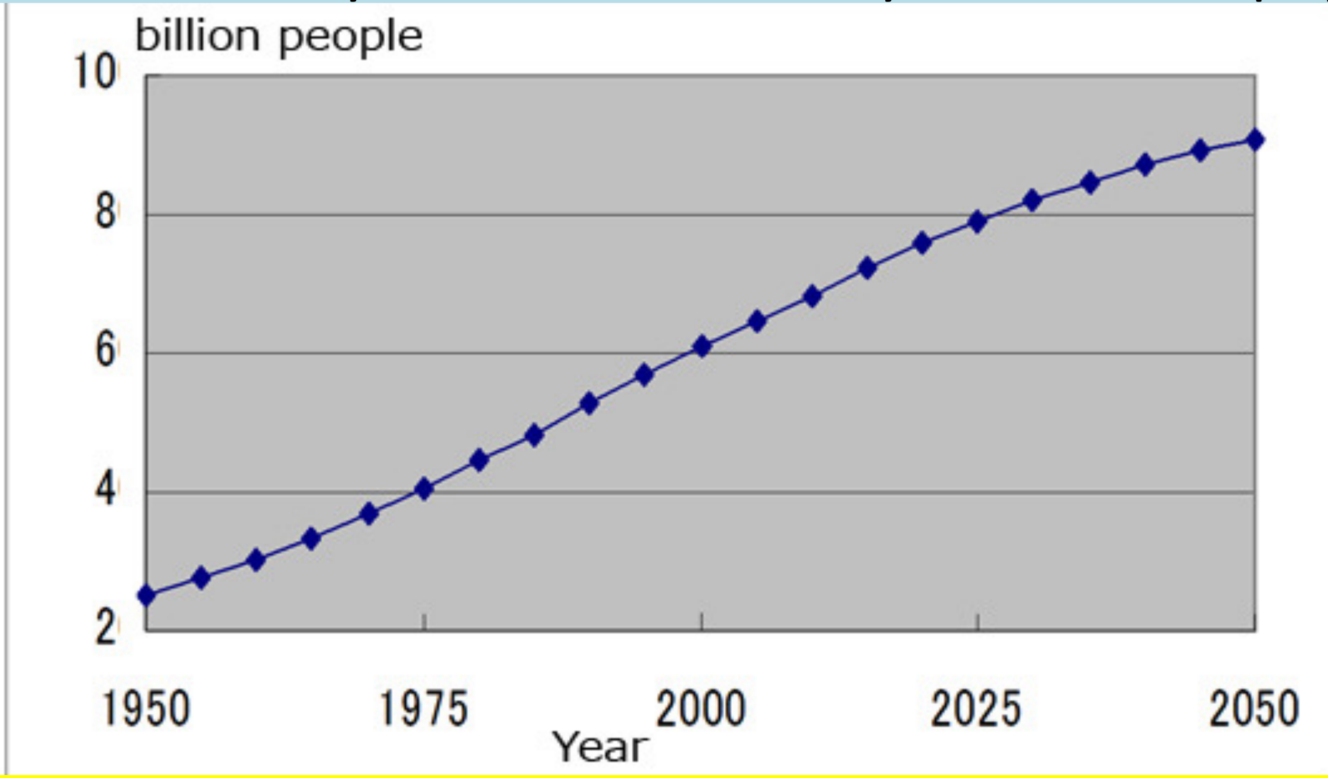
Global values of annual ecosystem services

(by US Dollar)

Biome ~ecosystem	Area (ha x 10^6)	Ecosystem Services	
		Per ha($ha^{-1} yr^{-1}$)	Total (yr^{-1} x10^9)
Estuaries	**180**	**22,832**	**4,110**
Seagrass/algae beds	**200**	**19,004**	**3,801**
Coral reefs	**62**	**6,075**	**375**
Shelf	**2,660**	**1,610**	**4,283**
Tidal marsh/mangroves	**165**	**9,990**	**1,648**
Coastal Zone	**3,267**	**4,352**	**14,217**
Tropical Forest	**1,900**	**2,007**	**3,813**
Temperate/boreal	**2,955**	**302**	**894**
Forest	**4,855**	**970**	**4,707**

Costanza et al. (1997) Nature, 387, 253-260, Summarized by Komatsu at al.

Coastal ecosystem threatened by in crease of population



Three quarters of world population will live within 100 km from the coast till 2025 and threaten coastal ecosystems

World Bank (2003) World Development Report

Coastal ecosystem threatened by in crease of human pressures

Dam construction influencing sand supply

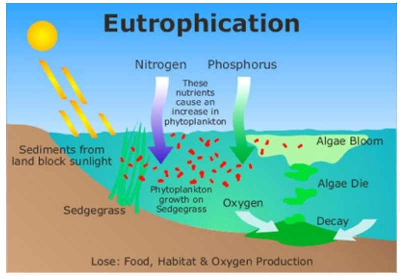
http://damnet.or.jp/cgi-bin/binranA/All.cgi?db4=0848

Deforestation influencing sand supply

https://sentientmedia.org/how-does-agriculture-cause-deforestation/

Dredging

https://www.skk-crane.co.jp/en/product/dredging/185/



Eutrophication

https://byjus.com/chemistry/eutrophication/

Industrial pollution

https://bestbalticproject.eu/about/assessing-the-current-situation-managment-of-industrial-waste-waters-in-bsr-wp2/

Reclamation

https://freshscience.org.au/2013/building

Port construction

https://www.vinci-construction-projets.com/en/realisations/port-2000-terminal/

Management of coastal habitats including seagrass meadows

- Monitoring of habitat distributions
- Protection of habitat areas
- Restoration of habitats

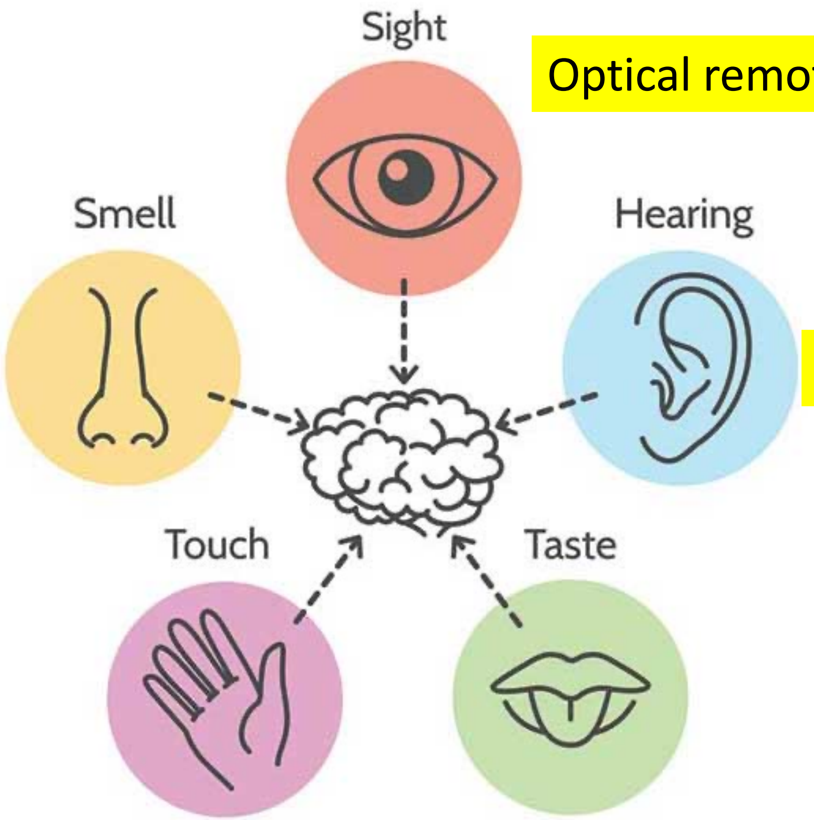
↓

Mapping coastal habitats is indispensable
for sustainable use of cosatal resources

Remote sensing

- Remote sensing is the acquiring of information from a distance.

5 senses



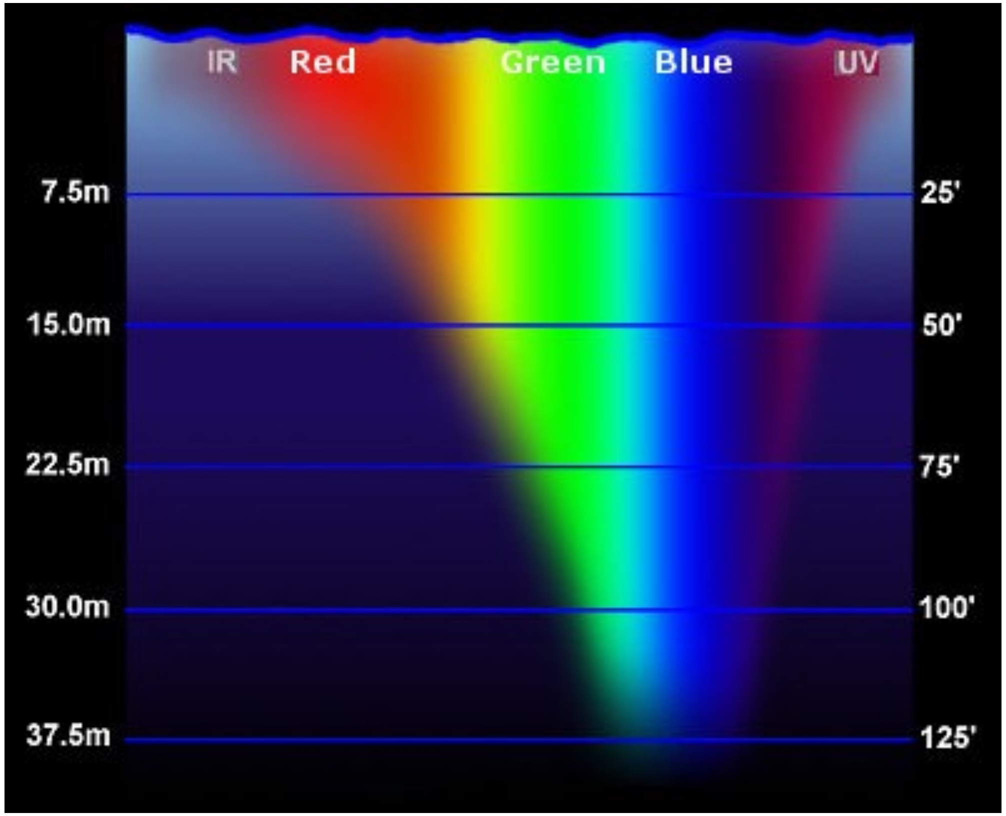
Optical remote sensing

Acoustic remote sensing

Remote sensing?

https://www.casdschools.org/site/handlers/filedownload.ashx?moduleinstanceid=9037&dataid=9516&FileName=sense%20of%20touch.pdf

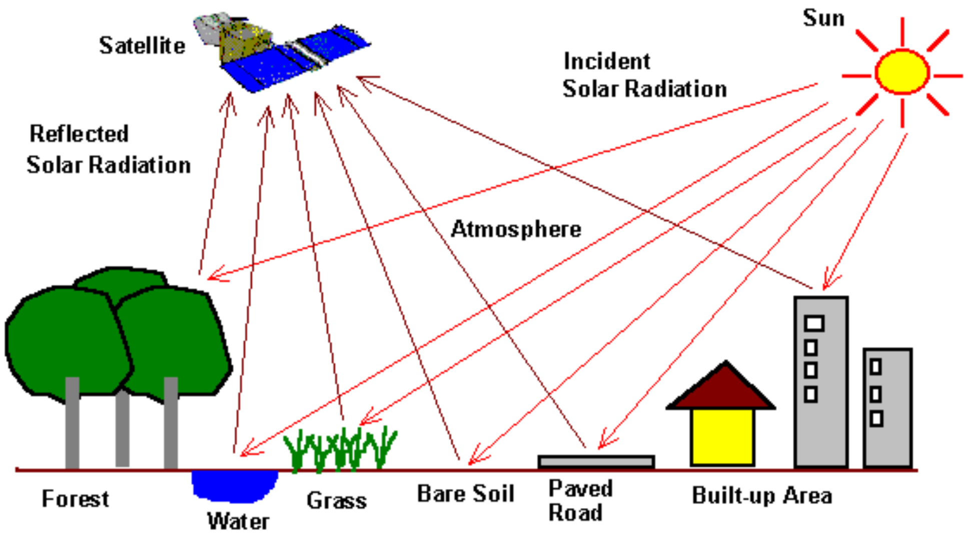
Optical remote sensing



Decrease of light under the sea

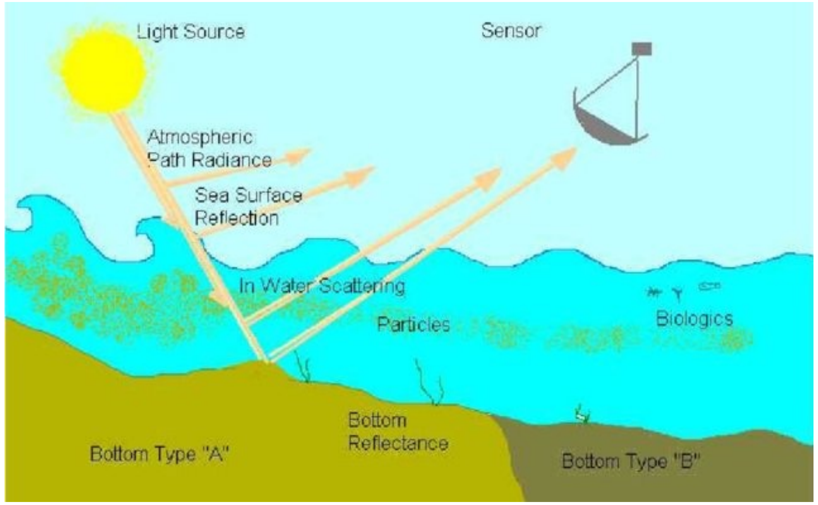
Patterns of light penetration into water.
Source: Tom Morris, Fullerton College.

Satellite remote sensing



Land

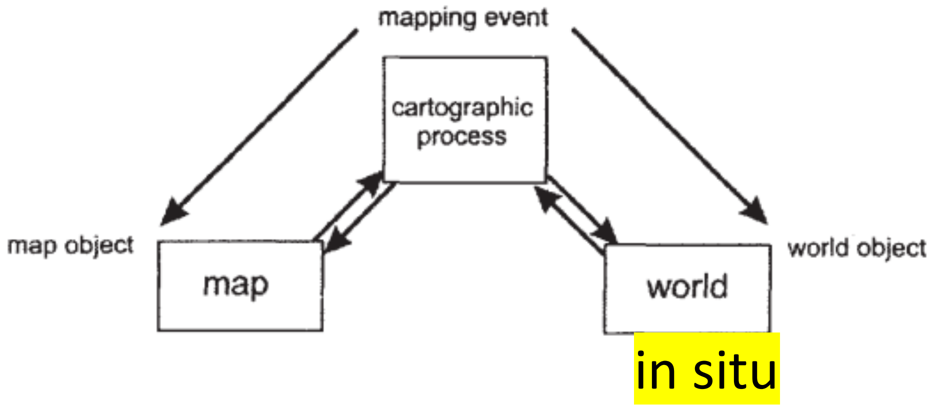
Ashraf et al. (2010) https://www.intechopen.com/chapters/19222



Sea

Murugaboopathi et al. (2014) https://www.biotech-asia.org/vol11no1/interactive-analyses-in-marine-fisheries-using-passive-optical-remote-sensing-techniques/

Ground truth



"ground truth" refers to information collected on location. Ground truth allows image data to be related to real features and materials on the ground. The collection of ground truth data enables calibration of remote-sensing data, and aids in the interpretation and analysis of what is being sensed.

Reference data for classifying seagrass bed and no seagrass distributions from a satellite image and evaluating classification results.

https://en.wikipedia.org/wiki/Ground_truth

Locating coastal habitats under the sea through direct and indirect surveys for obtaining ground truth data

Direct methods

- Walking
- Diving and its manta tow
- Observation from the ship
- Grabbing bottom sediments

+

GPS

Video camera observation

Photo by T. Komatsu

Direct methods (ground survey)

Characteristics

density estimation, species identification

assured method

Problems

low efficiency

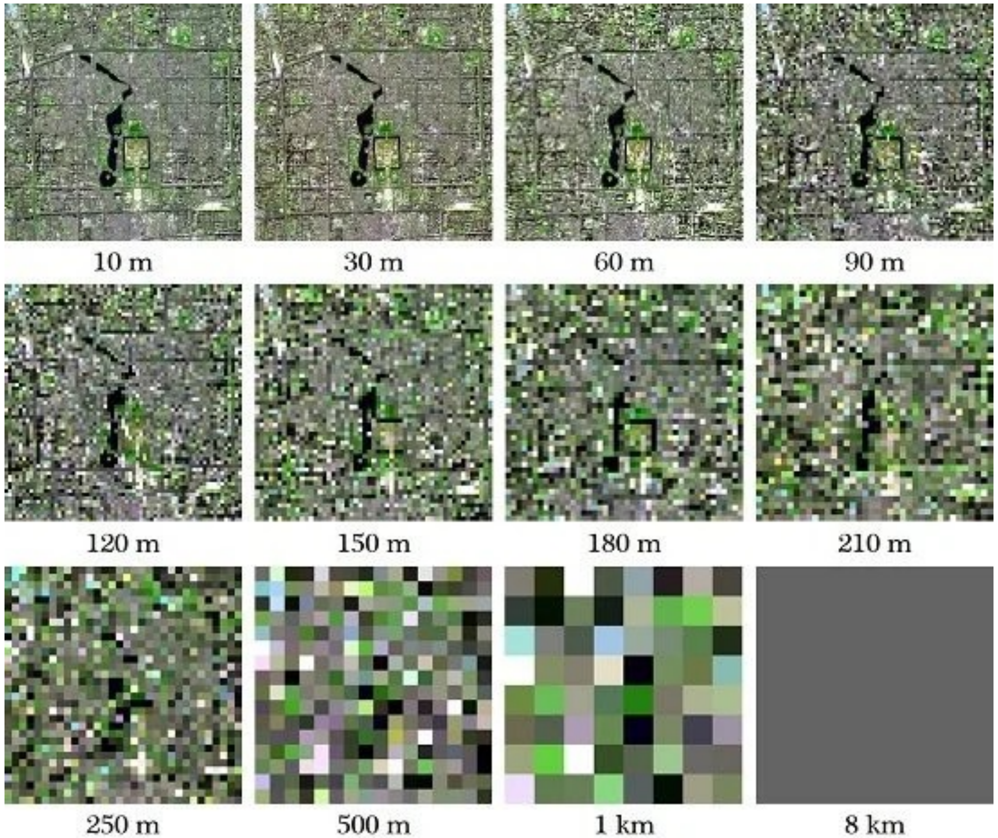
influence of turbidity of water and
high waves on field survey

Acquisition of ground truth data (field verification data) by direct methods

Diving, drop camera and sighting from boat and shore have the problem.

Often point data, which does not correspond to the size of a pixel in a satellite image

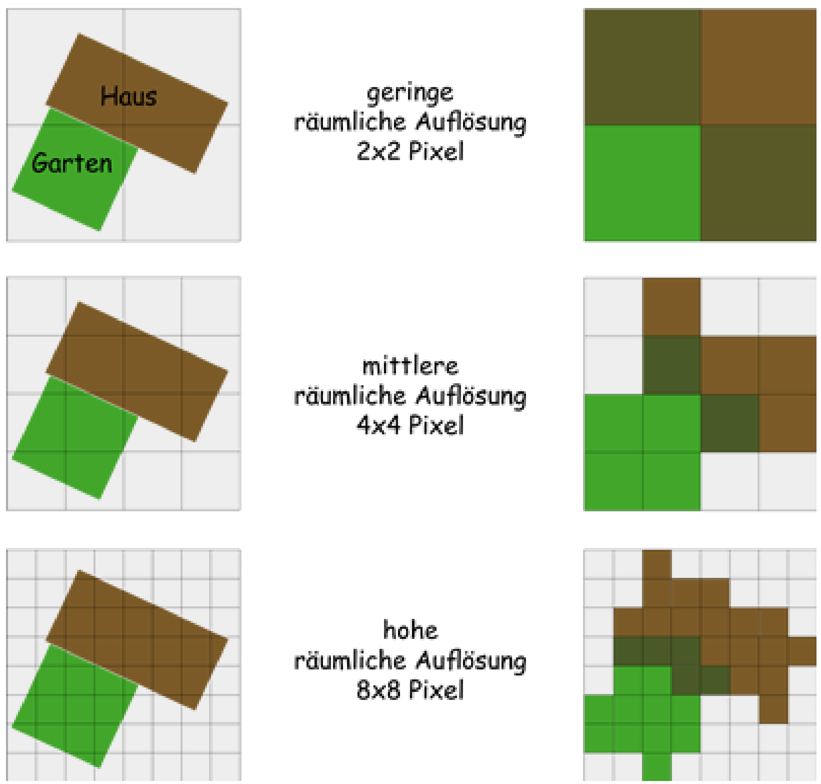
Ground images depending on a spatial resolution of satellite image



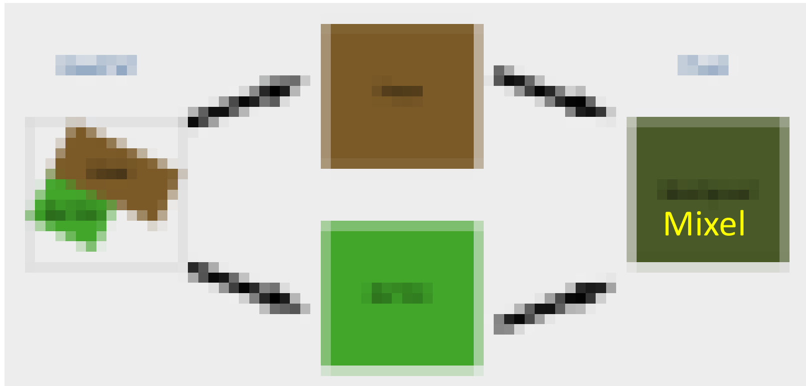
Tian et al. (2020) Remote Sensing

Satellite image and its spatial resolution

House and garden in situ Satellite image



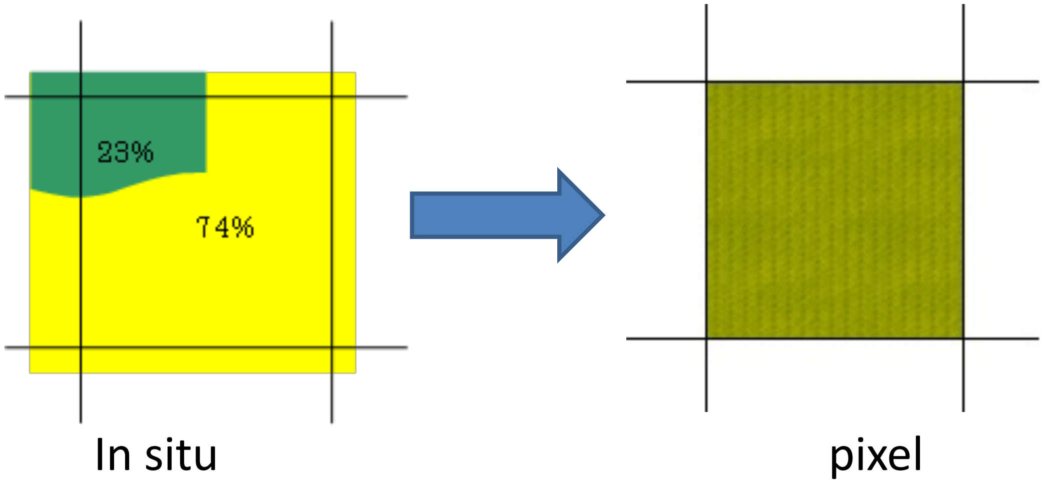
House



Garden

https://fis.uni-bonn.de/en/recherchetools/infobox/professionals/resolution/spatial-resolution

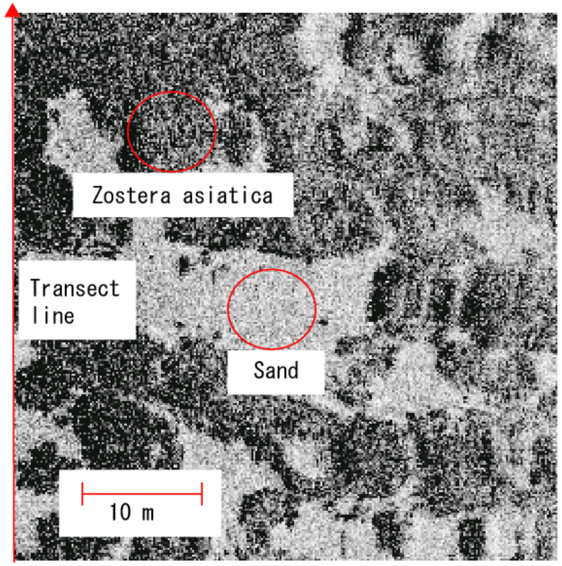
Mixel effect

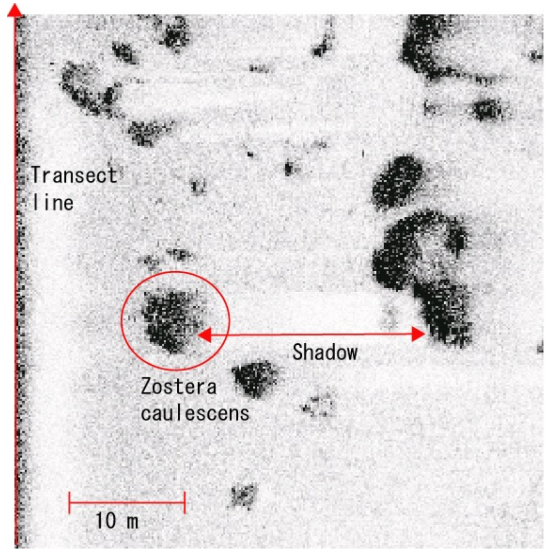


In the presence of sand and seagrass beds (left), a low spatial resolution of the pixels results in a mixed reflectance of sand and seagrass (called a mixel) (right)

Sagawa (2009)

Areal ground truth data is essential.





Examples of *Zostera asiatica* (left) and *Zostera caulescens* (right)

Point data cannot exclude areas with mixels

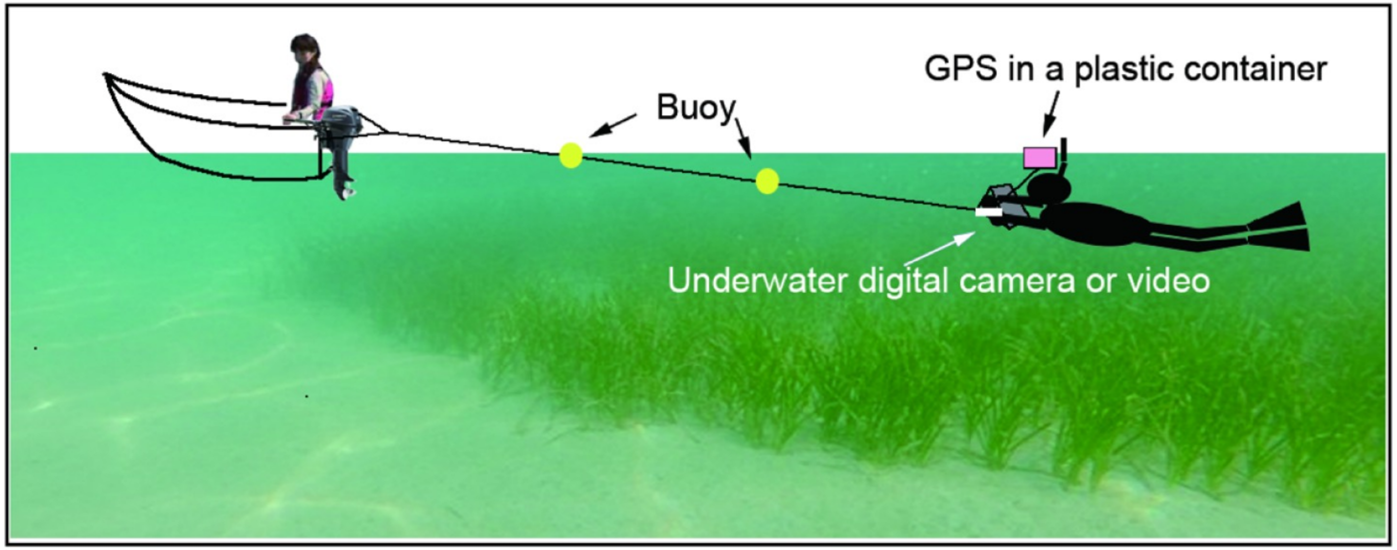
Sagawa et al. (2008) Int. J. Remote Sens.

Two low-cost methods to obtain continual ground truth data in clear water

Manta tow

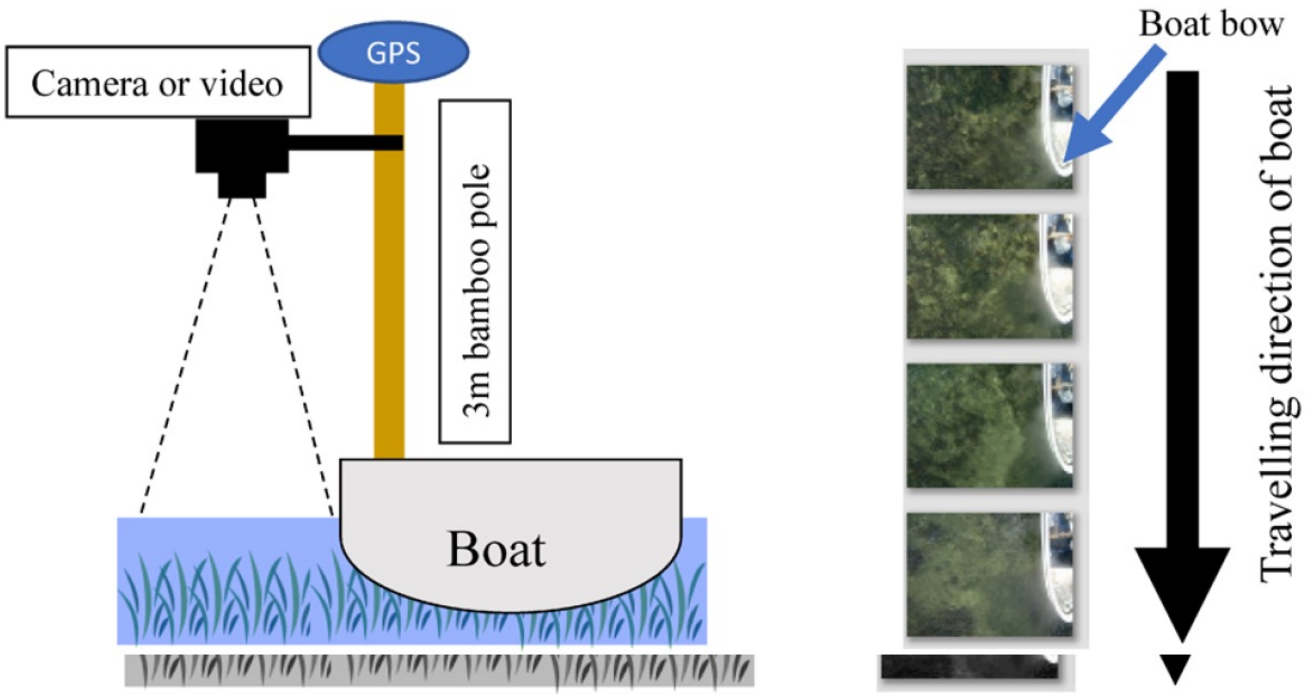
Bamboo camera system

Manta tow



Komatsu et al. (2020) Practical mapping methods of seagrass beds by satellite remote sensing and ground truthing Coastal Marine Science 43(1): 1–25.

Bamboo camera system developed by Prof. Ken-ichi Hayashizaki



Schematic diagram of a system using a digital camera or video protruding from the boat abeam, supported by a bar mounted on a bamboo pole at a height of 3 m from the boat deck (left panel) and four continual pictures obtained by the system (right panel).

Komatsu et al. (2020) Practical mapping methods of seagrass beds by satellite remote sensing and ground truthing Coastal Marine Science 43(1): 1–25.

Locating coastal habitats under the sea through indirect survey for obtaining ground truth data

Optical remote sensing

Drone

Acoustic remote sensing

Echosounder

Sidescan sonar

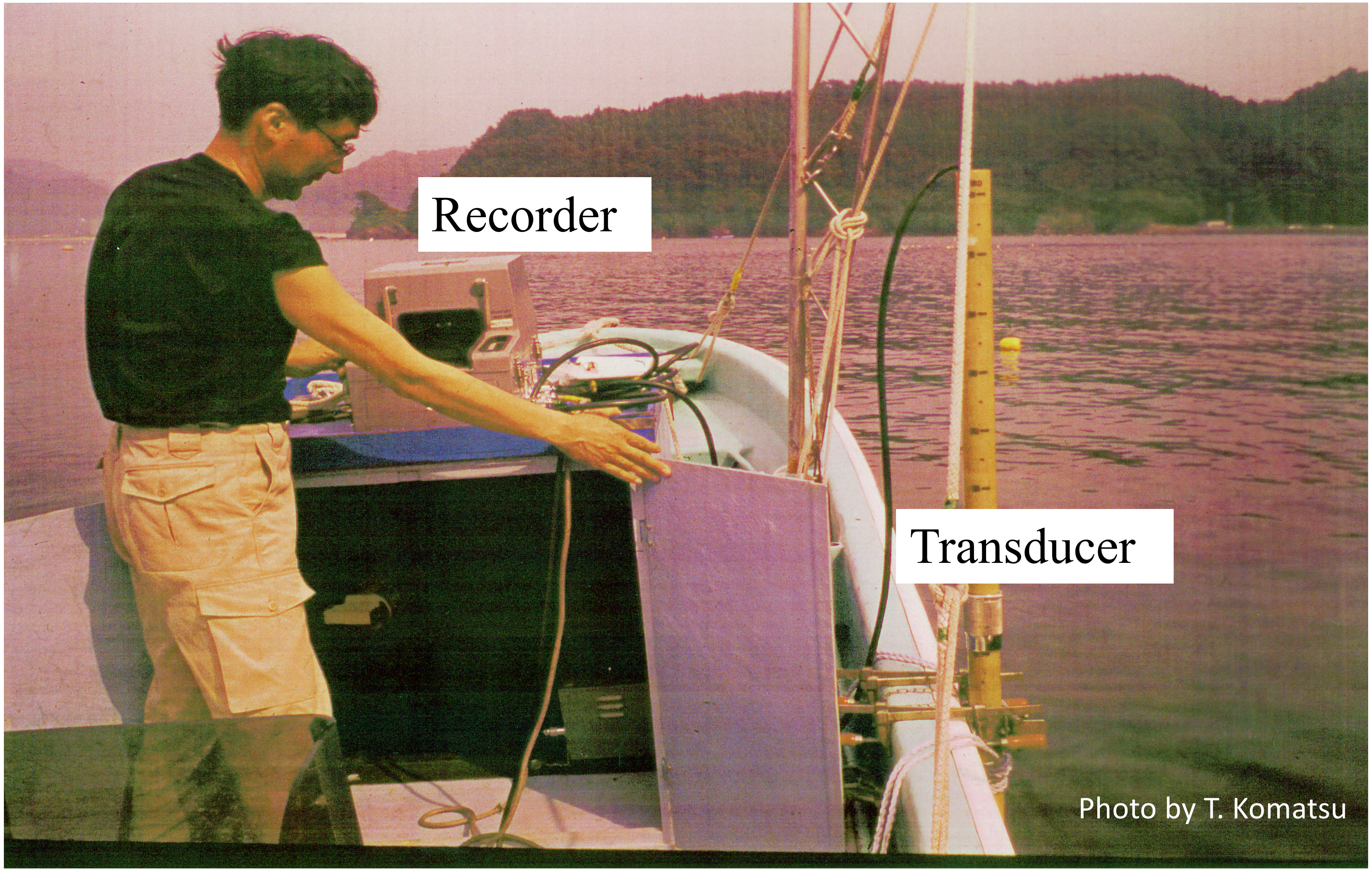
Drone

https://www.atlanticdroneservicespr.com/environmental

https://www.heliguy.com/blogs/posts
/tackling-coastal-erosion-with-drones

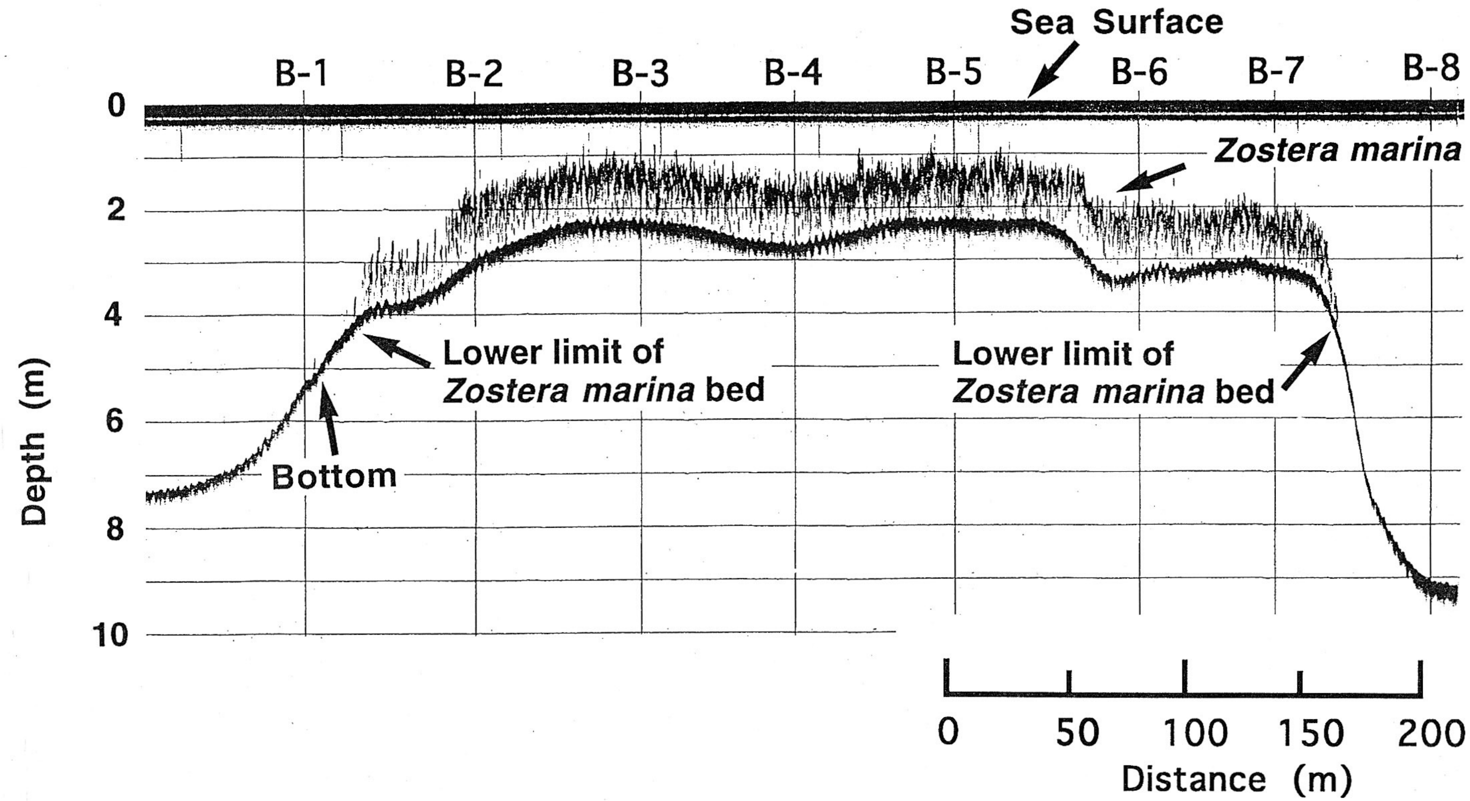
Echosounder

Echosounder



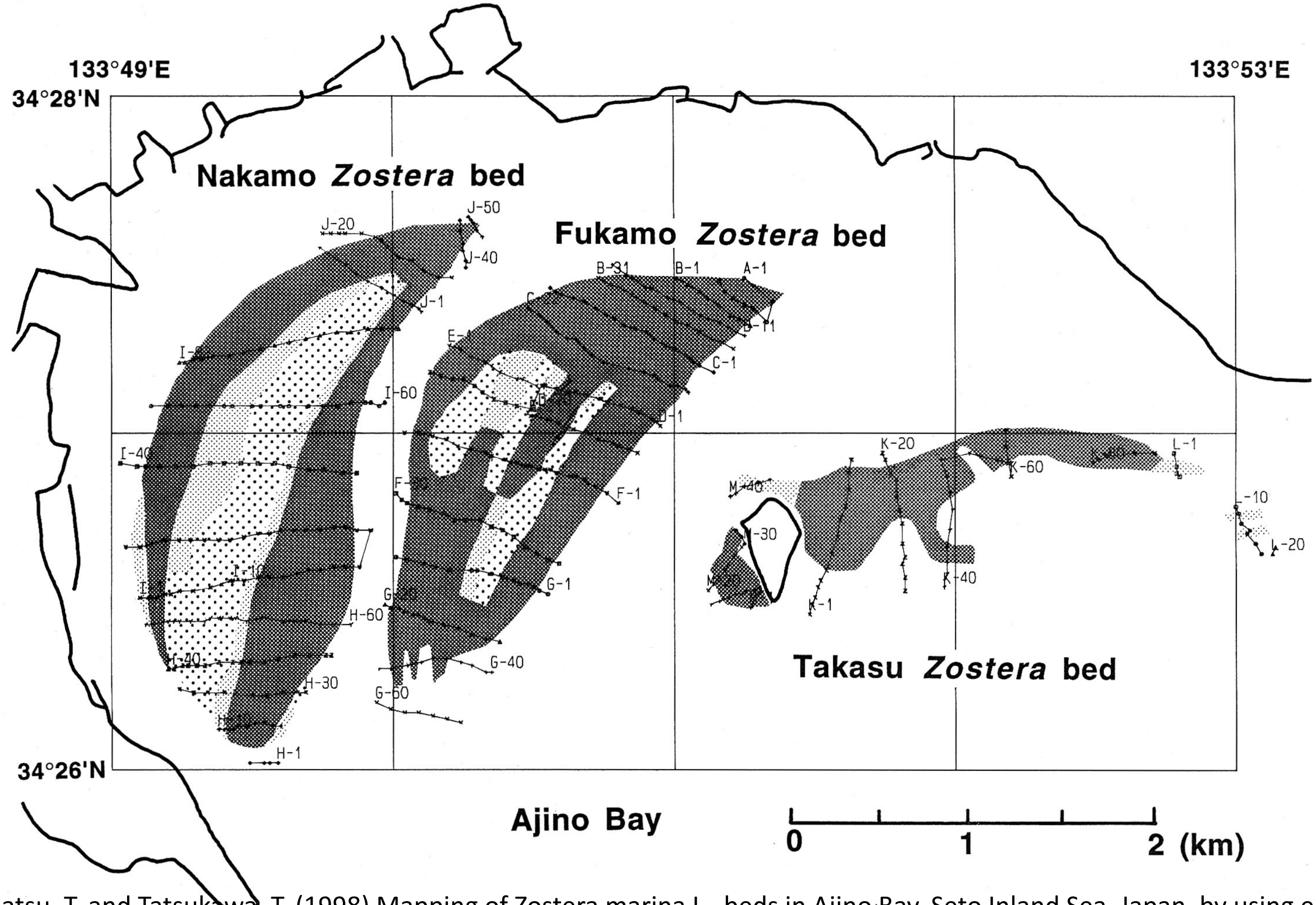

Zostera marina

Echogramme obtained in Ajino Bay in Seto Inland Sea



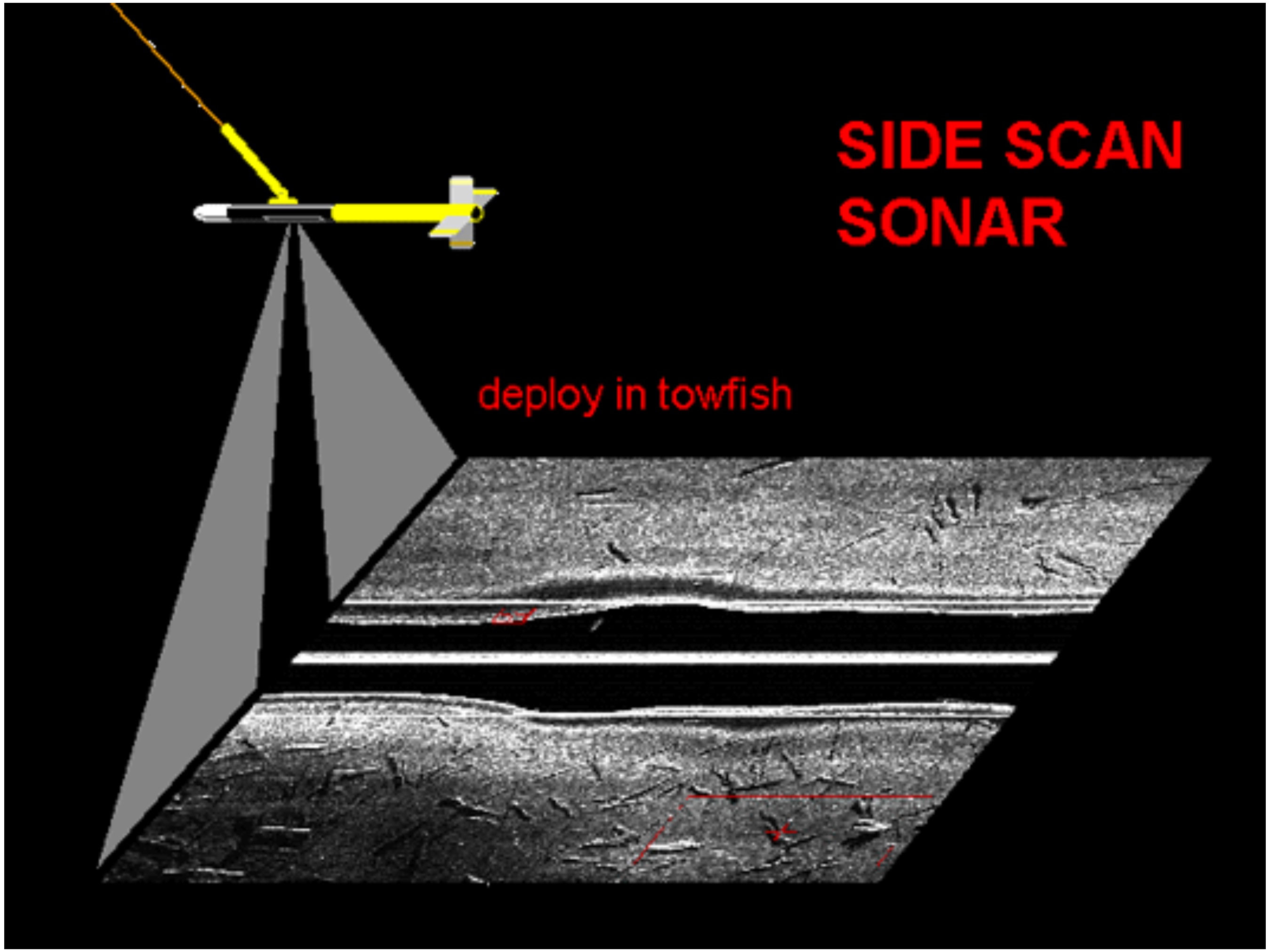
Komatsu, T. and Tatsukawa, T. (1998) Mapping of Zostera marina L. beds in Ajino Bay, Seto Inland Sea, Japan, by using echo-sounder and global positioning systems. J. Recherche Océanogr. 23: 39–46.

Distribution map of *Zostera marina* in Ajino Bay

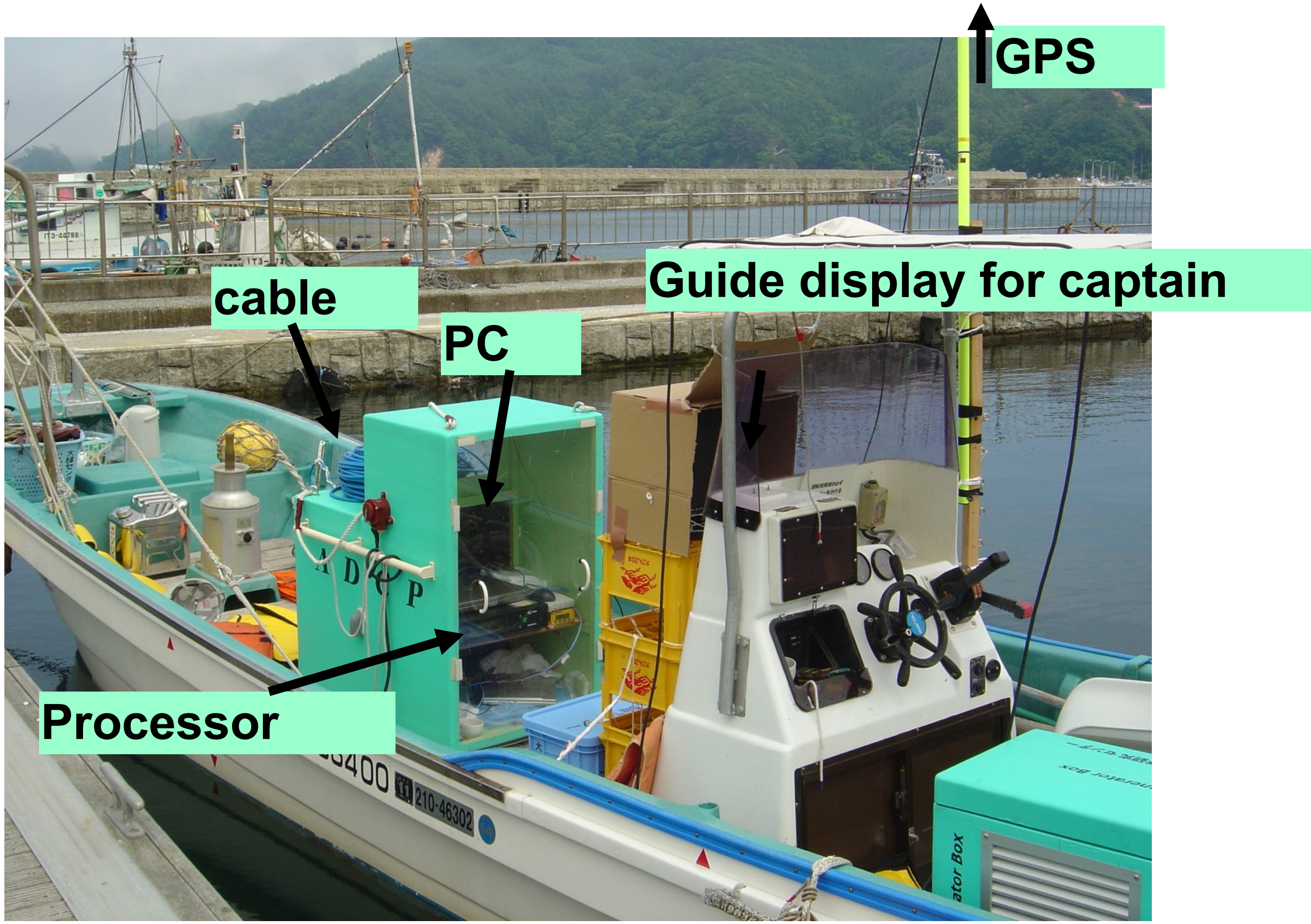


Komatsu, T. and Tatsukawa, T. (1998) Mapping of Zostera marina L. beds in Ajino Bay, Seto Inland Sea, Japan, by using echo-sounder and global positioning systems. J. Recherche Océanogr. 23: 39–46.

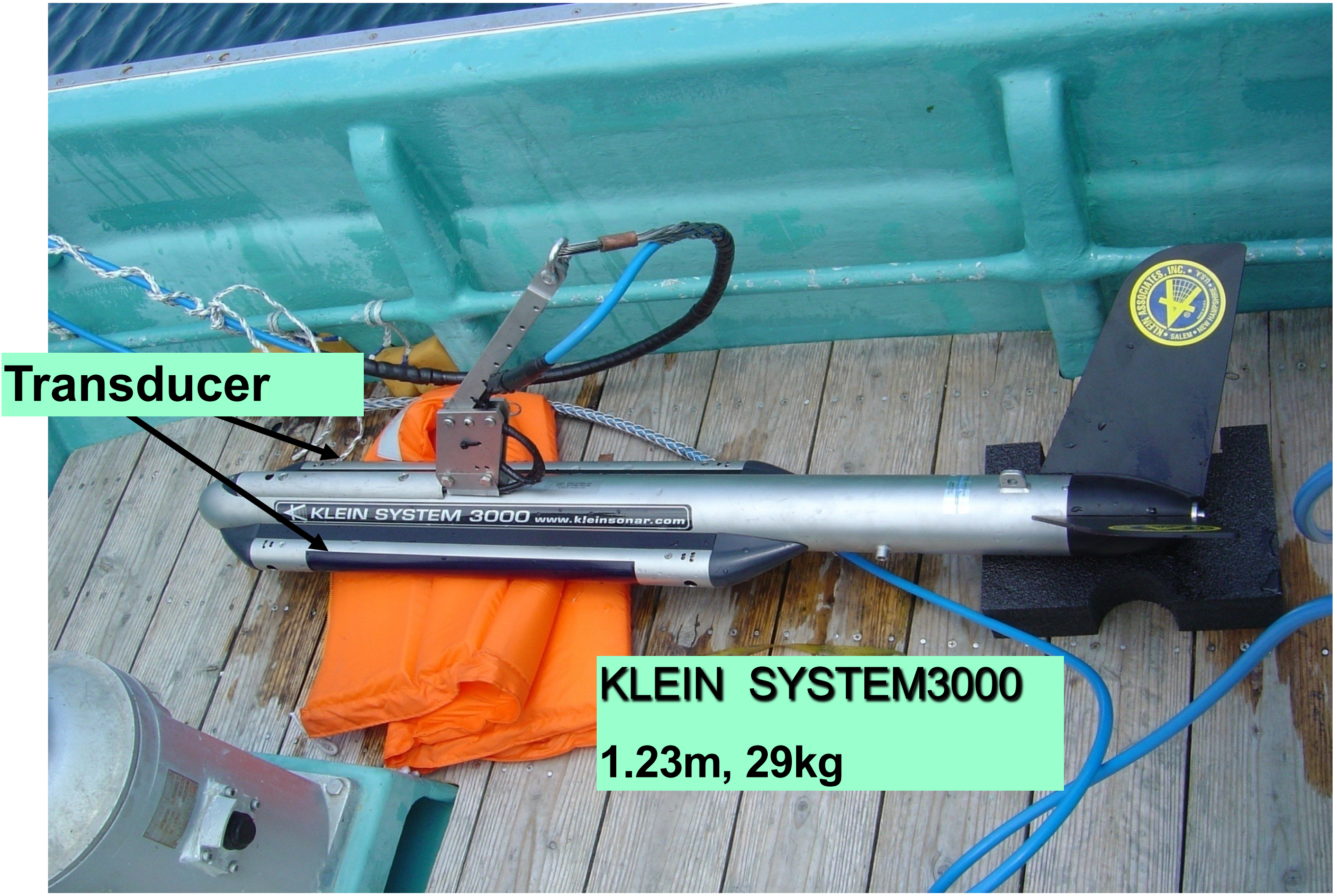
Sidescan sonar



Surveying equipment



Towfish


Transducer
KLEIN SYSTEM 3000 www.kleinsonar.com
KLEIN SYSTEM3000
1.23m, 29kg

Surveying

Example of sidescan sonar survey on seagrass beds

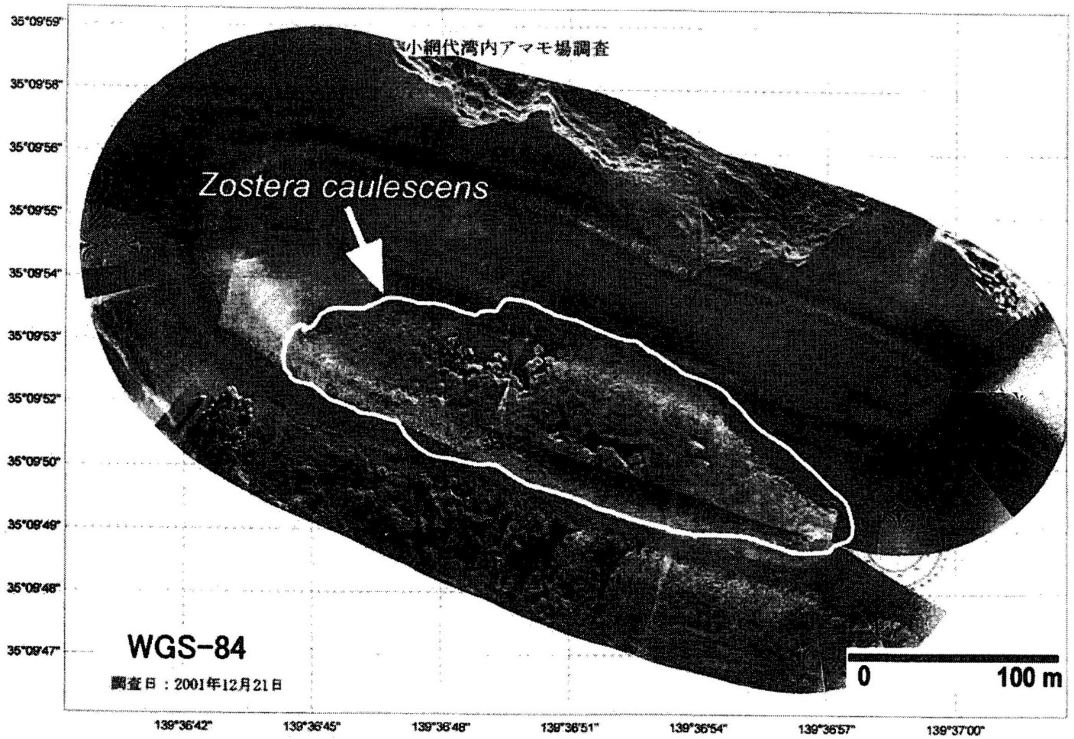


Fig. 2. Map showing horizontal distribution of *Zostera caulsecens* surveyed with side-scan sonar by T. Komatsu.

Komatsu et al. (2003) Hdro-acoustic methods as a practical tool for cartography of seagrass beds. Otsuchi Marine Science, 28, 72-79

Indirect acoustic methods (ground survey)

Characteristics

- **Efficient surveys**
- **No influence of turbidity**

Problems

- **Difficult identification of seagrass species**
- **Necessity of a boat**
- **High cost of equipments**

Summary

- Seagrass meadows are one of the coastal ecosystems that are essential for the sustainable development of human society and the maintenance of the global environment.
- It is essential to map the distribution of seagrasses over a wide area and visualise it as a map in order to conserve seagrass meadows.
- Satellite remote sensing is useful for mapping seagrass meadows.
- In order to extract seagrass meadows from satellite images, it is indispensable to obtain ground truth data.
- It is necessary to obtain ground truth data at a spatial scale corresponding to the spatial resolution of the satellite image.
- There are two methods of obtaining ground truth data: direct and indirect methods.
- It is important to select a ground truth data acquisition method that is available in the field and appropriate to the site.

Thank you for your attention