Nature and Earthquake

Five years after the Great East Japan Earthquake


Dianthus japonicus


Pantala flavescens

Ilyoplax pusilla


Calystegia soldanella


Chrysanthemum pacificum


Monochoria korsakowii


Cercion sexlineatum


Cicindela laetescripta


Emberiza fucata


Epacromius japonicus

2011.3.11—2016

環境省
Ministry of the Environment

生物多様性センター
Biodiversity Center of Japan

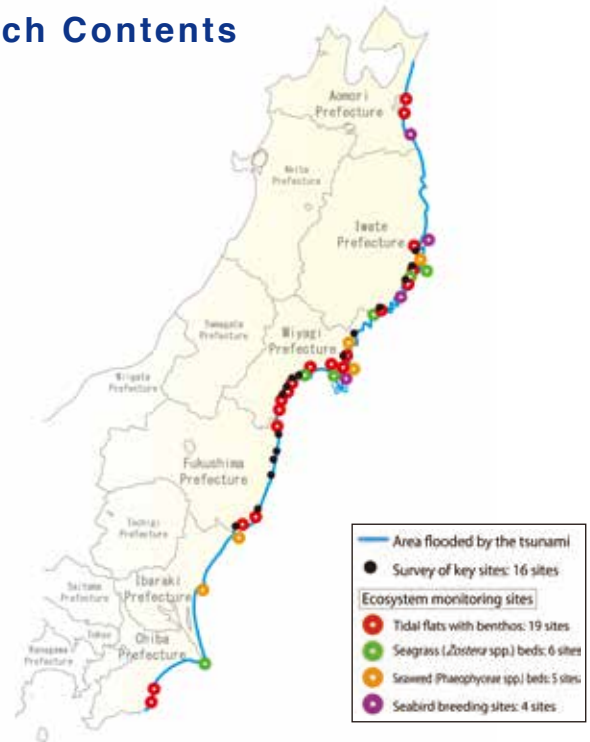
Five years since the Great East Japan Earthquake

On March 11, 2011, at 2:46 p.m., a magnitude-9.0 earthquake occurred off the shore of Sanriku, Japan. A wide area along the Pacific Coast, from Aomori to Chiba Prefecture, was hit by the resulting tsunami, which created a level of devastation said to occur only once every thousand years. The earthquake also led to liquefaction and land subsidence in many areas.
The tsunami destroyed seawalls and coastal forests and engulfed cities and towns, burying regions in debris and seawater. The tsunami disaster completely changed the rich coastal environments and ecosystems of the Tohoku coastal region.
In response to this catastrophic disaster, the Ministry of the Environment has been monitoring the changes that have affected the natural environment in the flooded areas during the 5 years since its occurrence.

Kesennuma Bay, Miyagi Pref. (Jun., 2015)

Itagawaura, Fukushima Pref. (Aug., 2012)

Research Contents



Vegetation changes
Using data from field surveys and image analyses, vegetation maps of the flooded areas before and after the disaster were produced to track changes in vegetation.

Survey of key sites
Sixteen sites that are thought to be important were chosen to conduct more detailed surveys. Belt-transect and fauna/flora surveys were performed in each site.

Coastal surveys
Sandy and muddy beaches along the Pacific coastline of the flooded areas were surveyed, especially shorelines and the land cover behind the shorelines.

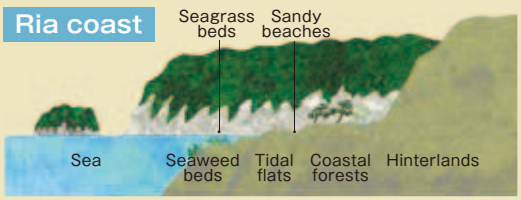
Seagrass and seaweed bed distribution survey
Distribution maps of seagrass and seaweed beds in the flooded areas were produced based on the field survey data, satellite images, and aerial photographs.

Ecosystem monitoring
Ecosystems thought to be particularly affected by the tsunami and earthquake (tidal flats [19 sites], seagrass beds [6 sites], seaweed beds [5 sites], and seabird breeding sites [4 sites]) were monitored before and after the earthquake.

Characteristics of the coastal area

Ria coast

The Sanriku coast is a representative ria coast of Japan. The various bays, large precipices, and shore reefs facing the Pacific Ocean are nationally famous landscapes. Moreover, the Sanriku coast harbors rich marine resources. The confluence of two offshore currents, the Oyashio and Kuroshio currents, supports a variety of fish and shellfish species. Aquaculture is a common practice in the clam bays.



Accipiter gentilis (National RL:NT, Miyagi RL:NT) and *Anas crecca* (Tsuyagawa River, Miyagi Pref., 2015)

Four important messages

The survey results from the 5 years following the disaster reveal strong environmental recovery from the damage and demonstrate the natural environment's resilience in response to such extreme phenomena. Nature's recovery and resilience have even helped to rehabilitate human livelihoods. There are four important lessons to be learned from this disaster; these inform us how to prepare for the future.

1 Changes in the natural environment caused by the disaster and subsequent recovery

The disaster led to huge and immediate changes in the natural environment; however, it has clearly been recovering over time. In particular, the sandy beaches and oceanic environments, such as seagrass and seaweed beds, have demonstrated incredible resilience.

2 Impacts of reconstruction projects and consideration for the environment

Several environments were lost as a result of reconstruction projects following the disaster, whereas others were intentionally protected from those processes. Analysis and evaluation of these cases can help us to prepare for future disasters and develop reconstruction strategies.

3 The bounty of nature and human livelihoods

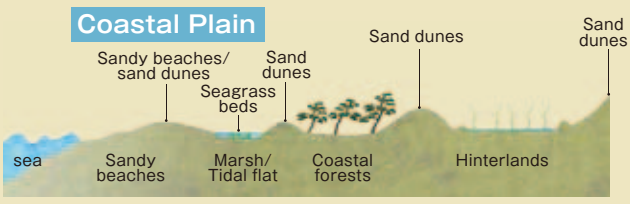
Since the beginning of the recovery process, local industries, such as fisheries and tourism, have benefited from the diversity of ecosystems (ecosystem services). Livelihoods surrounded by and reliant on healthy natural environments benefit from ecosystem services more than those surrounded only by manmade landscapes.

4 Involvement and coexistence with local natural environments

Familiarity with local geographical features and wildlife will help us to understand which areas are hazardous and the areas that need to be protected from anthropogenic activities. It is important to consider how we view nature, and we should bear in mind that, although nature can cause disasters, it can also benefit human lives.

Coastal plains

A 70-km length of sandy beaches runs north–south along the Sendai Plain coast. On the beaches, sand banks and dunes have developed where sand dune plants flower. Behind those dunes are pine-dominated coastal forests, which were planted generations ago, and coastal plains consisting of sand dunes and lowlands. These lowlands have a long history of use as paddy fields because of their wet environments. Additionally, there are natural levees and flood plains, which provide critical habitats for diverse wildlife.



Examples of plants and animals found during the 5-year survey are shown in this brochure along with their observed ranges, dates, and Red List categories. The abbreviations of the Red List categories are shown below.

◆ Red List (RL)

National RL: RL of the Ministry of the Environment
Iwate RL : RL of Iwate Prefecture
Miyagi RL: RL of Miyagi Prefecture
Fukushima RL: RL of Fukushima Prefecture

◆ RL Categories

CR : A taxon is Critically Endangered; in National RL
EN : A taxon is Endangered; in National RL
CR+EN : Species facing a risk of extinction; in Iwate RL, Miyagi RL, and Fukushima RL
VU : A taxon is Vulnerable; in National RL, Miyagi RL, Fukushima RL, and Iwate RL
NT : A taxon is Near-threatened; in National RL, Miyagi RL, Fukushima RL, and Iwate RL
Categories other than the above are shown in specific categories in this brochure (i.e., "Data Deficient" in National RL, "D rank" in Iwate RL, "Caution" in Fukushima RL).

Seagrass beds, seaweed beds, and remote islands

Sea

Marine ecosystems support the main coastal industry (fisheries) by providing diverse benefits in these regions. Seaweed (Phaeophyceae) and seagrass (*Zostera* spp.) beds, often referred to as “marine nurseries,” are found in the shallow waters close to the coastline, where they function as breeding sites and habitats for fish and many other organisms. The kelp and gulfweed beds on the shore reefs of the ria coasts and the seagrass beds on the sandy and muddy areas of inner bays and lagoons foster highly productive ocean environments. How were these critical shallow-sea ecosystems affected by the earthquake and tsunami?

Yamada Bay, Iwate Pref. (Aug., 2015)

Eisenia bicyclis
(Shizugawa Bay, Miyagi Pref., Jul., 2015)

Important message 1 Changes immediately after the earthquake

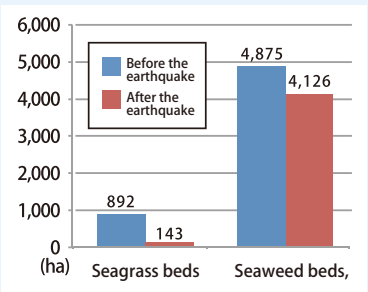
Impacts on seagrass beds

A considerable number of seagrass beds growing on sandy areas were, along with the sand, washed away by the tsunami. Even those that survived the tsunami damage due to their locations in bays were damaged because the earthquake caused land subsidence, which altered the light conditions.

Impacts on seaweed beds

Seaweed beds were less impacted by the tsunami than were the seagrass beds because the shore reefs on which they grow experienced limited damage. However, the organisms inhabiting the seaweed beds, such as sea urchins and abalones, were temporarily lost from these habitats. It is believed that the tsunami washed them away.

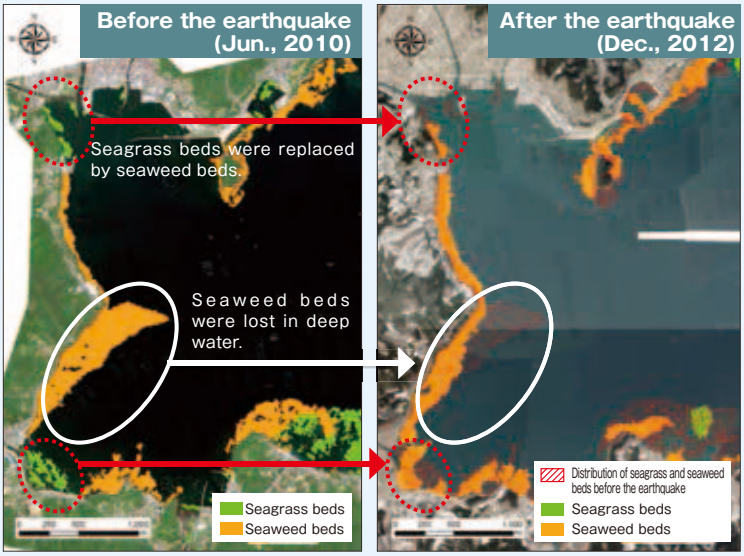
Changes in the distribution of seagrass and seaweed beds before and after the earthquake



Example of the distribution of seagrass and seaweed beds before and after the earthquake

In inner bays, changes in the distribution of seagrass and seaweed beds depended on the local topography. For example, seagrass beds were largely replaced by seaweed beds, but many seaweed beds were lost in Shizugawa Bay.

Distribution map of seagrass and seaweed beds in Shizugawa Bay, Miyagi Pref. before and after the earthquake



GeoEye-1(c)2015 Digital Globe inc. Geospatial Information Authority of Japan

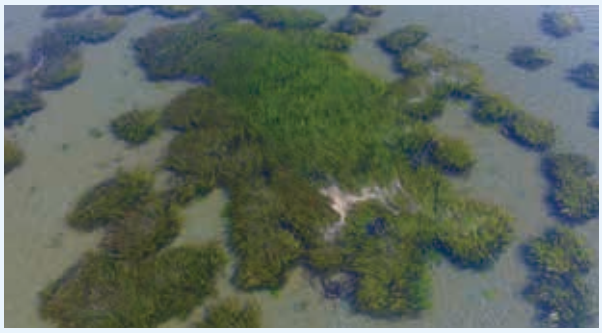
Changes in the distribution of seagrass and seaweed beds from Iwate Pref. to northern Fukushima Pref. before and after the earthquake

To create distribution maps of seagrass and seaweed beds, satellite images and aerial photographs from 2003 to 2011 were used to demonstrate conditions before the earthquake, whereas images from 2012 to 2013 were used to show conditions after the earthquake. Additionally, satellite images from 2015 were used for parts of some bays and sandy beach areas. Overall, the areal extent of seaweed and, in particular, seagrass beds decreased.

Important message 1 Five years changes and recovery after the earthquake

Changes in seagrass beds

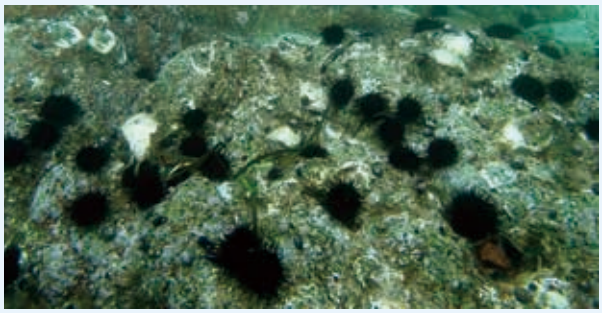
The damaged seagrass beds have been recovering over time. However, in areas where light conditions were altered by ground subsidence and murkiness, changes in species compositions have been observed (e.g., *Zostera marina* has been replaced by *Z. caulescens*). On the other hand, intensive growth of *Z. marina* has been observed at locations where light conditions improved after the earthquake.



Seagrass beds 4 years after the earthquake
(Nagatsuraura, Miyagi Pref. Jul., 2015)

Changes in seaweed beds

One year after the earthquake, considerable growth of seaweeds was observed over extensive coastal areas that suffered little tsunami damage. However, sea desertification, possibly caused by an overabundance of sea urchins, which leads to the disappearance of seaweed beds, was observed at several deeper locations.



Seabed following sea desertification, with many sea urchins
(Yamada Bay, Iwate Pref., Dec., 2015)

Impacts on seabirds on remote islands

The remote islands of the Sanriku ria coasts are important breeding habitats for seabirds, such as *Larus crassirostris, Calonectris leucomelas*, and other petrels. These islands were also hit by the tsunami, but the survey results do not suggest direct impacts of the tsunami on the birds' lives.

Breeding sites for *Larus crassirostris*
(Ashijima Island, Miyagi Pref., Jun., 2012)

Zostera marina
(Yamada Bay, Iwate Pref., Dec., 2015)

Calonectris leucomelas
Iwate RL: D Rank
(Hideshima Island, Iwate Pref., Jun., 2012)

Important message 2 Impacts of reconstruction projects

Extensive recovery and construction projects are taking place in affected communities, towns, and cities. The effusion of sediments from artificially cleared land is leading to turbidity in shallow waters, which changes the light conditions for seagrass and seaweed beds.
Moreover, there is concern over the impacts of seawall construction on seaweed beds at coastal areas because seaweed beds tend to be distributed along steep coasts, such as ria coasts.

Reconstruction projects (Shizugawa Bay, Miyagi Pref., Jul., 2015)

Coastal forests, sandy beaches, and tidal flats

Coast

Coastal forests on the sand dunes of the Sendai Plain have been grown and conserved for several generations; these forests, in turn, have protected local communities from harsh environmental conditions for hundreds of years. Along the coast from Sanriku to Fukushima Prefecture, there are numerous small but important tidal flats. These tidal flats are distributed around the estuaries and inner bays of the ria coastline and provide crucial habitats for benthos and other important organisms taken benthos as their food.

Matsushima Bay, Miyagi Pref. (Nov., 2013)

Numenius madagascariensis
National RL:VU, Miyagi RL:NT
(Gamo tidal flat, Miyagi Pref., Sep., 2013)

Nitidotellina nitidula
National RL:NT
(Samegawa River, Fukushima Pref., Oct., 2015)

Chaetodera laetescripta
National RL:EN, Miyagi RL: CR+EN
(Idoura, Miyagi Pref., Aug., 2015)

Important message 1 Changes immediately after the earthquake

Impacts on coastal forests

In the coastal forests on the Sendai Plain, many trees' trunks were broken, trees were uprooted by liquefaction, and many were swept away entirely due to the force of the tsunami. At the remaining coastal forest sites, various new environments, including sand-deposited areas and marshes created by land subsidence and erosion, are distributed in a patchwork mosaic.

The coastal forest immediately after the disaster (Arahama, Watari, Miyagi Pref., Apr., 2011)

Impacts on sandy beaches

Debris on beaches
(Onagawa, Miyagi Pref., May, 2011)

Almost all of the insects and other ground-surface organisms disappeared from many sandy beaches after the tsunami inundation. Those beaches were usually located either on estuaries or in areas where seawalls were destroyed. Thus, the erosion of the beaches was severe, and those that remained were covered with debris. The widths of certain beaches were reduced due to flood-driven land subsidence.

Impacts on tidal flats

Like the sandy beaches in the affected areas, the tidal flats were also impacted by erosion and land subsidence. The impacts of land subsidence were particularly significant and resulted in the loss of many tidal flats. By contrast, new tidal flats were also created as a result of land subsidence. A number of habitats for tidal-flat organisms were largely altered due to the changes in the bed soil composition.

Important message 1 Five years changes and recovery following the earthquake

Changes in coastal forests

After the earthquake, some coastal forests were converted to temporary storage areas for reconstruction projects. In some areas, canopy gaps created by the impacts of the tsunami improved the light conditions of the forest floor, triggering the germination and growth of seedlings. The tsunami also created small pools at the bottom of large trees, which became habitats for a variety of animals. The remaining forests became critical habitats for raptors and other birds.

Pool created near an uprooted tree (Hiroura, Miyagi Pref., Oct., 2012)

Changes in sandy beaches

With some exceptions, the sandy beaches impacted by the tsunami have been recovering their original shapes. Slow recovery of some beaches has been observed, such as those located in estuaries that suffered significant erosion and pocket beaches, which receive lower sediment inputs.

Changes in sandy beaches at the Gamo tidal flat

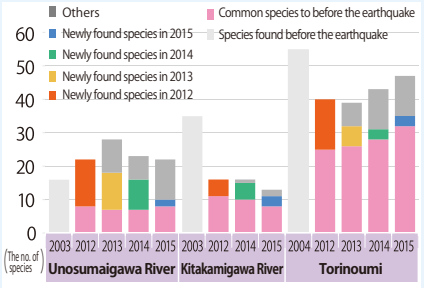
The sandy beaches and tidal flats of the Gamo tidal flat were lost due to the tsunami. However, sand and mud are returning, and the tidal flat and salt marsh are recovering gradually.

Changes in tidal flats

The impacts of the tsunami on tidal flats varied among locations. For example, the landscape of the Gamo tidal flats was largely altered immediately after the disaster; however, the sediments returned within a few months. By contrast, some of the tidal flats along the Sanriku coast, such as the Nagatsuraura, have recovered little over the past 5 years.

Benthic faunal changes also varied among locations (e.g., topography and water conditions). For example, in Torinoumi, which is large and is recovering its original tidal flat terrain, the species common before the earthquake are gradually increasing.

Change in the numbers of benthic species on tidal flats (qualitative data)



Glehnia littoralis Iwate RL: VU (Unosumaigawa, Iwate Pref., Sep., 2015)

Important message 2 Impacts of reconstruction projects

Impacts on coastal forests

While replanting the coastal forests in the Sendai Plain, banks were formed on the former coastal forests sites, on which new trees were planted. After the earthquake, various plant species were appeared to the former coastal forest sites from the seed bank, but large parts of the seed bank were lost in the process of bank construction.

Plantation with banking (Miyagi Pref., May, 2014)

Impacts on sandy beaches

Seawalls built on sandy beaches are taller and wider to cope with the force of tsunamis. In some cases, seawalls almost entirely cover the beach and eventually result in the loss of the remaining parts of the beach.

Impacts on tidal flats

Tidal flats in ria coast regions, which are primarily mountainous, consist of small flatlands. As such, some tidal flats have been reclaimed for seawalls and roads.

Important message 2 Considerations for natural environments

Remaining sites of former coastal forests

Efforts have been made in some areas, such as Matsukawaura in Fukushima Prefecture and the coastal areas of Sendai Bay in Miyagi Prefecture, to conserve the wetland environments that were formed as a consequence of the tsunami and land subsidence.

Sandy beaches

On the southern coasts of Sendai Bay and in some other areas, the lines of seawalls are bent to avoid destroying sand dune plant communities in sandy beaches. In addition, some construction plans are reconsidered that construction roads are not built on the side of sandy beaches.

Tidal flats

The seawalls at Otomoura in Rikuzentakata, Iwate Prefecture were moved further inland to protect tidal flats that were reverted by the tsunami.

Conserved tidal flats (Otomoura, Iwate Pref., Sep., 2015)

Wetlands and hinterlands
(paddy fields and croplands)

The Sendai Plain consists of rows of sand dunes that have been formed by the advancement of coastlines and the effects of wind. The sand dune uplands have been used as residential areas. The lowlands between the sand dunes have wet environments, some of which have been used for paddy fields, whereas the remaining marshlands provide important habitats for wildlife. The river channels have been altered and are sometimes flooded and enriched croplands.

Tsuyagawa River, Miyagi Pref. (Dec., 2013)

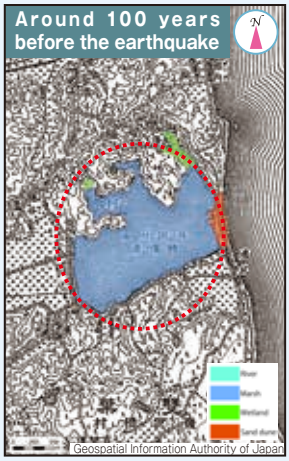
Important message 1 Changes immediately after the earthquake

Impacts on wetlands and hinterlands

Many ponds and small wetlands appeared in the hinterlands where ground subsidence and flooding occurred. Some reclaimed paddy fields became wetlands again following the tsunami inundation. Moreover, the infiltration of seawater damaged croplands and killed trees. Insects and small animals, as well as the birds that feed on these organisms, were also impacted by these landscape changes.

New wetlands generated by the tsunami (Ishinomaki, Miyagi Pref., Sep 2012)

Changes at Itagawaura



Idagawaura used to be a wet environment.

It was drained in 1929 and used as paddy fields.

After the earthquake, it reverted to wetlands due to the impact of the tsunami.

Four years after the disaster, the floodwater was drained, but this area has not yet been used for paddy fields.

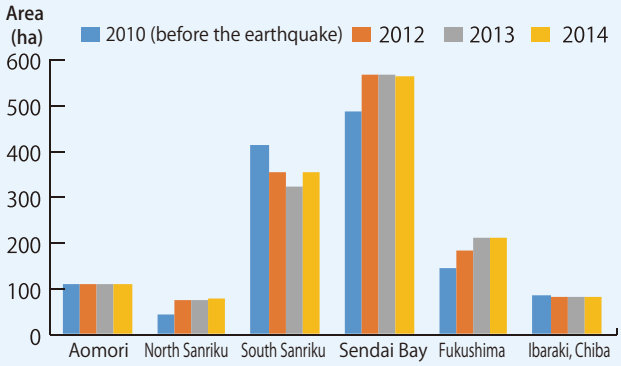
Important message 1

Five years changes and recovery following the earthquake

Changes in wetlands

Many valuable species that had not been seen before the earthquake were observed in the new wetlands after the floods. Many of these organisms have adapted to survive in disturbed environments and are considered highly dependent on such wetland habitats.

Changes to wetland areas over time



Near Sendai Bay and in Fukushima Prefecture, the total area of wetlands increased due to the creation of new wetlands. Despite this, in Sanriku Region, some newly created wetlands were observed, but many of the existing wetlands were lost because of land subsidence and severe tsunami inundation due to the topographic features of the ria coastline; thus, the total area of wetlands in this region has decreased. The changes in the total areas of wetlands differed among regions for several years after the earthquake.

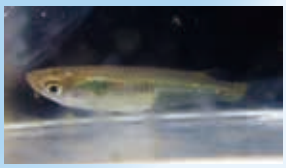
Changes in hinterlands (paddy fields and croplands)

Hygrophyte plants, such as *Echinochloa crus-galli*, *Typha domingensis*, and *Phragmites australis*, showed excessive growth on flooded croplands 1 year after the earthquake. However, the areas initially dominated by hygrophytes and annual plants became dominated by xerophyte and perennial plants, after which reconstruction projects began in earnest. On some croplands, rice farming has resumed after the reconstruction of irrigation and drainage facilities and the removal of salt.

Rice cultivation resumed after the disaster (Ishinomaki, Miyagi Pref., Sep., 2014)

Misgurnus anguillicaudatus
National RL: Data Deficient
(Orikasagawa River, Iwate Pref., Sep., 2015)

Monochoria korsakowii
National RL:NT
(Ishinomaki, Miyagi Pref., Aug., 2012)



Oryzias latipes
National RL:VU, Miyagi RL:NT
(Hiroura, Miyagi Pref., Oct., 2013)

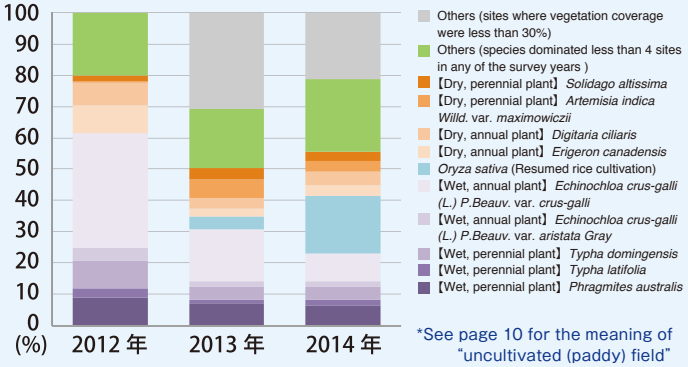
Sparganium erectum observed in new wetlands generated by the tsunami
National RL:NT, Fukushima RL: Caution
(Ukedogawa River, Fukushima Pref., Jul., 2015)

Aeshna mixta soneharai
National RL:NT, Iwate RL:VU
(Orikasagawa River, Iwate Pref., Oct., 2013)

Cybister japonicus
National RL:VU, Miyagi RL: NT
(Matsushima Bay, Miyagi Pref., Oct., 2013)

Sympetrum risi risi
Miyagi RL:VU
(Kitakamigawa River, Iwate Pref., Sep., 2015)

Changes in dominant species in uncultivated (paddy) fields (n = 169 sites) over time

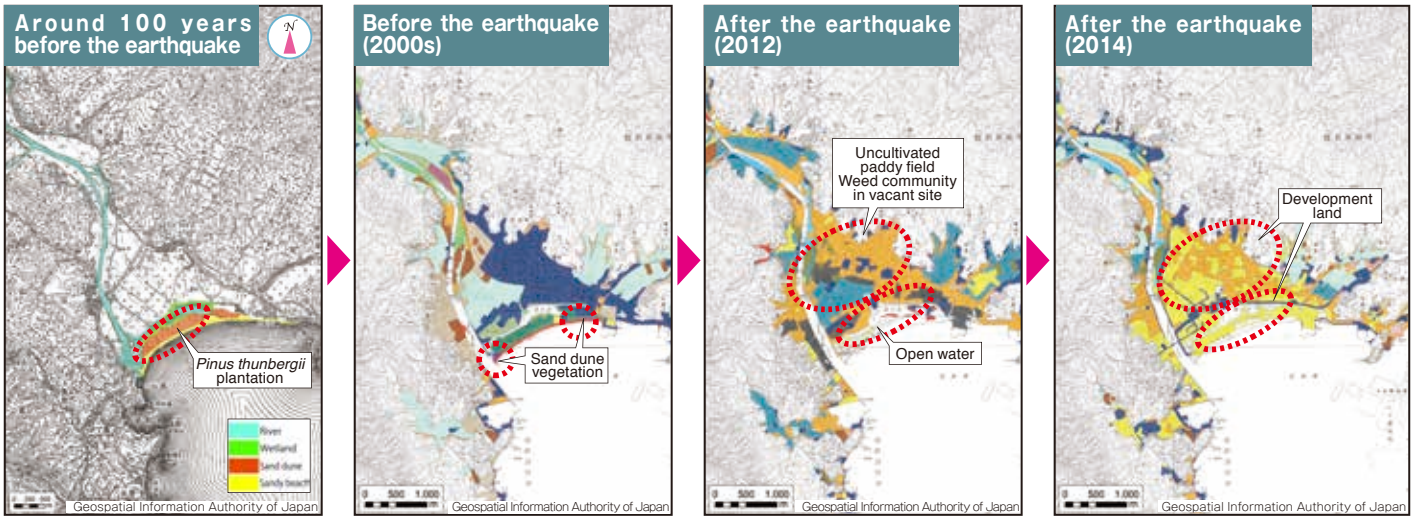


*See page 10 for the meaning of "uncultivated (paddy) field"

Changes in vegetation and land use

Vegetation maps before the earthquake (2000s), immediately following the earthquake (2012), and in the later aftermath of the earthquake (2014) were produced. Additionally, “rivers,” “wetlands,” “sand dunes,” and “sandy beaches” were identified from 100-year-old maps and were compared with the recent vegetation maps to review changes in land use. The changes in the ria coastline in Rikuzentakata and the coastal plains in the Gamo tidal flat are shown as examples.

Rikuzentakata



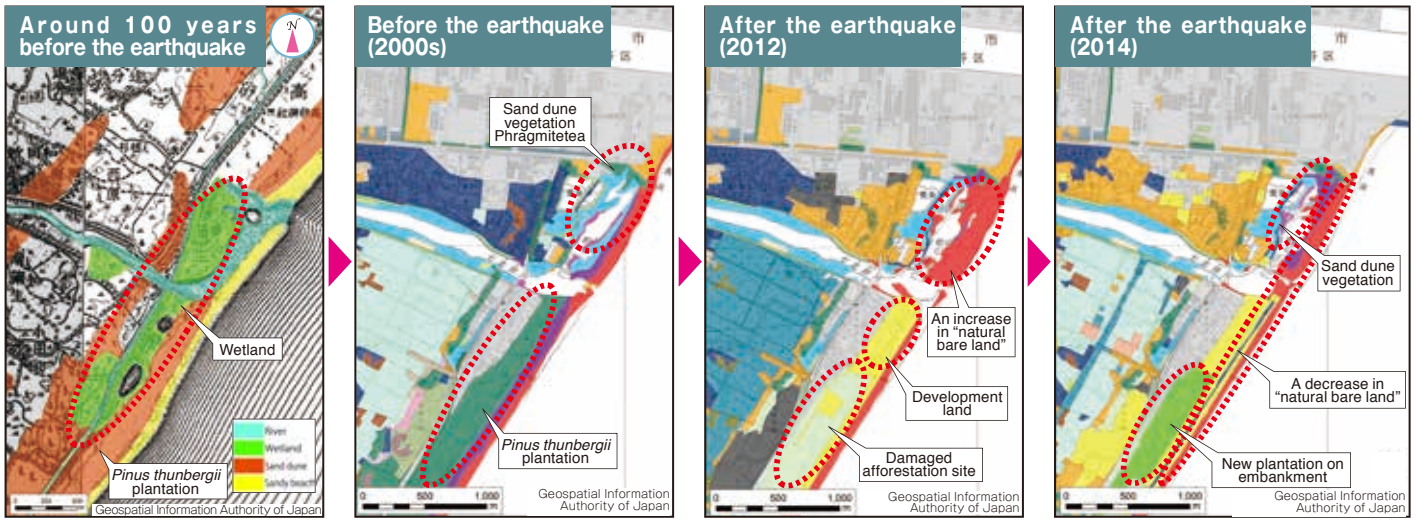
Japanese black pine (*Pinus thunbergii*) have been planted here for more than 100 years.

Sand dune plants on both sides of the Japanese black pine plantations were identified on the map from the 2000s.

Several areas where Japanese black pine plantations previously existed became open water. Weed communities in vacant sites and uncultivated paddy fields diversified in the hinterlands.

Many naturally bare lands, sandy beaches, open waters, and plant communities were artificially cleared over the 3-year period following the earthquake.

Gamo tidal flat



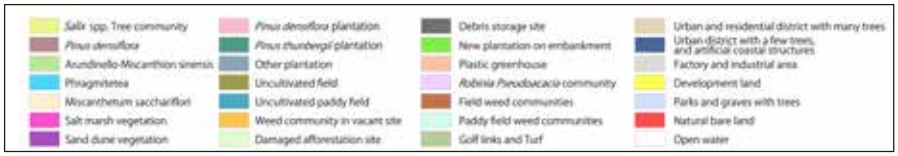
The land around the Nanakitagawa River, which meandered widely in the northeast, consisted of wetlands 100 years ago. Japanese black pines were planted on the sand dunes along the coast.

In the 2000s, there were Japanese black pine plantations, sand dunes, and plants along the coasts, as well as *Phragmites australis* communities and salt marsh vegetation in the wetlands.

Immediately after the earthquake, most coastal vegetation had disappeared, and some of the Japanese black pine plantations were cleared. Natural bare lands were widely distributed around the wetlands.

During the 3 years after the earthquake, new plantations were planted with banking in areas where Japanese black pines used to be cultivated. Natural bare lands along the coast were reduced by erosion, although sand dune vegetation developed around the wetlands.

* “Uncultivated (paddy) field” is a field where cultivation is not conducted. “Paddy field weed communities” are in fields where rice farming is conducted. “Field weed communities” are in fields where farming is conducted. The legends for “Paddy field weed communities” and “Field weed communities” follow the legends used in “Vegetation maps of 1/25,000,” which was produced by the Ministry of the Environment.



Biodiversity of coastal environments

As mentioned above, the once-in-a-thousand-years catastrophic disaster caused tremendous damage not only to human livelihoods but also to the natural environment. Nevertheless, the survey findings, such as nature's adaption and resilience, suggest that, although such events are rare on a human timescale, they have little long-term environmental impact considering that these environments have developed over millions of years.

Remaining important habitats

This disaster may be just one of many disturbances that the wildlife inhabiting the coastal environments have experienced and survived throughout history.

As long as their habitats are not lost entirely, these organisms will not easily go extinct because of such disasters. However, coastal environments and habitats were disrupted and fragmented by the reconstruction projects needed for our daily lives. We must be careful that these projects do not cause irreversible damage to our natural environments.

The Ministry of the Environment has conducted research to identify critical habitat sites for conservation efforts. When the survey results from 2012 and 2014 were compared, there was a noticeable decrease in important habitats in flooded areas. For example, areas of "uncultivated paddy field" had been reduced through conversion to paddy fields or land development processes.

Five years after the earthquake, there were many signs that the natural environment was recovering, but the recovery rates varied among regions. Additional long-term monitoring is critical.

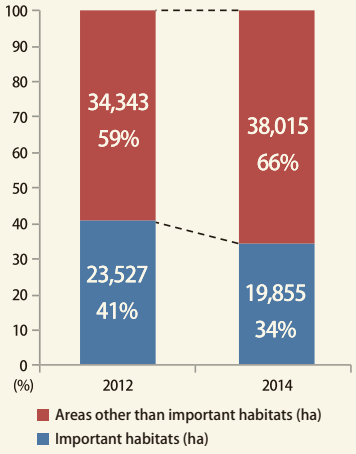
Gamo tidal flat, Miyagi Pref. (Sep., 2014)

Rosa rugosa
Miyagi RL:NT
(Gamo tidal flat, Miyagi Pref., Oct., 2015)

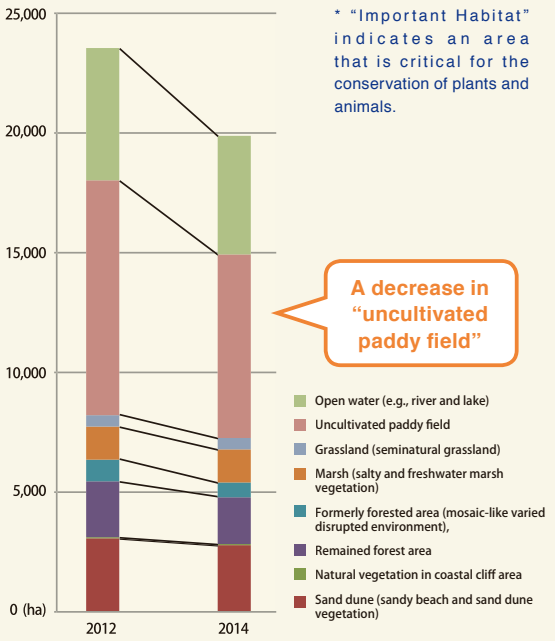
Glaux maritima var. *obtusifolia*
Iwate RL:CR+EN
(Orikasagawa River, Iwate Pref., Jul., 2014)

Rhaphiolepis umbellata var. *integerrima*
Fukushima RL:VU
(Ebihama, Fukushima Pref., Oct., 2013)

Changes in the areas and percentages of important habitats in tsunami-flooded areas



Changes in the compositions of important habitats in tsunami-flooded areas



* "Important Habitat" indicates an area that is critical for the conservation of plants and animals.

Invasive species

Although plants and animals have been returning along sandy beaches and tidal flats after the earthquake, invasive species have also been observed. Such situations need to be monitored.

Cakile edentula
(Tsuyagawa River, Miyagi Pref., Aug., 2012)

Euspira fortune
(Mangokuura, Miyagi Pref., Sep., 2012)

Ecosystem services and human

Anthropogenic activities benefit from ecosystems – interaction between environments and organisms – in a variety of ways, including the supply of food and water, as well as climate regulation. These benefits from the natural environment are called “ecosystem services.”

A variety of benefits from the environment

Such ecosystem services can be categorized into four types.

① Provisioning services

- Obtaining resources from the ecosystem that are needed for daily life (e.g., food, fuel, timber, fibers, medicine, and water).

② Regulating services

- Regulating environments through ecosystems (e.g., climate regulation through forests, and water purification through tidal flats and wetlands).

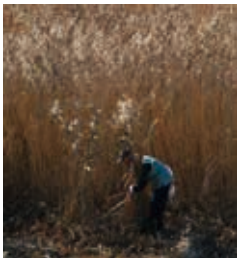
③ Cultural services

- Facilitating psychological relaxation, serving as the basis of religious and social systems, and offering recreational opportunities.

④ Supporting services

- Services that support all the above-mentioned services (e.g., supply of oxygen via photosynthesis, soil creation, and nutrient, and hydrologic cycles).

▶ **Examples of benefits to reconstruction processes provided by ecosystem services are introduced in the following pages.**



Harvesting *Phragmites australis* (Kitakamigawa River, Miyagi Pref., 2009)

Cultivated land
(Tsugaruishigawa River, Iwate Pref., Aug., 2015)

Clam *(Venerupis philippinarum)*
(Orikasagawa River, Iwate Pref., Sep., 2015)

Fisheries and marine product industries

Seaweed beds, often referred to as “marine nurseries,” are recognized as critical ecosystems for both aquatic organisms and humans. For aquatic organisms, seaweed beds provide breeding sites, habitats, and places to hide from predators. For humans, seaweed itself not only serves as a valuable food source but also fosters the growth of other seafood. Additionally, seaweed beds purify the seawater and seabed, thus maintaining suitable environments for aquatic organisms and humans.

Aquatic industries have suffered from the catastrophic damage caused by the tsunami; people who worked in fisheries or seafood processing industries lost their livelihoods. Nevertheless, the resilient marine environments of the Tohoku region played a key role in the recovery of both local areas and their industries. This highlights the importance of conserving seaweed beds and tidal flats, which support marine productivity. Moreover, maintaining the interactions between marine and terrestrial ecosystems is important.

Oyster culture (Mangokuura, Miyagi Pref., Jul., 2015)

Undaria pinnatifida culture
(Miyagi pref., Shizugawa Bay Feb., 2011)

livelihoods

Important message 3

Salmon (*Oncorhynchus keta*)
(Natsuigawa River, Fukushima Pref., Oct., 2015)

Land use in the context of disaster risk reduction and prevention: use of the natural environment

The scale of the damage caused by this natural disaster depended on the location of residential areas. Immediately after the earthquake, the community of Moune district in Kesennuma, in the northern part of Miyagi Prefecture, discussed how their reconstruction process should proceed. As a result, the community moved to newly reclaimed uplands to prevent further damage from future tsunamis. In the lowlands, steps were taken to ensure that anthropogenic activities impacted the new tidal flats and wetlands as little as possible, allowing residents to benefit from their ecosystem services. For example, the remaining tidal flats are expected to support rich marine resources, and the wetlands will purify the water, thereby increasing the quality of the seawater and seabed.

Conservation of the tidal flats by relocating houses to uplands
(Moune district, Miyagi Pref., 2016)

Creature observation event
(Matsukawaura, Fukushima Pref., Aug. 2015)

Michinoku Coastal Trail

The Michinoku Coastal Trail is a long trail that follows the Pacific coast in the Tohoku region of Japan. There are many sights to see, such as the most beautiful cliffs in Japan, the marvelous scenery of the ria coastline, the sheer abundance of the world's third largest fishing grounds, and so on. Additionally, the marks of the tsunami surrounding the trail exemplify both sides of nature—its beauty and its harshness. For more information, please visit ↓
http://tohoku.env.go.jp/mct/english/

Tsunami Memorial Park NAKANOHAMA
(passing point of the trail)

Environmental education and tourism

Natural environments that avoided damage played key roles in recovery by providing habitats and hiding places for surviving organisms. Additionally, new environments, such as wetlands, were created by the tsunami. Rare plants species appeared in the new wetlands, and high biodiversity is observed where new tidal flats appeared.

These natural environments have become valuable educational resources for local children and as tourism sites.

For instance, tidal flats appeared in the inner bays in Moune district, in the northern part of Miyagi Prefecture, and they are now used as environmental education sites for local primary school students.

Additionally, the environmental changes due to the earthquake can be experienced during the ecotours held at the tidal flats of Matsukawaura in Fukushima Prefecture. Such ecotours also bring tourists to the area, which helps to revive the tourism industry.

These are good examples of how the natural environments of tsunami-affected areas help the local communities.

Involvement and coexistence with local natural environments

Important message4

Outcome of the 5-year survey and the importance of monitoring

The environmental changes in areas affected by the catastrophic disaster were surveyed for 5 years following the earthquake. The results highlight nature's positive reaction to the earthquake and tsunami, as well as its resilience in response to such events. Recovery processes unique to each surveyed area were observed. It is important to learn from nature's response and resilience to prepare for and mitigate the impacts of future natural hazards.

▶ The recovery of nature in damaged areas is ongoing and changing; thus, it is critical to continue to monitor and study these changes.

Importance of local natural environments

Ecosystem services provide food resources, water purification, and areas for recreation that are inexhaustible as long as humans do not overexploit them. Furthermore, it is increasingly understood that nature will always be there to provide resilient ecosystem services, which help to rehabilitate our livelihoods even when we face difficulties, such as earthquakes.

▶ It is important to pass these ecosystems on to future generations by learning about and understanding them and by developing a symbiotic society that maintains ecosystem services and benefits from them in times of disaster as well as in times of prosperity.

Building a lifestyle that is symbiotic with nature

Landscapes and ecosystems have been shaped by the influence of the forces of nature, including the Great East Japan Earthquake. This suggests that the features of local natural environments reflect their histories of disasters. Thus, the impacts of future disasters can be mitigated by identifying and evaluating landscapes and events, such as floods, to understand what happened in the past.

▶ Understanding ecosystem services and how nature operates during and after a disaster will help us to prepare for unpredictable future disasters.

Hyla japonica
(Tsuyagawa River, Miyagi Pref., Aug., 2015)

Streptopelia orientalis
(Natsuigawa River, Fukushima Pref., Oct., 2015)

Lycaena phlaeas
(Idoura, Miyagi Pref., Sep., 2014)

Outcomes of the environmental surveys

Using the results of 5 years of surveys, a map called the "Important Habitat Map 2015" was created; this shows areas critical to organisms and ecosystem services. Additionally, a brochure summarizing the surveys was also published. They can be viewed on the website "Shiokaze Natural Environmental Log" (see right page). For the printed version, please contact Biodiversity Center of Japan, Ministry of the Environment, in Japanese.

Recommendation to observe natural environments

Why don't you observe the natural environment around you? Learn how the features of that environment are integrated with your daily life. Imagine what can be done to achieve a lifestyle that is more symbiotic with nature, which can make our lives safer and better.

Higashimatsushima, Miyagi Pref. (Mar., 2014)

Participatory survey (Matsukawaura, Fukushima Pref., May, 2014)

Where to post your observations of natural environments

Have you heard of the "Shiokaze Natural Environmental Survey?" This survey is performed to increase our understanding of the conditions of organisms following the Great East Japan Earthquake, particularly in areas impacted by the earthquake. The objectives of the survey are to identify the changes in habitats and habitat conditions of 20 target species by comparing observations taken before and after the earthquake.

The data are collected on the online system called "Ikimono Log," which is operated Biodiversity Centre of Japan, by the Ministry of the Environment; it involves the activities of citizens, who post records of the organisms they have observed, including the dates and places of such observations.

The guideline for the survey, the "Shiokaze Workbook," as well as apps that simplify the process of taking photos and posting them, are also available. The free apps can be downloaded from Google Play or the App Store.

The collected data will be used to evaluate changes in habitats and environmental factors, and the collected results will be published.

For those who want more information

The reports for each year, including the survey data, can be viewed/downloaded on the website "Shiokaze Natural Environment Log" (http://www.shiokaze.biodic.go.jp/).

Organisms observed in the Tohoku Coastal Region after the earthquake

Locations found in this brochure

Nakanohama
Hideshima Island
Estuary of Tsugaruishigawa River
Yamada Bay
Estuary of Orikasagawa River
Estuary of Unosumaigawa River
Rikuzentakata
Otomoura
Moune, Kesennuma
Kesennuma Bay
Estuary of Tsuyagawa River
Shizugawa Bay
Estuary of Kitakamigawa River
Nagatsuraura
Ishinomaki
Mangokuura
Onagawa
Ashijima Island
Matsushima Bay
Higashimatsushima
Gamo tidal flat
Hiroura
Idoura
Arahama, Watari
Torinoumi
Matsukawaura
Ebihama
Itagawaura
Estuary of Ukedogawa River
Estuary of Natsuigawa River
Estuary of Samegawa River


Scarites aterrimus


Rhomborhina unicolor


Helice tridens


Papilio machaon


Cynops pyrrhogaster


Everes argiades


Acrocephalus orientalis


Tridentiger brevispinis


Rhyothemis fuliginosa


Gallinula chloropus


Phalacrocorax carbo


Larus crassirostris


Asterias amurensis


Nattallia japonica

Published March 2016

Biodiversity Centre of Japan, Nature Conservation Bureau, Ministry of Environment
5597-1, Kenmarubi, Kamiyoshida, Fujiyoshida, Yamanashi 403-0005 Japan
TEL : +81-555-72-6031 FAX : +81-555-72-6035 HP: http://www.biodic.go.jp/
E-mail: webmaster@biodic.go.jp

Edited by: Asia Air Survey Co., Ltd.
Designed by: artpost Co., Ltd. Illustration: Daisuke Kimura