WWF Japan
Nansei Islands Biological Diversity Evaluation Project Report

WWF Japan

Introduction

WWF Japan's involvement with the Nansei Islands can be traced back to a request in 1982 by Prince Phillip, Duke of Edinburgh. The "World Conservation Strategy", which was drafted at the time through a collaborative effort by the WWF's network, the International Union for Conservation of Nature (IUCN), and the United Nations Environment Programme (UNEP), posed the notion that the problems affecting environments were problems that had global implications. Furthermore, the findings presented offered information on precious environments extant throughout the globe and where they were distributed, thereby providing an impetus for people to think about issues relevant to humankind's harmonious existence with the rest of nature.

One of the precious natural environments for Japan given in the "World Conservation Strategy" was the Nansei Islands. The Duke of Edinburgh, who was the President of the WWF at the time (now President Emeritus), naturally sought to promote acts of conservation by those who could see them through most effectively, i.e. pertinent conservation parties in the area, a mandate which naturally fell on the shoulders of WWF Japan with regard to nature conservation activities concerning the Nansei Islands. This marked the beginning of the Nansei Islands initiative of WWF Japan, and ever since, WWF Japan has not only consistently performed globally-relevant environmental studies of particular areas within the Nansei Islands during the 1980's and 1990's, but has put pressure on the national and local governments to use the findings of those studies in public policy.

Unfortunately, like many other places throughout the world, the deterioration of the natural environments in the Nansei Islands has yet to stop. In fact, it is quite possible that the effects of environmental deterioration are beginning to affect people's livelihoods. The purpose of this Biological Diversity Evaluation Project Report is to take in with the proper level of humility the findings yielded via the past 30 years of research and to identify what sorts of steps are needed.

Given the unique ecosystems seen from island to island, the Nansei Islands have been termed the "Galapagos of the East", and befitting that name they hang in the delicate balance between people's interest in their own lifestyles and concern for the actual earth itself. It is entirely possible that the future of these islands foresees the future of the rich natural environments of Japan itself. It is our hope that the biodiversity evaluation strategy of WWF Japan contributes to local management plans and helps bring about a better balance between comfortable lifestyles and nature conservation.

Takamasa Higuchi,

Director General of WWF Japan

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The Nansei Islands Biological Diversity Evaluation Project Outline

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1.1. The purpose and frameworks of the Nansei Islands Biological Diversity Evaluation Project

In October of 2006, WWF Japan initiated the Nansei Islands Biological Diversity Evaluation Project (also called the "Nansei Islands Biomapping Project"). The aim of this project is to identify areas in the Nansei Islands in which the preservation of biodiversity is a priority, and through these findings promote biodiversity conservation efforts in those areas and find sustainable ways for people to utilize what these islands have to offer. Specialized researchers, individuals engaged in conservation efforts in their respective communities, NPO's, and members in government have lent their support to the project, which is organized largely along major biological divisions (i.e. taxa).

1.2. Implementing the project

Over the three-year period leading up to September 2009, local committees and working groups were convened to collect and compile the data gathered by their members. Data was also gathered from interviews and surveys conducted in the field. These information and data gathered in these phases were used to refine the standards and methods for choosing important areas for organisms and selecting Biodiversity Priority Areas (BPA's). In addition to these measures, workshops were held and questionnaires were collected in order to understand prominent perceptions among relevant parties about natural resources and the presence of threats.

Indicator species for taxon priority areas were chosen based on degrees of endemicity and wide-area mobility from the following taxa: mammals, birds, amphibians/reptiles, insects, fish, crustaceans, mollusks, and seagrasses/algae. Specialized scientific methods were then used to yield priority areas within in the Nansei Islands. For reef-building coral, past study findings, environmental data on waves and other environmental factors, and assessments by local experts were all taken into consideration in selecting priority areas.

Biodiversity priority areas were arrived at by using information on important areas for each taxa that was converted into digitally manipulatable data, existing data such as the (former Environment Agency's) Natural Environment Conservation Basic Survey, and GIS (Geographic Information Systems).

Field surveys in this project were conducted as complementary measures in situations in which there were areas in which data was deficient or there were topics which needed urgent attention for the selection of priority areas for the chosen taxa. Furthermore, given the need to balance the conservation of community resources with their utilization, attempts were made to ascertain the opinions of community residents concerning the present and future of these resources. Specifically, Amami shima and Ishigaki Island were selected as model areas, and the members of the Chambers of Commerce in these communities were surveyed (see the Nansei Islands Biological Diversity Evaluation Project: Field Survey Report, published separately).

1.3. Results of the project and anticipated developments

In this project, we took into account factors such as diversity at the taxon level, the distribution of endemic species inhabiting the islands, pristine vegetation, the presence or absence of shore environments and catchment areas, etc., and set parameters so that at least 30 percent of the total area comprising the priority areas for all taxa would be selected, and based on that, proceeded to determine the biodiversity priority areas of the Nansei Islands and generate maps of them.

Field surveys conducted under the auspices of this report yielded surprisingly important findings, including data revealing the distribution of the Okinawa spiny rat (Tokudaia muenninki) in Okinawa Island's Yambaru area as well as findings contributing to the discovery of novel crustacean species on Minami Daitō Island. We received around 2,000 responses to the questionnaire, which enabled us to get a better understanding of how different business operators think about the utilization and conservation of natural resources.

We believe that the maps generated in this project will prove highly useful for relevant government bodies, researchers, local NPO's, business owners, local residents, and other parties in terms of the conservation and utilization of the biodiversity in the Nansei Islands. Nevertheless, it should be emphasized that the priority areas indicated in the maps were the result of an experimental attempt to comprehensively identify important areas, and therefore they are not intended to represent an accurate indication of areas that should immediately be protected by legal measures. Conversely, readers must also note that the absence of an area as a biodiversity priority area does not mean that that area can be commercially or otherwise developed with no impact to biodiversity.

The motivation behind the presentation of these maps is that local interest will be generated with regard to the biodiversity of the Nansei Islands. We also hope that they will serve as an impetus for the frank exchange of opinions among interested parties. Our primary hope is that this study contributes to the development of strategies for addressing biodiversity issues in the Nansei Islands and to initiatives designed to strike the proper balance between the protection of natural resources and their utilization in a sustainable and responsible manner in the pertinent areas.

Chapter 2. Summary of the Nansei Islands

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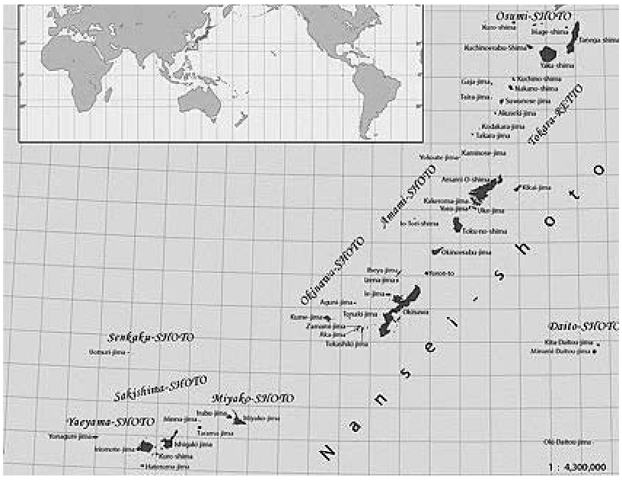
2.1. The scope of the Nansei Islands covered by the project



The current project evaluates the land portions of the Nansei Islands in addition to the surrounding waters. The term "Nansei Islands" as used in this report refers to a string of islanda stretching from the Ōsumi Islands to the north and the Yaeyama Islands to the south, along with several adjacent islands forming the Daitō Islands and the Senkaku Islands. In between the first two island groups are the Tokara Islands, Amami Islands, Okinawa Islands, and Miyako Islands. During the selection process for Biodiversity Priority Areas (BPA's), the land portions of these island groups were evaluated based on areas subdivided according to distributions of endemic species. Marine areas evaluated were chiefly waters of a depth of 20 meters and shallower. Despite belonging to the Minami-Satsuma City administrative units of Kagoshima Prefecture like the Ōsumi, Tokara and Amami Islands, the Uji and Kusagaki Islands were not included in this study.

2.2. The status of the project within the WWF network

The Nansei Islands have become the object of international focus due to their high levels of biodiversity and endemicity of its biota. The WWF was among the first to recognize these features of this region and initiate nature protection programs that are in place to this day.

WWF is an international environmental conservation group established in 1961. The group initially focused its efforts mainly on the conservation of wildlife in danger of extinction, but in the process of expanding the scope of its work over the years, it has come to focus on the importance of habitat conservation in general, rather than just the protection of particular species.

The scope of habitat conservation was expanded to include the global environment in general in 1980, the year that the WWF drafted the "World Conservation Strategy" in cooperation with the International Union for Conservation of Nature (IUCN), the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), and UNESCO.

The three main objectives of the Strategy are:

1. To maintain essential ecological processes and life-support systems
2. To preserve genetic diversity
3. To ensure the sustainable utilization of species and ecosystems

Using the World Conservation Strategy as a framework, over 50 countries have developed and implemented individual "National Conservation Strategies". Since the framing of the Strategy, the WWF began to concentrate its efforts on putting its proposals into practice. The 1982 Tropical Rainforest Campaign, the 1985 Wetlands Campaign, and the 1989—1993 Biological Diversity Campaign are concrete examples of those efforts.

WWF Japan, which was established in 1971, began a five-year campaign in 1989 to coincide with the 20th anniversary of its inception. The campaign, called "Protecting nature around the world-The importance of biological diversity", was organized around four broad themes: the Nansei Islands, tropical forests, the wildlife trade, and wetlands. Further, in 1996, the WWF network created a list called the "Global 200" (a list of 238 ecoregions around the world that the group deemed as priorities for the conservation of biodiversity). The Nansei Islands were placed on the list as an important ecoregion (i.e. a biological region viewed from a broad environmental perspective, chosen for features such as biodiversity, endemicity, uniqueness, etc.) for Japan.

It is amidst this backdrop that WWF Japan's Nansei Islands Protection Project has gained momentum. The groundwork was laid through research done in cooperation with diverse individuals and groups, and conservation-related petitions, petitions which take into account local concerns, have been filed with Okinawa Prefecture and other relevant government agencies as part of this project.

2.3 Ecological importance

The Nansei Islands are in an ecotone between the Palearctic and Indomalaya ecozones, with flora and fauna of both northern and southern origins. In terms of forest ecosystems, Yakushima is covered by subtropical evergreen broadleaf forest and cool-temperate mixed forest of coniferous and broad-leaved species. Other islands such as Iriomote Island, Ishigaki Island, Okinawa Island, and Amami Ōshima are home to subtropical evergreen broadleaf forest. The islands are home to species endemic to specific regions, such as the Amami rabbit (Pentalagus furnessi), Okinawa woodpecker (Sapheopipo noguchii), and Iriomote cat (Prionailurus iriomotensis), as well as habitats for many rare species listed on the Red Lists of the Japanese Ministry of the Environment and the IUCN.

There are well-developed mangrove tidal flats at the mouths of rivers and in bays where seawater mixes with freshwater, and these flats serve as important stopovers and nesting grounds for birds that migrate between Russia, Alaska, and Australia. Over 300 diverse species of reef-building coral have been observed in the waters in the area, which are nourished by the warm Kuroshio Current. The waters are also important breeding grounds for migratory whales, and form crucial habitats for sea turtles. What follows is a collection of summaries demonstrating the ecological importance of the Nansei Islands to the classes of organisms with which this project is concerned.

1. Ōsumi Islands

Ōsumi Islands: (i) Mammals

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Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

The Ōsumi Islands are separated from the main island of Kyushu by the Ōsumi Strait. Some differences in the mammalian fauna can be seen among the islands. Kuchinoerabujima is the northernmost limit for the distribution of Erabu flying fox (*Pteropus dasymallus dasymallus*), an indicator species (subspecies), and while their numbers are estimated to be less than 100 individuals, they are distributed over a broad area on this island. Yakushima is home to the Yakushima macaque (*Macaca fuscata yakui*) and the Yakushima deer (*Cervus nippon yakushimae*), both of which are endemic subspecies, the latter of which can also be found on Kuchinoerabujima. The island of Mageshima is inhabited by *C. nippon mageshimae*, an endemic subspecies of deer. This subspecies is also thought to live on Tanegashima. These subspecies have adapted independently on these islands, making them extremely valuable from a scientific standpoint. *Mustela itatsi sho*, a subspecies of the Japanese weasel, lives on Yakushima and Tanegashima, but much remains unknown about its ecology, etc.

Ōsumi Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

On Yakushima can be seen vegetation zones that correspond with altitude, stretching from the shore to around the islands highest peak, which is nearly 2,000 meters, and birds associated with these vegetation zones can be observed in a vertical distribution pattern (Hanawa, 2006). The western part of the island in particular has seen little human alteration, and contains contiguous stretches of natural vegetation, making it an important habitat for a diverse variety of birds. With the exception of the shoreline and farmland, the island is covered with well-developed forests. The forests see resident coal tits (*Periparus ater*), Eurasian jays (*Garrulus glandarius*), Japanese bush warblers (*Cettia diphone*), varied tits (*Cyanistes varius*), Japanese green woodpeckers (*Picus awokera*), and Japanese wood pigeons (*Columba janthina janthina*) during breeding periods, Japanese robins (*Erithacus akahige*), narcissus flycatchers (*Ficedula narcissina*) and others during the summer, and both resident and wintering thrushes, forming a distinctive bird community. Endemic subspecies of these birds have evolved on the island, including a subspecies of the Yakushima jay (*Garrulus glandarius orii*) as well as the Yakushima varied tit (*Parus varius yakushimensis*).

Tanegashima is covered by gently sloping hills, and much of the island has been converted to farmland. There are bird habitats, which include trees, estuaries, and rice paddies, but they are split up. The remaining evergreen broadleaf forestland is an important habitat for Japanese wood pigeons, Japanese green woodpeckers, and Japanese white-eyes (*Zosterops japonicus*), and although on a smaller scale, estuaries and mudflats are likewise important habitats for snipes and plovers (Numaguchi et al., 1995).

There is very little survey data available on birds on Kuchinoerabujima and Mageshima, but it is clear that the roseate tern (*Sterna dougallii bangsi*) breeds on the reefs of Mageshima.

The Ōsumi Islands' bird fauna shares much with that of Kyushu, but like other small islands, the fact that they are islands means that fewer species breed there, and certain species within related species groups are absent.

Ōsumi Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

Excluding those supposedly nonnative to this region (Ota et al., 2004), there are six species of amphibians and 14 species of terrestrial reptiles that have been recorded on this island group (Maenosono and Toda, 2007). As is the case with most other classes of animals as well, nearly all of the species and subspecies of amphibians and terrestrial reptiles in this area are also common to the main island of Kyushu. The only exceptions are Yakushima Tago's brown frog (*Rana tagoi yakushimensis*), an endemic subspecies of Yakushima, and the Ryukyu brown skink (*Ateuchosaurus pellopleurus*), a species that lives on Kuroshima, Iōjima, and Takeshima and is exclusively shared with the Tokara Islands, the Amami Islands, and the Okinawa Islands, are the only two endemic species. Of the species shared with the main island of Kyushu, the Japanese pond turtle (*Mauremys japonica*), which in the Ōsumi Islands is only seen on Tanegashima, differs slightly in color from turtles on the main island (Ota, unpublished), but its status in terms of population genetics/evolutionary genetics has yet to be determined.

As for marine reptiles, there are two species of sea turtles (the loggerhead turtle, *Caretta caretta*, and the common green turtle, *Chelonia mydas*) whose nesting beaches have been found in this region. Of these, the loggerhead turtle is the more prolific, and many individuals have been confirmed landing and laying eggs on beaches on Yakushima and Tanegashima (Kamezaki et al., 1994; Kamezaki et al., 2003). The number of turtles that lay eggs on these beaches accounts for a relatively large portion of those that lay eggs throughout the entirety of Japan, and when one considers that Japan is the only breeding ground for the loggerhead turtle populations in the Pacific Ocean north of the equator (Bowen et al., 1995), the nesting beaches in this region are of extreme importance for the preservation of communities of loggerhead turtles in the North Pacific. While significantly fewer numbers of common green turtles land and nest compared with loggerhead turtles, it is worthy of note that this region forms the northern boundary of the area in which this species is regularly seen nesting (Kamezaki et al., 1994).

Although not subject to evaluation in this study, in addition to these marine reptiles there are two species of sea kraits (the Erabu black-banded sea krait, *Laticauda semifasciata*, and the blue-lipped sea krait, *L. laticaudata*) that land and nest in this region, both of which are found in shallow tropical and subtropical waters of the Indian and Pacific Oceans. Just as with the common green turtle, this region is the northernmost nesting boundary for these sea snake species (Ota and Masunaga, 2005)

Ōsumi Islands: (iv) Insects

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Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

The Ōsumi Islands themselves are rich in diversity, with islands like Yakushima with extremely high mountains, relatively flat islands such as Tanegashima and Mageshima, and islands with active volcanoes like Kuchinoerabujima. *Nigidius lewisi*, *Figulus punctatus*, and other species might have been carried by the Kuroshio Current on decaying wood (Shimoji, 2006) are distributed widely throughout the islands. On Yakushima, Tanegashima, and Mageshima lives *Dorcus rectus yakushimaensis* (endemic subspecies?). The interior of Yakushima is inhabited by known endemic and new endemic species such as *Tibicen esakii*, *Rhipidolestes aculeatus yakusimensis,* and *Chrysozephyrus ataxus yakushimaensis*. It is also the southern limit of *Polyergus samurai*, a Japanese slave-making ant. *Cicindela sumatrensis niponensis* (expanded distribution) has been discovered on the relatively pristine western part of Tanegashima and southern shore area. In addition, there are records of *Noterus japonicus* being found on Tanegashima's farmlands, whose presence has not been recorded on Yakushima even though it is a common species. On Kuchinoerabujima, *Aphaenogaster erabu* (endemic species), *Protaetia exasperata erabuana* (endemic subspecies), and *Xylocopa amamensis* (regional population) live on the shores, in forests of low elevation, and even in populated areas.

Ōsumi Islands: (v) Fish

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Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Yakushima and Tanegashima are located at the northernmost tip of the Ryukyu Islands. Both have extensive river and other terrestrial water systems. Many of the rivers on Yakushima are mountainous across their entire lengths. Running on steep inclines and lacking estuarine basins and brackish estuaries, water often flows right into the sea. The fish fauna in such mountain streams is generally sparse, but loach goby (*Rhyacichthys aspro*) and belted rockclimbing goby (*Sicyopus zosterophorum*) have been confirmed in some rivers. Such rivers in fact mark the global northern edge of the distribution of these species (Yonezawa et al., 2003). Tanegashima, on the other hand, possesses a relatively gently sloping terrain. As a result, many of its rivers have substantial middle and downstream reaches, and some have estuaries with mangroves. For this reason, brackish-water gobiid fish carried from the south by the Kuroshio Current, such as the northern mud gudgeon (*Ophiocara porocephala*) and golden goby (*Glossogobius aureus*), are present. In addition, such rivers also form the southern limit of distribution for the yellowfin goby (*Acanthogobius flavimanus*), *Gymnogobius breunigii*, and other temperate species (Hayashi, 1976; Mukai et al., 2002; Suzuki and Shibukawa, 2004). Furthermore, while no conclusive records have been produced in recent years, the Japanese lates (*Lates japonicus*) is a species worthy of note (Imai, 1987). No major river development projects have been undertaken in the Ōsumi Islands, and natural habitats have been kept in relatively good condition.

Ōsumi Islands: (vi) Crustaceans

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Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The Ōsumi Islands region contains relatively large islands —most notably Yakushima and Tanegashima— and its terrestrial and river environments are considered to be relatively well-preserved. Because these islands are located at the northernmost area of the Nansei Islands, they have developed a very distinctive biota, which is characterized by a mixture of (temperate) species with their southern limits as well as (tropical) species with their northern limits of distribution located here.

Yakushima and Tanegashima still have rivers that are highly pristine. From the mouths to the middle reaches and upstream areas of these rivers there are very limited habitats (or, more precisely, locality records of collected specimens) of rare species such as the East Asian fiddler crab (*Uca arcuata*), Yakushima freshwater crab (*Geothelphusa* marmorata), single-dotted brackishwater prawn (*Palaemon concinnus*), rainbow freshwater prawn (*Macrobrachium gracilirostre*), and others. In particular, the Yakushima freshwater crab a freshwater crab endemic to Yakushima occurs only in mountain streams of more than 700 meters in elevation (Suzuki and Okano, 2000). Among the freshwater crabs on Kuroshima is a species endemic to the island that is distinct from the Japanese freshwater crab (*G. dehaani*) and is currently being described (Suzuki, private correspondence). These circumstances suggest that the habitats of Ōsumi Islands will take on a growing importance.

Ōsumi Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

The terrestrial mollusk (i.e. land snail) fauna of the Ōsumi Islands share many species in common with the island of Kyushu, but there are also more than a few species endemic to Ōsumi. About 50 land snail species occur on Yakushima, and about 30 on Tanegashima (Minato, 1989).

Sea snail fauna in the area is a mixture of temperate species generally distributed around Kyushu or farther north and tropical species that see distribution in the Indian and Pacific Oceans. Many in the latter category have their northern limits at the Ōsumi Islands.

There are contiguous vegetation zones on Yakushima that stretch from the shoreline to the mountains and alter their composition according to altitude. Groups of land snail species found vary according to these different types of vegetation, such as subalpine natural forest, etc. The habitats of sea snails in the coastal waters consist mostly of rock reefs, but also include sandy beach areas and coral reefs. The coasts at Kurio and Nagata, which support a highly diverse variety of reef-dwelling mollusks, are areas of particular importance.

The natural forests that remain in the hilly regions of Tanegashima, fragmentary though they may be, form the main habitats for endemic land snails seen only on this island. The Kumano shore area (mouth of the Ōura River) is an intact shore environment that includes tidal mudflats and sandy beaches, and serves as a crucial environment for mollusks that dwell in brackish water and mudflats.

Ōsumi Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

Tanegashima: During a field study of seagrass beds and algae around Tanegashima and Yakushima conducted in April of 2008 (Kamura et al., 2008), no seagrass beds were observed, although the survey interval was short. Furthermore, interviews of people employed in the local fisheries industry yielded no information about seagrass beds. Fringing coral reefs can be found in numerous spots in the area around Tanegashima, and there are also two very well-formed mangrove swamps (pure forests of naturally occurring Kandelia obovata mangroves at the mouths of the Minato River in Nishino-omote City and the Ōura River in Minamitane Town). As for indicator species of algal flora, one brackish species and seven marine species of algae (tropical/subtropical: 6; temperate: 1) were confirmed growing. However, two temperate species that grow as far south as Okinawa Island (*Sargassum thunbergii* and *S. fusiformis*) could not be confirmed. This result was unexpected, but interviews with local fishermen likewise were fruitless in yielding information on *S. fusiformis*. Locations rich with algae in general, not to mention indicator species, were those with coral reefs with the complex microenvironments necessary for seagrass to attach itself to and grow. As for indicator species on coral reefs in particular, seven species at Sumiyoshi in Nishino-omote City were observed, as were three species at Annō. Three species were confirmed on the rocky reef-covered shore at Kajio, but these species exhibited low levels of diversity. From the above observations, it can be concluded that the coral reefs at Sumiyoshi and those at Annō are especially important conservation areas for the diversity of species, including non-indicator species. In addition, the Minato River and Ōura River mouth are important areas from a conservation perspective, for the mangrove forests themselves, the mangrove algae (*Bostrychia, Caloglossa*, etc.) that mangrove swamps attract, and for fauna as well as flora.

Yakushima: In contrast to the relatively flat Tanegashima, Yakushima is a circular mountainous island. A total of seven indicator species of algal flora were confirmed off the shores of Yakushima: six species of algae and one brackish-water species. As is the case with Tanegashima, the shoreline of Yakushima richest in indicator species has a coral reef located at the east end of the island and called the "Kasuga Beach Coral Reef". Five indicator species were observed off this shore. Located on the southwest side of the island, situated on a small peninsula, is "Tsukazaki Beach", an undulating sand and rock shoreline. The water channels and tide pools alike are teeming with coral varieties, and the subtidal zone offers a splendid underwater view of growths of table coral. The entirety of this area is protected as part of the Kurio Marine Park Zone. There were just three indicator species found off this shore, but diverse species of algae grow here. These two sites, namely the "Kasuga Beach Coral Reef" and "Tsukazaki Beach" (Kurio), are areas where conservation is critical.

Yakushima has many rivers with high discharge levels, and since brackish-water olgal species are observed around the island, the estuarine regions are areas that are important for conservation purposes. These rivers cannot compare with wealth of algae in marine waters, but it should be noted that the water of the estuaries is extraordinarily clear, and because of the relative paucity of housing in the area, pollution levels of household wastewater and such are extremely low. These estuaries are home to *Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis*, which are types of mangrove algae that have been designated as indicator species.

2. Tokara and Amami Islands

Tokara and Amami Islands: (i) Mammals

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Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
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Yukari HANDA (Amami Mammalogical Society)

The Erabu flying fox (*Pteropus dasymallus dasymallus*) has been reported to be living on Nakanoshima, Tairajima, and Akusekijima, which are all part of the Tokara Islands. Since the 1990's this subspecies has not been found on Takarajima, which suggests a high probability that it is extinct on this island. One report of notable mammalian fauna includes sightings of Suncus murinus temmincki on Nakanoshima (Nagai, 1928), but the animal has not been observed on the island since. With the exception of the distribution of the Erabu flying fox, mammalian fauna changes drastically across the division created by the Tokara Strait (the Watase Line), with Akusekijima and areas northward belonging to one ecozone (the Palearctic), and Takarajima, Kotakarajima and areas farther south belonging to another ecozone (the Indomalaya).

Amami Ōshima and Tokunoshima, which are part of the Amami Islands and have subtropical forests, are inhabited by indicator species such as the Amami rabbit (*Pentalagus furnessi*), Orii's shrew (*Crocidura orii*), the Ryukyu long-furred rat (*Diplothrix legata*), Amami spiny rat (*Tokudaia osimensis*), Tokudaia tokunoshimensis, the forest-dwelling Yanbaru whiskered bat (*Myotis yanbarensis*) and Ryukyu tube-nosed bat (*Murina ryukyuana*), as well as the cave-dwelling East Asian little bent-winged bat (*Miniopterus fuscus*). Still, for the purposes of establishing priority areas on Amami Ōshima and Tokunoshima, such areas could not be considered to adequately reflect bat habitats, due to insufficient data on the distribution of bats when compared to information on other species types.

Other notable mammals include Orii's least horseshoe bat (*Rhinolophus cornutus orii*), a rare subspecies that lives on Amami Ōshima, Kakeromajima, Tokunoshima, and Okinoerabujima, and the lesser Ryukyu shrew (*Crocidura watasei*), which inhabits these islands in addition to Kikaijima and Yoronjima.

Tokara and Amami Islands: (ii) Birds

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The islands of the Tokara group are of considerable significance as a stopover point for migratory birds in between the Ōsumi Islands to Amami Ōshima. Nakanoshima is important as a nesting ground for the Ryukyu robin (*Erithacus komadori komadori*) (Kawaji et al., 1989), and it is possible that the Ryukyu robin and the Izu thrush (*Turdus celaenops*) breed on Suwanosejima (Hanawa and Tobai, 1994). There are no records of sightings of these two species on either Yakushima or Tanegashima in recent years. Furthermore, the Izu thrush, Japanese robin, Ijima's leaf warbler (*Phylloscopus ijimae*), and Japanese white-eye seen on the Ōsumi and Tokara Islands are thought to be the same species/subspecies as those of the Izu Islands, and are therefore important in biogeographical terms. There have been interesting findings concerning the routes of small migratory birds on Tairajima that suggest that this island is in the path of the migration route from the Asian continent to the island of Kyushu, and that the birds exhibit characteristics slightly different from the Ryukyu Islands' migratory species (Kawaji et al., 1987).

The bird fauna observed on Amami Ōshima exhibits characteristics different from those seen on the small islands north of it. Lidth's jay (*Garrulus lidthi*, a species endemic to Amami Ōshima and surrounding islands), the white-backed woodpecker (*Dendrocopos leucotos owstoni*), White's thrush (*Zoothera dauma major*, a subspecies endemic to Amami Ōshima), and the Amami woodcock (*Scolopax mira*, a species endemic to Amami Ōshima and the Okinawa Islands) all breed in these islands. Moreover, in addition to the Ryukyu robin (a species endemic to the Danjo Islands, Tokara Islands, Amami Islands and Okinawa Islands), the cinnamon bittern (*Ixobrychus cinnamomeus*), the barred buttonquail (*Turnix* *suscitator*), the Ryukyu scops owl (*Otus elegans elegans*), the whistling green-pigeon (*Treron formosae*), and other Ryukyu-derived species are resident birds on these islands.

There are mature natural evergreen broadleaf forests that stretch from Kinsakubaru in central Amami Ōshima to the Kamiya National Forest and Mt. Yuwan areas which serve as important habitats for species and subspecies of the arboreal birds mentioned above. The mudflats of the Ōse shoreline form important migration points and habitats for waterfowl such as snipes and plovers, e.g. the Kentish plover (*Charadrius alexandrines*), Pacific golden plover (Pluvialis fulva), and terns such as the roseate (*Sterna dougallii bangsi*). The same applies for the Sumiyō River mangrove forests in relation to the cinnamon bittern, the intermediate egret (*Egretta intermedia intermedia*), and other heron-like birds. The Cinnamon bittern and Indian small blue kingfisher (*Alcedo atthis bengalensis*) live on farms in such places as Akina and Komihō, to which the Pacific golden plover also migrates. These areas are also important habitats for small birds and birds of prey during migration cycles and for wintering.

The Japanese wood pigeon, the whistling green-pigeon, and Japanese sparrowhawk (*Accipiter gularis*) inhabit the evergreen broadleaf forests of Kikaijima. At the same time, the forests of Tokunoshima are home to the Ryukyu robin, Japanese wood pigeon, and whistling green-pigeon, while the roseate tern and black-napped tern (*Sterna sumatrana*) migrate to the shores. The Japanese wood pigeon, the whistling green-pigeon, and Japanese sparrowhawk can also be observed in the forests of Okinoerabujima. Yoronjima has a high ratio of farmland coverage. Remaining forests are mostly located on precipitous sites and inhabited by the Japanese wood pigeon. Many varieties of snipes, plovers and small birds have been documented wintering and stopping over on these small islands (Amami Ornithologists' Club, 1997, 2009).

Tokara and Amami Islands: (iii) Amphibians/Reptiles

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Northern Tokara: Stretched out from northeast to southwest just south of the Ōsumi Islands and cut off by the Tokara Tectonic Strait, the islands of Northern Tokara are home to one amphibian species and four reptile species (Maenosono and Toda, 2007), though this account excludes species introduced by man, such as the Okinawan narrow mouthed frog (*Microhyla okinavensis*) from Suwanosejima and the Japanese striped snake (*Elaphe quadrivirgata*) from Kuchinoshima (Ota et al., 2004).

Nearly the whole of this area was formed relatively recently, i.e. towards the end of the Pleistocene or even later, and is made up of volcanic islands. It is an ecotone between the Central Ryukyus and the Ōsumi Islands, between which nearly all of the constituent species of the amphibian and terrestrial reptile fauna differ (Hikida et al., 1992; Ota et al., 1994), although there are multiple island populations of the Okinawan five-lined skink (*Plestiodon marginatus marginatus*) that exhibit genetic differentiation and characteristic variation (Motokawa and Hikida, 2003). Also, populations of the Japanese grass lizard

(*Takydromus tachydromoides*) in this area, together with populations in the Ōsumi Islands, show a relatively large degree of differentiation compared with those normally seen on the island of Kyushu and northwards, and there is a strong possibility that they are part of a unique evolutionary lineage (Ota et al., 2002). Populations of the hokou gecko (*Gekko hokouensis*) seen in parts of Southern Tokara (Yokoatejima), the Ōsumi Islands, and the southern tip of Kyushu are relatively distinct from those of other areas (Toda et al., 1997). As for marine reptiles, just as on the Ōsumi Islands, there are nesting beaches for sea turtles and nesting caves for sea kraits, particularly on Nakanoshima and Suwanosejima (Ota, unpublished data).

Southern Tokara: The islands of Southern Tokara, which are located immediately south of the Tokara Tectonic Strait and face Amami Ōshima to the south, are home to one amphibian species and eight land-dwelling reptiles. While most of them are identical to those seen on Amami Ōshima (Maenosono and Toda, 2007), the Takara gecko (*Gekko shibatai*) and the Tokara habu (*Protobothrops tokarensis*) are endemic to the area (Maenosono and Toda, 2007; Toda et al., 2008). The Tokara habu is genetically very similar to the habu (*P. flavoviridis*) populations on Amami Ōshima and Tokunoshima (Toda et al., 1999). The Okinawan five-lined skink (subspecies *P. marginatus oshimensis*) and the Ryukyu green snake (*Cyclophiops semicarinatus*) occurring in the area have distinct variations in scale pattern and body size, but both are thought to have developed rapidly in the limited space offered by the small island environments (Ota et al., 1994).

The loggerhead turtle has been observed nesting on Takarajima, but only infrequently (Makiguchi, private correspondence). The Erabu black-banded sea krait and blue-lipped sea krait land and nest on Kotakarajima very frequently. Although these two species also make land and nest on Takarajima, they do so far less frequently than on Kotakarajima (Ota, 1995; unpublished data).

Northern Amami: The major islands are large in area, and perhaps because the area is highly diverse in terms of topography, vegetation, and sources of water, there are many species of amphibians and reptiles here. If one excludes those that are clearly nonnative to this region (the American bullfrog, soft-shelled turtle, red-eared slider, common house gecko, etc.; Ota et al., 2004), there are 11 amphibian species and 19 terrestrial reptiles (Maenosono and Toda, 2007). The Okinawan five-lined skink (subspecies *P. marginatus oshimensis*) in this area exhibits fairly large morphological and genetic variations (Kato et al., 1994; Motokawa et al., 2001; Toda et al., 2002). Although species-wise the area shares many species with the islands of Southern Tokara, Southern Amami and the Okinawa Islands, it shares few with other areas (Ota, 2000a). The reason for this is thought to be that, as a large group of continental islands, it has been separated from other areas for a relatively long span of time (Ota, 1998). Among endemic species and subspecies are the Amami tip-nosed frog (*Rana amamiensis*), the Otton frog (*R. subaspera*), the banded ground gecko (*Goniurosaurus kuroiwae splendens*), and the Amami coral snake (*Sinomicrurus japonicus*). In addition, as evidenced by the sword-tail newt (*Cynops ensicauda*) for example, there are more than a few taxa that the area shares in common with the Okinawa Islands but that also exhibit a strong degree of genetic variation (Hayashi and Matsui, 1988).

As for marine reptiles, the islands are scattered with beaches where sea turtles nest. In addition to the loggerhead turtle and common green turtle, some beaches are visited by nesting hawksbill turtles (*Eretmochelys imbricate*) (Kamezaki et al., 1994, 2001). In 2002 there was an instance of a leatherback turtle (*Dermochelys coriacea*) laying eggs on Amami Ōshima, but this is thought to be a chance occurrence (Kamezaki et al., 2002). There are no known examples of sea kraits nesting in this area (Ota, 1995).

Southern Amami: The islands of Southern Amami, which are located between Tokunoshima and the Okinawa Islands, are low-lying cays composed of Ryukyu limestone. When we exclude species that are clearly nonnative (Ota et al., 1994), there are only four amphibian species and nine land-dwelling reptile species (Maenosono and Toda, 2007). Furthermore, geographically speaking, they are all species that are also found on the surrounding groups of islands (the islands of Northern Amami and the Okinawa Islands). Based on morphological characteristics, the populations of the Okinawan five-lined skink found in this area were initially thought to be the subspecies *P. marginatus oshimensis*, i.e. as is found on the islands of Northern Amami and Southern Tokara, but recent studies have shown that they are genetically closer to the nominotypical subspecies *P. m. marginatus* seen on the Okinawa Islands, and that they have characteristics unique to this area (Kato et al., 1994). The populations of *Ateuchosaurus pellopleurus*, the Ryukyu green snake, Ryukyu odd-tooth snake or Akamata (*Dinodon semicarinatum*), and Ryukyu keelback (*Amphiesma pryeri*) on Okinoerabujima each either have morphological variations that place them in between populations of the same on the islands of Northern Amami and the Okinawa Islands or that are distinct from both (Ota et al., 1995, 1999a; Ota, unpublished data).

As for marine reptiles, Okinoerabujima and Yoronjima both have beaches where loggerhead turtles make land and nest relatively frequently (Kamezaki, unpublished data). There are also nesting sites of the Erabu black-banded sea krait on Yoronjima (Ota, 1995).

Tokara and Amami Islands: (iv) Insects

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The Tokara Islands are astonishingly rich in endemic insect lives. There are records of *Rhabdoblatta takarana* (endemic species, 2 females only), *Symploce striata striata* (southern limit), *Prosopogryllacris okadai* (northern limit), *Dorcus titanus takaraensis* (endemic subspecies), and *Zizina otis riukuensis* (northern limit of Okinawan subspecies) on Takarajima. Fire fly species of the family *Lampilidae* are not distributed in the Tokara Islands, with an exception of *Drilaster akusekianus*, which is endemic to Akusekijima. Other notable species include *Melanotus akusekianus* (endemic) and *Cryptophagus* *callosipennis* (only on Izu Hachijōjima and Akusekijima). *Camponotus kaguya* is an ant species seen on Aksekijima and in the Amami Islands. *Hexacentrus unicolor* has its northern limit of distribution at Akusekijima. Nakanoshima is home to *Madrasostes kazumai* (endemic species), and *Papilio bianor tokaraensis* (subspecies endemic to Tokara). Nakanoshima is also the northern limit of *Rhyothemis variegata imperatrix*, *Hermatobates weddi*, and *Curtos costipennis*, and the southern limit of *Planaeschna milnei*. Suwanosejima is inhabited by *Protaetia exasperata suwanoseana* (subspecies endemic to Suwanosejima and Yokoatejima), while on Yokoatejima can be seen *Peratogonus reversus* (disjunct distribution).

Amami Ōshima has tall mountains in the interior and many mountain streams and rivers, which nurture endemic subspecies such as *Asiagomphus amamiensis amamiensis* and *Planaeschna ishigakiana nagaminei*. It is also the northern limit of *Matrona basilaris japonica* and *Rhipidolestes amamiensis amamiensis*. The island supports an extremely rich composition of insect fauna, such as *Pararrhynchium tsunekii* (endemic species), *Vollenhovia amamiana* (endemic species to Amami and Tokunoshima Is.), *Diestrammena gigas*, which was found in an abandoned manganese mine on Mt. Yuwan (Oshiro, 1986), *Periplaneta suzukii* (disjunct distribution, northern limit), *Pyrocoelia oshimana* (endemic species), *Dorcus titanus elegans* (endemic subspecies), and many more. There are also subspecies of *Papilio okinawensis amamiensis* and *Atrophaneura alcinous loochooana* that are endemic subspecies to the Amami Islands and live in populated areas.

Kakeromajima shares many of the same endemic species and subspecies in common with Amami Ōshima, but it is also part of larger habitats made up of several islands that share many of the same endemic subspecies, including *Coeliccia ryukyuensis amamii* (Amami, Kakeromajima, Tokunoshima, and Okinawa Island) and *Matrona basilaris japonica* (Amami, Kakeromajima, Tokunoshima, and Okinawa Island). Despite its proximity to Amami Ōshima, Ukeshima has *Neolucanus progenetivus hamaii* as an endemic subspecies. *Aegus laevicollis taurulus* and *Dorcus titanus tokunoshimaensis* occur on Yoronjima.

Kikaijima is home to endemic species and subspecies like *Nocticola uenoi kikaiensis* (only one male and one female), *Agrypnus miyamotoi kikai* and *Paracardiophorus tokara kikai* (endemic subspecies). Butterflies include the rice paper butterfly (*Idea leuconoe clara*), of which Kikaijima is its northern distribution limit. Tokunoshima is also quite mountainous. In addition to endemic species and subspecies such as *Dorcus amamianus kubotai*, *Drilaster iokii*, *Tiphia tokunoshimana*, and *Planaeschna naica* (endemic species of Amami and Tokunoshima), *Graphium doson albidum* (subspecies north to the Okinawa Islands) is also distributed in Tokunoshima. Okinoerabujima is a virtual treasure chest of endemic species and subspecies, including *Symploce okinoerabuensis*, *Aegus laevicollis tamanukii*, and *Dorcus titanus okinoerabuensis*. Okinoerabujima is also the northern distribution limit of *Curtos okinawanus*. Yoronjima is mostly covered by buildings and farmland. It also has a burgeoning tourism industry. Yoronjima is inhabited by dragonflies of the family Aeshnidae, and is a habitat for a local community of common roses (*Pachliopta aristorochiae interposita*) as they expand north (their current northern limit is Amami Ōshima).

Tokara and Amami Islands: (v) Fish

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The terrain of Amami Ōshima is mountainous, with high peaks and a well-developed terrestrial water system. Many of its rivers have middle reaches of significant scale. Several rivers in the central and southern parts of the island nurture the Ryukyu ayu (*Plecoglossus altivelis ryukyuensis*), a subspecies endemic to the Ryukyu Islands (Nishida et al., 1992). These rivers produce many fish in the genera *Sicyopterus* and *Rhinogobius*. Living in the very pristine downstream parts of these rivers are the tropical carp-gudgeon (*Hypseleotris cyprinoides*), and mud gudgeon (*Ophieleotris* sp.) (Yonezawa et al., 2003). The estuarine regions of some rivers have mangrove forests, where many mangrove red snapper (*Lutjanus argentimaculatus*), Okinawa seabream (*Acanthopagrus* sivicolus), and other peripheral freshwater fish can be seen. These areas also sustain a diverse variety of freshwater gobies (Shinomiya and Ike, 1992; Hayashi et al., 1992). Amami Ōshima is the northern distribution boundary for many of these fish.

Among the Amami Islands, Tokunoshima has the second best terrestrial water system next to Amami Ōshima, but it has no rivers with tidal mudflats or mangrove forests at their estuaries. There is a paucity of information on fish in inland water sources, but there are reports of mud gudgeon and stream goby (*Rhinogobius sp.*) on the island (Ike et al., 1990; Sawashi, 1995).

Tokara and Amami Islands: (vi) Crustaceans

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The Tokara Islands are the northern distribution limits for rare species such as the Sakishima freshwater shrimp (*Caridina rapaensis*) and Sakamoto's freshwater crab (*Geothelphusa sakamotoana*) in the island group's rivers and the coconut crab (*Birgus latro*) and the unilobed porcelain crab (*Petrolisthes unilobatus*) on its beaches. Nakanoshima is notable as the southern limit for the distribution of the Japanese freshwater crab .

Of the Amami Islands, Amami Ōshima, Kakeromajima and Tokunoshima have rivers that are nearly unadulterated. Extremely rare habitats for rare species of freshwater crabs and prawns can be found in sites (locality records of collected specimens) in the middle reaches and upstream regions of the mountain rivers. The mudflats around river estuaries and inlet environments form important habitats for rare crabs. Kasari Bay, Sumiyō Bay, and shore facing the Ōshima Strait still retain extensive mudflats, and the presence of many rivers contributing to inflow makes them particularly important. In addition, the rocky splash zones at Amami Ōshima and Kakeromajima serve as important habitats for land crabs such as the polished dwarf land crab (*Epigrapsus politus*), purple land crab (*Gecarcoidea lalandii*), and *Metasesarma obesum*.

The islands of Kikaijima, Okinoerabujima and Yoronjima all possess few rivers, yet they do have good groundwater systems in addition to caves and springs (Yoshigou et al., 2005). These islands are the northern distribution limit for long-legged troglobitic shrimp (*Caridina rubella*), *Metabetaeus minutus*, and similar anchialine shrimp.

Tokara and Amami Islands: (vii) Mollusks

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Eighty species of terrestrial mollusks have been reported in the Tokara Islands (Kurozumi, 1994). They can be divided into two species groups: the Yakushima/Tanegashima group and the Amami group (Minato, 1989). The forested regions of Nakanoshima, Takarajima, and Akusekijima are critical habitats for endemic species that only occur there. Most marine mollusks are rock reef-dwelling tropical species that are distributed throughout the Indian and Pacific Oceans.

The land snail fauna of the Amami Islands contains many endemic species and is highly diverse. These snails have speciated into several groups (genera). The evergreen broadleaf forests in the mountains on the whole of Amami Ōshima, the eastern part of Kikaijima, the northern and central parts of Tokunoshima, and the central part of Okinoerabujima contain land snails rich in species diversity and are important habitats for many endemic species.

The habitats of sea snails that live in the waters off the shores of the Amami Islands constitute a diverse combination of environments, including mangrove forests, mudflats, and coral and rock reefs. The mangroves and mudflats in Kasari Bay, Sumiyō Bay, and the Ōshima Strait shore each have distinctive mollusk fauna and are therefore habitats of particular importance. A total of 227 mollusks have been reported in the mudflat areas of the Amami Islands (Nawa, 2008). Most of them are tropical species seen throughout the Indian and Pacific Oceans, but a few are temperate species with distributions in Kyushu and farther north and the coast of continental China.

Tokara and Amami Islands: (viii) Seagrasses/Algae

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The Tokara Islands: There is currently only fragmentary data on algal flora in the Tokara Islands, so more comprehensive descriptions must wait for future studies. There is a report by Ogura et al. (2005) on dugong and seagrass as a food source for the animal. According to that study, the shore topology and ocean currents make Nakanoshima and Takarajima unsuited to the growth of seagrass.

The Amami Islands: The waters around the Amami Islands have well-developed coral reefs. The present overview of seagrasses and algae draws upon the findings of a study done in 2008 that focused chiefly on Amami Ōshima (Kamura et al., 2008) as well as information sources concerning seagrass beds and algae around Amami Ōshima (Kida 1964; Tanaka and Itono, 1968; Ogura et al., 2005). According to Kamura et al. (2008), seagrass beds consisting of mostly tape grasses in the genus *Halophila* (*H. ovalis* and *H. major*), can be seen at the coral reefs of Amami City's Yōan and Ayamaruzaki, which face the Pacific. The narrow sounds formed by the Amami Strait is pitted with bays like the teeth of a comb, and perhaps due to the relative tranquility offered by these conditions, the sand and gravel beds feature *Halophila tape grasses*, Halodule sea grasses, and noodle sea grass (Syringodium isoetifolium) beds. In addition, *Acetabularia ryukyuensis* and many other forms of algae grow near the banks.

Considering the reports above, the conservation of the seagrass beds in these tranquil sounds of Setouchi is crucial. A total of eight indicator species of algae have been confirmed from studies of Amami Ōshima. Particularly worthy of note are the seven indicator species —among which are species listed in Okinawa Prefecture's Red Data Book— found at Ayamaruzaki. At the same time, in addition to many types of species of algae, lush communities of *Boergesenia forbesii* and *Cymopolia vanbosseae* have been reported thriving in the coral reefs of Sani in Amami City. Given these observations, it can be concluded that the waters containing the coral reefs extending from Sani, Kasarizaki and around to Ayamaruzaki are crucial from a conservation standpoint. The presence of widgeon grass (*Ruppia maritime*), which grows in brackish waters, has been confirmed in a brackish area of Yadon district in Uken Village (Kamura et al., 2008). Two rivers flank the brackish water area in which widgeon grass occurs, and mangrove algae can be seen on concrete faces of these river banks and in their tributary streams. The possibility of including the sites where widgeon grass naturally occurs and the estuarine regions of both rivers in one protected wilderness area must be considered. The widgeon grass issue is one that needs to be addressed as soon as possible.

3. Okinawa and Kerama Islands

Okinawa and Kerama Islands: (i) Mammals

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Important areas for mammals on Okinawa Island can be classified into three zones: the forests of Yanbaru on the northern part of Okinawa, the surrounding waters, and the caves in which bats dwell.

As in other areas, the importance of the Yanbaru area lies in the fact that subtropical forests representative of the Central Ryukyus remain there, and these forests serve as habitats for endemic arboreal species. Among these species are the Okinawa spiny rat (*Tokudaia muenninki*) and Ryukyu long-furred rat, two species for which it has finally become possible in recent years to gather population/distribution and ecological information, and two novel species of arboreal bats (*Myotis yanbarensis* and *Murina ryukyuana*) which had recently been discovered but about which little was known. One feature of rare mammalian species endemic to this area is that they are highly dependent upon forests. Forests composed of old trees and forests of a certain expanse and contiguity are important for such species. Furthermore, there are a great many species that have inherent scientific value as subjects in biological comparative studies with related species and biogeographic research in general.

The waters in the area have well developed seagrass beds. The formation of such beds is important in and of itself, and they also serve as a major food source for dugong. There have been sporadic reports of dugong sightings chiefly in this area (Okinawa Island and the surrounding waters). Seagrass beds are being maintained in good condition.

The caves of cave-dwelling bats are widely distributed from north to south, but since cave conditions have a major affect on birthing, rearing and hibernation, the caves favorable to those conditions become limited. Suitable caves are scarce even on Iheyajima and other nearby remote islands. One interesting feature of least horseshoe bats seen in the central and southern parts of the area is that their abilities of flight are limited so when rearing young they must forage for food in forests nearby their nesting caves. For this reason, caves they depend upon are not only ones in unadulterated natural settings. They are also located in populated settlements, even around urban areas.

Okinawa and Kerama Islands: (ii) Birds

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Okinawa Island and the nearby remote islands are biogeographically similar to the Amami Islands that neighbor to the north, and many species are found in both island groups. There are animals, however, whose subspecies differ between the two. One such example is the brown-eared bulbul (*Hypsipetes amaurotis*).

It is thought that Okinawa Island was at one time covered by evergreen broadleaf forest, but in the central and southern parts of the island, the effects of the Battle of Okinawa and post-war urbanization drastically reduced the coverage of forestland (Takehara et al., 2009). The northern part of the island, in contrast, has well-preserved forests. Particularly important is the Yanbaru forest that hosts arboreal birds. In addition to the Okinawa woodpecker and Okinawa rail (*Gallirallus okinawae*), which are endemic to the island, there are also distinctive species such as the Amami woodcock and Ryukyu robin that the island shares with the Amami Islands. In addition to these, there are many species and subspecies endemic to the Ryukyu Islands, such as Ryukyu scops owl and narcissus flycatcher. The surrounding remote islands that have mountains, including the Kerama Islands, Kumejima, Iheyajima, and Izenajima are covered by evergreen broadleaf forest, much like Yanbaru.

The beaches and tidal mudflats are vital as breeding grounds for terns and as wintering grounds for snipes and plovers. The shores of Okinawa Island and the surrounding remote islands still have many well-developed sandy beaches, but many of them are being lost to reclamation projects.

Okinawa Island has a good system of rivers that play an important role in the survival of snipes, cinnamon bitterns and other birds, but there are almost no river systems on the surrounding islands. With the exception of artificial lakes created by dams, there is little swampland on Okinawa or the remote islands in the group, but the paddies left in Kin Town, Ōgimi Village's Kijoka district, and the islands of Tokashikijima and Izenajima play important roles as wintering sites for terns, snipes and plovers.

Okinawa and Kerama Islands: (iii) Amphibians/Reptiles

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Mamoru TODA (University of the Ryukyus),
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If one excludes species that are obviously nonnative (Ota et al., 2004), there are 12 amphibian and 21 terrestrial reptile species and subspecies on the Okinawa Islands, exclusive of Kumejima (Maenosono and Toda, 2007). Of these, those endemic to this island group include the Ryukyu tip-nosed frog (*Odorrana narina*), Namie's frog (*Limnonectes namiyei*), Holst's frog (*Babina holsti*), Kuroiwa's eyelid gecko (*Goniurosaurus kuroiwae*), Toyama's eyelid gecko (*G. kuroiwae toyamai*), and the mottled eyelid gecko (*G. kuroiwae orientalis*). The vast majority of the remaining species and subspecies are endemic to the Okinawa Islands as inclusive of, such as the Okinawa green tree frog (*Rhacophorus viridis viridis*), the Ryukyu black-breasted leaf turtle (*Geoemyda japonica*), Takara's oriental coral snake (*Sinomicrurus japonicus takarai*), and the undescribed Okinawa Gecko (Gekko sp.), or to the the Central Ryukyus as inclusive of the Amami Islands and the islands of Southern Tokara in addition to the Okinawa Islands. Furthermore, many of these endemics have no corresponding sister groups in neighboring regions (the islands north of the Tokara Tectonic Strait, or the Northern Ryukyus, and the islands south of the Kerama Gap, or the Southern Ryukus), and thus are considered to be relicts. As was noted in the section on the islands of Northern Amami, phylogeographic characteristics of these amphibians and reptiles are thought to reflect the consistent isolation of the Central Ryukyus as a large island or an assemblage of islands at least since the end of Pliocene (Ota, 1998). Okinawa Island is the largest landmass not only of this region, but also of all islands belonging to the Nansei Islands. Hence, it is not surprising that the island also has the largest number of amphibians and terrestrial reptile species. Nevertheless, there are some subspecies, such as Toyama's eyelid gecko (only found on Iheyajima) and mottled eyelid gecko (only found on Iejima, Tokashikijima, Akajima, and Tonakijima) whose distributions are confined to a few surrounding remote islands.

The northern part of Okinawa Island, Kudakajima, and the islands of Kerama have beaches that are frequently used by sea turtles for nesting. Okinawa Island and Kudakajima are visited mainly by nesting loggerhead turtles, while Yakabijima and other islands of Kerama are used for nesting mostly by common green turtles. Aside from these two species, hawksbill turtles have been known to land and nest on the beaches in this area, although fairly infrequently (Okinawa Prefectural Board of Education, 1996). To date, Kudakajima is the only island in this area known to be a nesting site for sea kraits, specifically black-banded and blue-lipped sea kraits (Ota, 1995).

When we exclude species that are obviously nonnative (Ota et al., 2004), there are five species of amphibians and 17 species of terrestrial reptiles on Kumejima. Of these, Kikuzato's stream snake (*Opisthotropis kikuzatoi*) and Yamashina's eyelid gecko (*Goniurosaurus kuroiwae yamashinae*) are species and subspecies, respectively, endemic to this island (Maenosono and Toda, 2007). Snakes of the genus Opisthotropis, to which Kikuzato's stream snake belongs, are not seen anywhere else in the Ryukyu Islands or Taiwan, and because other species of this genus whose morphological characteristics suggest close affinity are found only in Fujian Province of mainland China and southwards, Kikuzato's stream snake is considered to be in an extremely relict state (Okinawa Prefectural Board of Education, 1993). Also, this snake is the only snake in Japan that is mostly active in terrestrial water sources (Ota, 2004), and these ecological peculiarities are likewise worthy of note. Kumejima is also a habitat for Takara's oriental coral snake which also lives on Tonakijima, the islands of Kerama, and Iejima. All other species and subspecies of amphibians and terrestrial reptiles on Kumejima also occur on Okinawa Island, and as far as the currently available data are concerned, conspecific populations on these two islands are genetically relatively similar (Toda et al., 1999, 2001; Ota and Hamaguchi, 2003).

A study of sea turtles, which was based mainly on interviews of inhabitants, confirmed the existence of nesting beaches on Kumejima (Uchida et al., 1984), but very little information is available regarding the species composition of nesting turtles, nesting frequency, etc. There is no evidence of sea kraits nesting on this island (Ota, 1995).

Okinawa and Kerama Islands: (iv) Insects

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Highly detailed investigations have been conducted of the natural forests in the mountains of Kumejima, its mountain streams, populated areas, low-lying marshes, swamps and even of the artificial ponds on the island. The data presented here are based on the findings of those studies by Fumiyasu Sato, who is director of the Kumejima Fire fly Museum ("Kumejima Hotaru-kan"). Kumejima is inhabited not only by many species and subspecies endemic to the island, including the Kumejima fire fly (*Luciola owadai*, a prefectural Natural Monument), *Stenocladius flavipennis*, *Prosopocoilus dissimilis kumejimaensis*, *Aphaenogaster kumejimana*, and *Atachycines apicalis gusouma*, but also a great number of species endemic to the Okinawa Islands or the Central/Southern Ryukyus, such as *Muda kuroiwae*, *Euodynerus nipanicus flavicornis*, and *Coeliccia ryukyuensis ryukyuensis*. What is more, a considerable number of those species have traits unique to Kumejima (Sato, private correspondence). *Dorcus titanus okinawanus* and *Aegus laevicollis nakanei*, which occur in the Kerama Islands, reflect the historical geological relationships between the Kerama and Okinawa Islands. The *Drilaster fuscicollis keramensis* population on Tokashikijima is an endemic subspecies.

Iheyajima has many endemic species and subspecies, such as *Drilaster akakanajai*, *Aegus laevicollis doii*, *Neotachycines obliquofasciatus*, and *Protaetia exasperata iheyana*. In the mountainous area further inland are confined habitats for Iheya's populations of *Coeliccia ryukyuensis ryukyuensis*. Iejima is inhabited by *Gampsocleis ryukyuensis* (Near Threatened) and Izenajima by *Enithares sinica* (Near Threatened).

For reasons of continuity in vegetation and habitat types, Okinawa Island is divided here into three regions: the northern region, which spans the area commonly known as Yanbaru (Kunigami administrative district) to Nago City and Kin Town, the Motobu Peninsula (for geological reasons), and central/southern Okinawa.

The northern region of Okinawa Island serves as a habitat for many endemic species and subspecies such as the Yanbaru long-armed scarab beetle (*Cheirotonus jambar*), *Neolucanus okinawanus*, *Hydraticus pacificus sakishimanus*, *Chlorogomphus brunneus brunneus Paterdecolyus yanbarensis*, *Vollenhovia yambaru*, and *Parachauliodes yanbaru*, in addition to species of disjunct distribution and those whose northern distribution borders are located here. Furthermore, the dams, fallowed rice paddies, reservoirs and other artificial water systems in Nago City and Kin Town support *Cybister rugosus* (classified as Vulnerable) and *Notonecta montandoni* (Near Threatened). There are also species and subspecies like *Okinawepipona kogimai kogimai* (endemic subspecies of the Okinawa Islands; different subspecies live in Southern Tokara and Amami) which depend upon environments populated by humans.

The Motobu Peninsula has geological strata that are older than those of Yanbaru and in fact date back to the Permian period of the Paleozoic Era and Triassic period of the Mesozoic Era. This region was cut off from Nago by the Butsuzo Tectonic Line (a geological formation; see Nakamura et al., 1996). Part of the peninsula contains a tract of limestone formed from coral reefs that are several hundred million years old (ibid.). Insects that live on the peninsula include *Drilaster fuscicollis fuscicollis* (endemic subspecies; lives only in the northern part of Okinawa Island), *Ornebius longipennis ryukyuensis*, *Muda kuroiwae* (Endangered or Vulnerable, Nakijin Gusuku), *Meimuna oshimensis* communities (Nakijin Gusuku), the orange oakleaf (*Kallima inachus eucerca*) and *Polyura eudamippus weismanni* (a prefectural Natural Monument).

Broadly speaking, central/southern Okinawa Island is composed of Ryukyu limestone. Much of this area is covered by urban establishments and farmland, not to mention the vast area taken up by United States military installations. Nevertheless, there are still sporadic biotic groups that provide important clues to understanding the natural history of the Ryukyu Islands. Regarding cicadas (Sasaki et al., 2006), the mountain-dwelling *Platypleura kaempferi* (for which the central part of the island is the southern limit), the flatland-dwelling *Meimuna kuroiwae* (showing drastic decreases in the south), and grassland-dwelling *Mogannia minuta* (northern boundary). Among noteworthy beetle species is *Drilaster tenebrosus* (endemic species found only on central/southern Okinawa Island). *Curtos okinawanus* (around housing) still inhabits this region, yet in the past 20 years, numbers in Naha City have dropped of drastically. Other species in this region worthy of note are *Protaetia lewisi lewisi* (Near Threatened, Nakijin Gusuku), *Prosopocoilus dissimilis okinawanus* (campus of the University of the Ryukyus, Naha, Tamagusuku, etc.), and *Cybister rugosus* (Gushikawa City). Notable butterfly data includes the localized occurrence of *Daphnis nerii* (Ginowan City), reports of *Zizula hylax* (Naha, northern limit), and in Kudeken wintering groups of *Ideopsis similis similis* and *Parantica sita niphonica*. *Xylocopa flavifrons* (Hyakuna elsewhere) and *Diacamma* sp. (endemic to the Ryukyu Islands; undescribed species) have been confirmed in the forests of Utaki, Gusuku, and surrounding sites in the south. The tussocks and park edges in urbanized areas are habitats for *Amantis nawai*, *Loxoblemmus equestris* (in Japan, distributed only in the Ryukyu Islands), *Taulia ornata okinawaensis* (localized), *Cardiodactylus guttulus* (localized), and *Duolandrevus ivani*. (Tamagusuku). The pond and marshes where *Rhyothemis variegata imperatrix* live in have decreased dramatically because of the construction of roads and housing. In the Awase Tidal Flats, much of which was reclaimed, *Clunio marinus*, which lives in rock depressions, was discovered (specimen confirmed).

Okinawa and Kerama Islands: (v) Fish

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Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Okinawa Island is the largest of the Nansei Islands, and although they are not very long, there is a diverse system of rivers (Tachihara, 2003). Particularly in the northern part of the island informally known as “Yanbaru”, there are many river environments that are cool, clear, and relatively large for the Nansei Islands. Ryukyu ayu, which once lived in the northern part of Okinawa Island, became locally extinct in the late 1970’s, and there are many freshwater fish in danger of extinction in the terrestrial waters of this area. One such species is a landlocked species of freshwater goby (*Rhinogobius* sp.) endemic to the north of Okinawa Island. Sightings of populations of the belted rockclimbing goby, specklefin rockclimbing goby (*Sicyopus leprurus*), *Stiphodon atropurpureus*, and loach goby were once fairly rare, but they have increased in recent years. This is assumed to be a consequence of a northern expansion in distribution resulting from global warming. Careful monitoring is necessary to determine if this distribution expansion is only temporary or will become more permanent.

The Uka River, which is located near the eastern shore of Okinawa Island, is very rare in that it is the only river on the island that is completely surrounded by subtropical forest, from its uppermost reaches to its mouth. In the Teima River, which empties into the Ōura Bay, at least 191 species of fish have been confirmed, making it a highly diverse water system (Maeda and Tachihara, 2006). Also emptying into Ōura Bay is the Ōura River, which likewise contains a highly diverse array of fish fauna. One of the reasons for so many rare species of fish living in these two rivers is thought to be the unique shape of the Ōura Bay, which is characterized by deep waters stretching from well off the shore to the innermost parts of the bay. Ōura Bay and the water systems around it are some of the most important places on Okinawa Island.

Okinawa and Kerama Islands: (vi) Crustaceans

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Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The region on the northern part of Okinawa Island known as Yanbaru is blessed with high-quality river, forest, and shore environments, and is an important habitat for many creatures. Okinawa Island's Motobu Peninsula has a mountainous area made up of Paleozoic limestone that supports the long-legged freshwater crab (*Geothelphusa* tenuimanus). The area also has rare environments such as saltwater rivers generated by saline springs, and anchialine shrimp have been reported. The central and southern parts of Okinawa Island still has caves and springs which sustain freshwater crabs, as well as scattered areas of high-quality shore and mudflat environments, which serve as important habitats for rare species (Osawa and Fujita, 2005a). The Ōura Bay, Kin Bay, and Nakagusuku Bay of the eastern coast of Okinawa Island, together with inflowing rivers, support peculiar fauna, including crustaceans that are rarely seen elsewhere (e.g. Shokita et al., 2002). Furthermore, many new crustacean species have been discovered in recent years (Naruse, 2005; Osawa and Fujita, 2005b; Osawa and Fujita, 2007; Naruse et al., 2009).

As for the small islands around Okinawa Island, no exhaustive studies have been done, and data available is only fragmentary, but it is known that the endemic Iheya big freshwater crab (*G. iheya*) lives around the rivers of Iheyajima (Naruse et al., 2006).

No extensive studies have been done of the Kerama Islands either, and information is limited, but the river areas are inhabited by several endemic species, including the Tokashiki big freshwater crab (*G. levicervix*) and Kerama freshwater crab (*G. amagui*) (Naruse et al., 2006, 2007).

There are a number of distinctive microenvironments on Kumejima, including the rivers that run through its mountains, rocky splash zones of high quality, caves with extensive underground water systems, shallow seas with underwater caves, etc. The areas around the rivers serve as habitats for the endemic Kumejima freshwater crab (*Geothelphusa kumejima*) and Kerama freshwater crab (*G. amagui*).

Okinawa and Kerama Islands: (vii) Mollusks

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The Okinawa Islands have many endemic species of terrestrial mollusks and a high degree of species diversity. The evergreen broadleaf forests of the northern mountainous region of Okinawa Island (the Yanbaru area) and the limestone areas of the Motobu Peninsula and Ōgimi Village are very important habitats for many endemic species. The limestone areas in central Okinawa (Okinawa City) and to the south of the island (Tamagusuku of Nanjō City and Itoman City) are likewise important as habitats for endemic species that are only found in each of those areas.

The habitats of marine mollusks that live in the waters off the shores of the Okinawa Islands comprise a diverse combination of environments, including mangrove forests, tidal mudflats, seagrass and algae beds, and coral and rock reefs. The mangroves and mudflats of Haneji Inland Sea, Ōura Bay, and Nakagusuku Bay each have distinctive mollusk fauna and form important habitats for them. To date, 524 species of mollusks have been reported in the mudflat areas of the Okinawa Islands (Nawa, 2009). They consist of tropical species seen throughout the Indian and Pacific Oceans, and temperate species with distributions in Kyushu and farther north and the coast of mainland China (mainland coastal species).

The terrestrial water-dwelling mollusks (mostly brackish water-dwelling species) seen at the mouths of several rivers (in brackish water) in the north of Okinawa Island and Kumejima have a high degree of species diversity, which makes these areas important environments.

There are 28 species of land snails in Zamami Village in the Kerama Islands, including Pulchraptyx longiplicata, which belongs to a genus endemic to these islands (Kurozumi, 1981). These species live in what little forested area there is left. The habitats of marine mollusks off the shores of the Kerama Islands range from rocky reefs, sandy beaches, moat and mudflats on the shoreline to the seagrass and algae beds off the shores. The shores of the Kerama Islands are known to have an extremely high degree of mollusk species diversity. Habe and Tsuchiya (1998) recorded 975 mollusks (including cephalopods) on Akajima and the surrounding waters. The moat, mudflats and seagrass/algae beds in the coves are some of the few places where certain large gastropods like auger snails thrive.

Okinawa and Kerama Islands: (viii) Seagrasses/Algae

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Okinawa Island: The Okinawa Islands consist of Okinawa Island, which is the largest landmass in the Nansei Islands, and the multiple islands around it. Seagrass beds have developed in the sand and gravel beds in moats (colloquially known as “inō”), as well as in the island’s bays. This summary draws heavily upon Okinawa Prefecture’s *Guidelines for Environmental Conservation* (1998, 1999), which is a compilation of findings from existing studies, and Broad Survey Report on *the Dugong and Seagrass Beds* (2002b, 2003, 2003b, 2004, 2005), which was commissioned by the Ministry of the Environment. The primary distribution of seagrass beds off Okinawa Island is as follows: the region from Awase to the Katsuren Peninsula side of Nakagusuku Bay, both sides of Uruma City's bridge connecting its lesser islands to Okinawa Island, the east side of Miyagijima, the area from Kin to Teniya, the north sides of Yagajishima and Kourijima, the moat in Onna Village, the area from Naha Airport to Tomigusuku City, and the village of Kyan in Itoman City. These seagrass beds are also important in terms of marine resources.

When we examine five indicator species in brackish and inland freshwater systems, (namely the brackish widgeon grass and red alga, *Catenella caespitosa*, the brackish and freshwater red alga *Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis*, and the freshwater green alga *Dichotomosiphon tuberosus*), widgeon grass in Okinawa Prefecture grows in the saline streams that are part of the Sugā salty river complex on the Motobu Peninsula (Omori, Kamura and Shokita, 1983; National Natural Monument), and the marshland in the Okinawa Prefectural Athletics Park in Okinawa City (this habitat is threatened because there is no more saline inflow (Kamura et al., 2007)), and conservation of these two sites should be a priority. The famous Yanbaru area of Okinawa Island is widely-known for its rich flora and fauna. Algae in the area include *Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis*, which are distributed from brackish areas to the upper reaches of rivers. Information on the distribution of these two species in Yanbaru was gathered from data from the Okinawa General Bureau (2002). These two species can be seen in rivers throughout the area. Given this fact, it is clear that forested regions with numerous water systems are extremely important from a conservation perspective.

Dichotomosiphon tuberosus, which occurs only in freshwater, needs a certain degree of water flow and a muddy bed to attach to, either around springs in raised coral reef bases, or in water channels or dikes that supply springs (Kamura and Ie, 1998; Kamura, 1998). The area encompassing the group of springs on the south slope at Chinen in Nanjō City, and the fields of *taumu* (an edible plant) in Ōyama in Ginowan City should be selected as wilderness areas for the preservation of this species. The hinterland of the taumu fields has a group of prolific springs, and with all of the other flora and fauna here, its presence is like that of an urban oasis. In the mangrove marshes grow forms of algae that are unique to such brackish water regions, and are therefore collectively referred to as "mangrove algae" (Kamura, 2000).

The Sugā River (literally "salt river" in the local dialect), which is located on a section of the Motobu Peninsula, is a river supplied by water that springs from a cave, and is a National Natural Monument. As this saline river contains rare and precious forms of algae and animal life, its value as a wilderness area is immense (Omori, Kamura and Shokita, 1983). In addition to indicator species such as *Bostrychia simpliciuscula*, *Caloglossa ogasawaraensis*, widgeon grass, and *Catenella impudica* (Near Threatened species), the river also contains several other species of algae, including *Enteromorpha compressa* and Ulva reticulate.

Iheyajima and Izenajima: Only fragmentary data exists for seagrasses/algae on these islands. However, a report by the Ministry of the Environment (2004b) does indicate the distribution and location of seagrass beds. The waters around Iheyajima have fringing reefs with moats. The east and west sides each have small seagrass beds in some of the moats. The coral reefs present a breathtaking view, so much so that one can almost sense the richness of flora and fauna. Izenajima has expansive coral reefs spanning from its port to its northern side. There is a fairly large seagrass bed between Kubazaki and Jicchaku to the northwest of the island.

The Kerama Islands: Ohba (1996) reported 219 species of algae and three species of seagrass in the area around Akajima (4 km^2) in the Kerama Islands. Baba (1997) reported 18 species of crustose coralline algae. The fact that over 200 species of algae grow around this small island is indicative of the richness and diversity of the species here, making this tiny island extremely valuable. As more studies are done that encompass all of the Kerama Islands, the number of species will surely rise. A total of 12 indicator species have been recorded: 10 algae species and two seagrass species. Seagrass beds are relatively few in number, with small ones off Tokashikijima, Zamamijima, and Akajima.

Agunijima and Tonakijima: A summary of algal flora for Agunijima and Tonakijima must wait for further studies, as no data is currently available. There is a seagrass bed in a moat off the east side of Agunijima. There are also seagrass beds in moats on the east and west sides of Tonakijima that cover roughly 26 hectares in area (Ministry of the Environment, 2005).

Kumejima: One of the reasons the whole island of Kumejima was classified as the “Kumejima Prefectural Natural Park” was the rich variety of its shoreline’s topological features. To the east of the island is a raised coral reef that is shaped like a giant fishhook, so the south side is shaped like a bay. Fringing coral reefs can be seen on the west side. There is still much to be learned about the algae and seagrasses of this island, but six seagrass species have been reported (Ministry of the Environment, 2006; Toma, 1999). There are several seagrass beds in the inner part of the bay on the east side and on the east reef (about 72 ha), and three inside a barrier reef (about 48 ha) (Ministry of the Environment, 2006). Kumejima has four indicator species of seagrass (sickle seagrass [*Thalassia hemprichii*], serrated ribbon seagrass [*Cymodocea serrulata*], spoon seagrass [*Halophila ovalis*], and *Zostera japonica*) and nine indicator species of algae (Ministry of the Environment, 2006; Kamura and Iida, 1981; Toma, 1999). As a side note, the red alga *Laurencia palisade*, which was previously thought to only occur in Taiwan, was found among the coral reef in the bay on the east side of the island (Masuda et al., 1998). This species is classified as DD (Data Deficient) in *Red Data Okinawa*, but since Okinawa Prefecture had no information concerning this species, it should be upgraded to a Threatened status. Kumejima must be protected, from both a biodiversity perspective and to preserve the scenery offered by the bay on the east of the island and moat on the west.

4. Daitō Islands

Daitō Islands: (i) Mammals

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The Daitō Islands are the only oceanic islands in the Nansei Islands, making its flora and fauna especially interesting. The Daito flying fox (*Pteropus dasymallus daitoensis*) is an endemic subspecies found only here, and it differs morphologically from related subspecies on other islands. It is also assumed to have ecological variations that are specially adapted to its unique environment.

Daitō Islands: (ii) Birds

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The Daitō Islands, which are the only oceanic islands in the Nansei group, are separated from its neighbor Okinawa Island by nearly 400 kilometers. This separation has nurtured a rare and valuable ecosystem of the type peculiar to oceanic islands, with many endemic species and subspecies.

However, people began to settle on the islands around the year 1900. The primitive forests that once covered Kita Daitō and Minami Daitō (literally “North” and “South” Daitō, respectively) Islands have all but been cleared, replaced by sugarcane fields. At least four species and subspecies endemic to these two islands are now extinct, and the Daito Island buzzard (*Buteo buteo oshiroi*, which is likely already practically extinct) and Daito scops owl (*Otus elegans interpositus*) are considered endangered species. Given the isolation of these remote and small islands, it is not hard to imagine the irreparable devastation to species survival that was caused by development.

Despite this push for development, there are belt-shaped formations called hagu that could not be converted to farmland where windbreak forests remain, and as a result of the tree-planting that started around 1920, there are still forests on hagu and around shrines. These forests serve as important nesting and feeding grounds for birds.

The topography of Kita Daitō and Minami Daitō Islands is peculiar in that they are surrounded by precipitous cliffs dropping off into the ocean, but the centers of the islands have depressions. For this reason, there are many ponds and marshes in the islands’ centers. These ponds and marshes support resident birds such as the Borodino Islands grebe (*Tachybaptus ruficollis kunikyonis*) the cinnamon bittern, and the Indian small blue kingfisher (*Alcedo atthis bengalensis*), and provides a resting place for migratory birds.

Daitō Islands: (iii) Amphibians/Reptiles

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Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

Just as with many other oceanic islands, there are no native amphibians on the Daitō Islands. The two toad species, the cane toad (*Bufo marinus*) and the Miyko toad (*B. gargarizans miyakonis*) and Sakishima rice frogs (*Rana sakishimensis*) were all introduced by people (Ota et al., 2004). Nearly all of the terrestrial reptiles are also alien invasive species, but one exception is the parthenogenetic mourning gecko (*Lepidodactylus lugubris*), which, unlike the mourning gecko seen elsewhere in the Nansei Islands or Ogasawara Islands, is probably native to the Daitō Islands. The communities of this species on the Daitō Islands exhibit a high degree of clone diversity (one diploid clone and 11 triploid clones) and endemicity (only one clone is possibly distributed outside the Daitō Islands) (Yamashiro et al., 2000), and therefore it is noteworthy from a scientific perspective.

Because all of the islands are almost entirely surrounded by precipitous cliffs, there is no possibility that sea turtles nest on them. Also, there have been no sightings or evidence of sea kraits nesting on the Daitō Islands.

Daitō Islands: (iv) Insects

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Seiki YAMANE (Faculty of Science, Kagoshima University),
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Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

The Daitō Islands are oceanic islands, and have never in their geological history been connected to the Okinawa Islands. Japan's southernmost lakes and marshes are located on these isolated islands of raised coral (Nakamura et al., 1996.). In these lakes and marshes *Zyxomma obtusum* (disjunct distribution, Red Data Book) lives, a species that is distributed over Indonesia, Polynesia, and the Philippines. In the mere 100 years since the islands were covered by forests, the habitats of *Figulus daitoensis* (endemic species), *Dorcus titanus daitoensis* (Near threatened, endemic subspecies) and similar endemic stag beetles have been reduced to the marginal forest zone on the precipitous cliffs surrounding the islands. Nevertheless, many endemic species/subspecies and locally important populations are found on the islands, including *Oryctes hisamatsui* (endemic to Minami Daitō Island), *Camponotus daitoensis* (endemic species), *Euterpnosia chibensis daitoensis* (Endangered or Vulnerable), *Caconemobius daitoensis* (Near Threatened), *Cybister rugosus* (Vulnerable, endemic to Minami Daitō Island), and others.

Daitō Islands: (v) Fish

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Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Minami Daitō Island has multiple lakes and marshes, which is a rarity for the Nansei Islands. Because it is an oceanic island, there are no native pure freshwater fish, but there are paradise fish (*Macropodus opercularis*), Japanese rice fish (*Oryzias latipes*), and dojo loach (*Misgurnus anguillicaudatus*) that were brought from Okinawa Island when people began to settle here. In addition, introduced Mozambique tilapia (*Oreochromis mossambicus*) and guppies have invaded most bodies of water on the island. Although there are no rivers, there are extensive and complex underground water veins, and the giant mottled eel (*Anguilla marmorata*) has been confirmed in the lakes and marshes connected to the ocean.

Daitō Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

Kita Daitō Island and Minami Daitō Island are oceanic islands encircled by steep cliffs. There are no rivers to speak of, but there are groups of lakes and marshes, especially on Minami Daitō Island. There are also a number of grottos on the islands, including spots where subterranean water sources can be seen. The cavernous subterranean water system on Minami Daitō Island is inhabited by the long-legged troglobitic shrimp which has been selected as an indicator species, as well as rare subterranean water-dwelling decapods such as *Antecaridina lauensis* and *Metabetaeus minutus*. In 2009, a new species in the order Thermosbaenacea was described based on material from an anchialine cave on Minami Daitō Island (Shimomura and Fujita, 2009). The Daitō Islands have geological origins and histories very different from the Ryukyu Islands, and partially for this reason they exhibit biogeographically fascinating flora and fauna. At the same time, the shorelines of the islands are made up almost entirely of rocky reefs, with almost no sandy beaches or splash zones. Coconut crabs and land crabs live around the shores. Old sources tell us that Oki Daitō Island had a considerable coconut crab population, but it is unclear whether this is still the case.

Daitō Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

The terrestrial mollusks of the Daitō Islands share some species in common with the Ogasawara Islands and the Northern Mariana Islands, so the species composition is distinct from the rest of the Ryukyu Islands. There are several species endemic to the Daitō Islands, including *Nesiohelix omphalina proximate*. The habitats of terrestrial mollusks are disjunct, confined to shoreline vegetation belts on uplifted limestone called hagu and to forests associated with shrines.

Daitō Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

The Daitō Islands are located 300 to 400 kilometers east of Okinawa Island. Only Kita Daitō Island and Minami Daitō Island are inhabited. Both of these islands were formed from uplifted coral reefs. Their intertidal zones are made up of narrow terraces. The only data available on the algal flora of the Daitō Islands is a report by Oshiro (1970) on Minami Daitō Island. The island has about 21 kilometers of coastline, and from four collection sites corresponding to each cardinal direction were recorded 110 species of algae. Eight of those species (including temperate *Sargassum fusiformis* and *S. thunbergii*, which also grow on Okinawa Island) were selected as indicator species. On the other hand, given that the coral reefs are narrow, it is unlikely that any seagrass would grow here. Kamura visited both Kita Daitō and Minami Daitō Islands in 2000 to study algae in brackish and freshwater areas, but did not observe any algae corresponding to indicator species.

Minami Daitō Island has an artificial pool made from excavating a coral reef. A fishing port has recently been completed on the island, but aside from this, the intertidal zone seems to be in the same condition as before.

5. Miyako Islands

Miyako Islands: (i) Mammals

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Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

At present, no caves in which *Rhinolophus pumilus miyakonis* dwell were confirmed, so the species was not selected. Further habitat and population studies need to be conducted.

Miyako Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

Miyakojima is located about 360 kilometers south of Okinawa Island, with no islands in between them. For this reason, as is the case with the Yaeyama Islands even farther south, more birds of southern origin (Indomalayan) such as the emerald dove (*Chalcophaps indica yamashinai*), Malayan night heron

(*Gorsachius melanolophus*), and purple heron (*Ardea purpurea*) can be seen than in the Okinawa Islands. Miyakojima and the surrounding islands are composed of terraces of Ryukyu limestone. As such, there are no tall mountains, nor are there rivers. The Nobarudake Hill area in the center of Miyakojima and the Mt. Ōno Forest area to the northeast of the Hirara urban center are important habitats for arboreal birds. The island of Miyakojima has sandy beaches where snipes and plovers winter and where terns nest. Particularly worthy of note is Yonaha Bay off Miyakojima's west bank, as it has mudflats which herons, snipes and plovers visit. The marshes on Ikemajima, which is an island to the north of Miyakojima, is visited by herons and ducks for wintering.

Since the Miyako Islands are situated between Okinawa Island and the Yaeyama Islands, they form an important leg of the migratory course for the grey-faced buzzard (*Butastur indicus*) on its way south in autumn.

Miyako Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

If one excludes species that are obviously nonnative (Ota et al., 2004), there are three known species of amphibians and 13 species of terrestrial reptiles on the Miyako Islands. Of these, one amphibian, the Miyako toad (*Bufo gargarizans miyakonis*), is a subspecies endemic to this area, while three reptiles, the Miyako grass lizard (*Takydromus toyamai*), Pfeffer's reed snake (*Calamaria pfefferi*), and the Miyako keelback snake (*Amphiesma concelarum*) are also endemic species of this island group (Maenosono and Toda, 2007). The popularity of the "eradication by seawater inundation" hypothesis (Hanzawa, 1935) proposed to explain the current absence of the habu on the Miyako Islands has contributed to an underestimation of the uniqueness of the terrestrial fauna of these islands. Rather, recent phylogenetic, molecular phylogenetic, and paleontological findings strongly suggest that biogeographically speaking, this island group is an independent center of endemicity that is very different from the neighboring Okinawa Islands and Yaeyama Islands (Ota and Takahashi, 2008). Also worthy of note is the coastal skink (*Emoia atrocostata atrocostata*), which as its name implies possesses the rare ecological feature of inhabiting coastlines, and although it is not endemic, this is the only place in Japan where it is found (Maenosono and Toda, 2007). Together with the endemic species and subspecies mentioned above, this skink helps to define the unique nature of this region.

From 1995 to 1997, Kamezaki and other specialists were commissioned by the Okinawa Prefectural Board of Education to do a comprehensive and exhaustive survey of nearly all of the beaches on which sea turtles might land and nest. It was found that sea turtles land and nest on several beaches on the eastern part of Miyakojima particularly frequently. The species nesting most frequently in this area was the loggerhead turtle, followed by the common green turtle. The hawksbill turtle showed the lowest frequency in nesting, but it was still relatively high compared to the nesting frequency of this species in other areas of the Nansei Islands (Okinawa Prefectural Board of Education, 1998). Sea kraits have also been reported nesting in the area, especially on Ikemajima (Ota, 1995). There is also the strong possibility that, in addition to the Erabu black-banded sea krait and blue-lipped sea krait, which also nest in the Central Ryukyus and farther north (see above), the yellow-lipped sea krait (*Laticauda colubrina*) also nests here, which is very likely the farthest north in which this species reproduces (Ota, unpublished data).

Miyako Islands: (iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of the Ryukyus),
Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

The Miyako Islands are fairly flat, and it is thought that because sea levels rose greatly around 1,300,000 to 200,000 years ago (Kimura, 2002), the islands were submerged, though the matter has not been the subject of a significant amount of research. However, in recent years there have been rational criticisms of this "submersion theory" (Ota, 2002). The Miyako Islands are home to *Pyrocoelia* (Near Threatened, endemic), *Platypleura miyakona* (endemic), and other non-migratory species. As for highly migratory butterflies, there are locally important populations of species such as *Atrophaneura alcinous miyakoensis* and *Salatura genutia genuyia* (northern limit). According to a survey from 1970 to 2007, while 11 species were confirmed to have established on the island, species which included the great mormon (*Papilio memnon thungergii*), the striped blue crow (*Euploea mulciber barsine*), and the grass demon (*Udaspes folus*), other species that were once very common, such as the mimic (*Hypolimnas misippus*), the plain tiger (*Anosia chrysippus chrysippus*), and the mottled emigrant (*Catopsilia pyranthe*) have drastically dropped off in numbers in recent years, which suggests that the butterfly fauna here is also quite volatile (Sunagawa, 2007). It is also a place where distributions overlap, as seen in the fact that *Xylocopa flavifrons* has its southern limit here (Miyakojima and Taramajima) while *X. albinotus* has its northern limit here (Minnajima). Species found only on Miyakojima are *Nocticola uenoi miyakoensis* (Vulnerable), *Nipponosemia terminalis* (Threatened Local Population, raised in a protected environment in the former village of Ueno), *Curtos costipennis* (limited distribution), and *Taulia ornata* spp. (undocumented endemic subspecies). Miyakojima has low-lying regions that follow a striation pattern along a fault (Nakamura et al., eds., 1996) and many small undulations on the surface of unconformity (Kizaki, ed., 1985), and it is more humid in these areas than on flatland (Sunagawa, private correspondence). The few native species remaining in these areas, plus the areas around traditional places of worship (utaki), houses and farms, form an extremely fine mosaic-like ecosystem. It is thought that this structure has enabled many species —most notably cockroaches, fire flies and other non-migratory insects— to survive. Among Miyako Islands with poor water systems, the Ikema Marsh on Ikemajima is an important habitat for species such as *Cybister rugosus* and *C. sugillatus* (listed in the Red Data Book).

Miyako Islands: (v) Fish

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Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Miyakojima has no major rivers, but it does have subterranean water veins. The inlets in the Shimajiri and Kadekaru districts have mangrove forests. These mangrove estuaries have an abundance of rare fish (Tachihara et al, 2003). Recently, however, a walkway for sightseeing has been installed in the Shimajiri mangrove forest, and the surface of the creek is exposed to more light. There are concerns that these alternations may negatively affect the environment. In spite of the poor terrestrial water environment, pure freshwater dojo loaches inhabit the area, and these fish are crucial for understanding the development of the island's freshwater flora and fauna. Their habitat, however, is undergoing radical changes, so it is necessary to implement measures to protect them as soon as possible. Furthermore, there still is a relative paucity of research into the subterranean water veins. Future studies would likely result in the discovery of anchialine fish.

Miyako Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The Miyako Islands consist of Miyakojima, Ikemajima, Kurimajima, Ōgamijima, Irabujima, and Shimojishima. Ikemajima and Kurimajima are linked to Miyako by bridges, and the Irabu Bridge, which will connect Miyakojima with Irabujima and Shimojishima is currently under construction. There are no rivers on the Miyako Islands, but there are extensive subterranean water systems, and anchialine caves and wells can be seen throughout the islands. These groundwater systems are known to support anchialine caridean shrimps. To date, eight species of anchialine caridean shrimp (including two undescribed species) have been recorded in Japan, all of which occur exclusively in the Nansei Islands. and seven of them occur in the Miyako Islands (Shokita, 1996; Komai and Fujita, 2005; Fujita, 2007; Cai and Shokita, 2006; Fujita, unpublished data). Furthermore, the surface-water springs on the eastern part of Miyakojima are inhabited by the endemic Miyako freshwater crab (*Geothelphusa miyakoensis*) (Shokita et al., 2002; Fujita, 2009a). The flora and fauna of the Miyako Islands has traditionally been unduly disregarded, but in terms of terrestrial water environments with groundwater ecosystems, the Miyako Islands have arguably the most distinctive and scientifically valuable water environments of all of the Nansei Islands. As for

Miyakojima's coasts, the northwest and southeast parts of the island have relatively pristine natural shores that are characterized by rocky reefs and splash zones. These are important nursery zones for coconut crabs, land crabs, and other land-dwelling species (Fujita and Ito, 2007; Fujita, 2009b).

Taramajima is a small island located almost right between Miyakojima and Ishigaki Island. In terms of terrestrial water, the island is spotted with anchialine caves, in which anchialine caridean shrimp have been reported (Fujita and Sagawa, 2008)

Miyako Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

About 40 species of terrestrial mollusks occur in the Miyako Islands (Minato, 1989), and many of them are endemic to this island group. They consist of a mixture of Okinawa-derived and Taiwan-derived species groups. The habitats of the endemic land snails are extremely disjunct, located sparsely in hilly areas and in forests under limestone precipices. The habitats of marine mollusks that inhabit the waters off the Miyako Islands comprise a diverse combination of environments, including mangrove forests, tidal mudflats, seagrass and algae beds, and coral and rock reefs. The seagrass and algae beds in Yonaha Bay and Ōura Bay and the Shimajiri mangrove forest are particularly important habitats for distinctive communities of mollusks with high levels of species diversity. To date, 201 species of mollusks have been confirmed in the mudflats of the Miyako Islands (Nawa, 2009). They consist of tropical species seen throughout the Indian and Pacific Oceans, but lack communities of temperate species and mainland China coastal species.

Miyako Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

The composition of the algal flora of the Miyako Islands has largely been clarified by Ohba (2009), who reported 132 species of algae. There are 18 algal species selected from Miyakojima as indicator species, and nearly all of them were confirmed.

A report by the Ministry of the Environment compiled from accumulated data (2004b) indicates the locations and size of seagrass beds. According to this report, there is a massive seagrass bed stretching from the mouth of Yonaha Bay off into the ocean. In addition to this one, there are beds in moats off the northwest sides of Irabujima and Shimojishima, inside Ōura Bay, and on the northeast-facing moats and mudflats from Gusukube to Ikemajima, where the seagrass beds line up in belt formations hugging the geological formations. The waters described above are important for the preservations of seagrass beds and the organisms they sustain. There are no seagrass beds from Bora to Ueno because the shoreline consists of seaside cliffs.

6. Yaeyama and Senkaku Islands

Yaeyama and Senkaku Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

This area is very pristine, and boasts many of the same endemic species and subspecies as the Southern Ryukyus. Iriomote Island is particularly notable for its contiguous stretches of rich vegetation that changes from the ocean and rivers to the mountains, vegetation which features mangrove forests and marshland flora. It is one of the few islands of Nansei to possess such rich natural features. The majority of flatland on Ishigaki Island is occupied by residential areas and farms. The island is undergoing considerable changes due to its growing status as a resort spot, but Mt. Omotodake, the highest peak in Okinawa Prefecture, still has well-preserved communities of *Pleioblastus linearis* stretching from its lower reaches to its summit, as well as environments peculiar to cloud belts. Iriomote Island is inhabited by the Iriomote cat (*Prionailurus iriomotensis*), the only native carnivoran in the Ryukyu Islands. The Senkaku Islands are inhabited by the Senkaku mole (*Mogera uchida*), only one specimen of which has ever been confirmed, as well as the striped field mouse (*Apodemus agrarius*). These examples are indicative of the high degree of endemicity from island to island in this region. It is also highly probable that flying animals on Yonagunijima, Japan’s westernmost island, migrate to and from Taiwan, which is a prospect of considerable scientific importance.

Yaeyama and Senkaku Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

The Yaeyama Islands comprise Ishigaki Island, Iriomote Island, and numerous islands that dot the ocean around them. Since they are the southernmost part of the Ryukyu Islands, birds of southern origin dominate. There are also many endemic species and subspecies, and well-known among them are a subspecies of the crested serpent eagle (*Spilornis cheela perplexus*) and a subspecies of the emerald dove. Some smaller islands in the Yaeyama Islands group, such as the southernmost Haterumajima (20 km from Iriomote) and the westernmost Yonagunijima (60 km from Iriomote) are located between the main Ishigaki and Iriomote Islands and Taiwan, which makes them important stopovers for migrating birds of southern origin.

The islands of Ishigaki, Iriomote, Haterumajima, and Yonagunijima all have mountainous areas. Ishigaki and Iriomote, which are by far the largest of the group, have well-developed river systems. The forests that cover the mountainous regions support a rich variety of bird fauna.

As for river systems, the Amparu Tidal Flats that extend from the mouth of the Nagura River on Ishigaki Island, in addition to the mouths of Iriomote's Nakama River and Urauchi River, serve as important wintering sites for herons, snipes and plovers, and as feeding grounds for terns.

The shores and rock reefs are nesting grounds and habitats for terns, brown boobies (*Sula leucogaster plotus*), and red-tailed tropicbirds (*Phaethon rubricauda*), but of these locales, the island of Nakanoganjima, located to the south of Iriomote, is a particularly important nesting ground for these species.

The Senkaku Islands are located about 150 kilometers or more north of Iriomote. A survey conducted in 1971 confirmed the presence of terns, barred buttonquails (*Turnix suscitator*), red-footed boobies (*Sula sula*), and short-tailed albatrosses (*Diomedea albatrus*) (Ikehara and Shimojana, 1971), but their current status is unknown.

Yaeyama and Senkaku Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

When we exclude species that are obviously nonnative (Ota et al., 2004), there are eight amphibian and 19 terrestrial reptile species and subspecies in the Yaeyama Islands (exclusive of Yonagunijima). Of these, three amphibians are endemic to this region, two being members of the Ryukyu tip-nosed frog group and the other Owston's green tree frog (*Rhacophorus owstoni*). Of those terrestrial reptiles, six are endemic, and six endemic terrestrial reptiles, namely the Sakishima grass lizard (*Takydromus dorsalis*), Ishigaki blue-tailed skink (*Plestiodon stimpsonii*), Iwasaki's snail-eating snake (*Pareas iwasakii*), Sakishima green snake (*Cyclophiops herminae*), Yaeyama keelback snake (*Amphiesma ishigakiense*), and the elegant pitviper (*Protobothrops elegans*). Additionally, the Yaeyama box-turtle (*Cuora flavomarginata evelynae*), Chigira's odd-scaled snake (*Achalinus formosanus chigirai*), and Iwasaki's oriental coral snake (*Sinomicrurus macclellandi iwasakii*) are endemic at the subspecies level. Many of the remaining species and subspecies are endemic to the Southern Ryukyus, which here includes this region, the Miyako Islands, and Yonagunijima (Maenosono and Toda, 2007). Many of the amphibians and terrestrial reptiles in the Yaeyama Islands have closely related groups (populations of the same species, different subspecies of the same species, closelyrelated species of the same genera, etc.) in Taiwan and the southeast part of mainland China (Ota, 1998), but as molecular phylogenetic research progresses, it is becoming increasingly apparent that, as is the case with the large tip-nosed frog (*Rana supranarina*) and the Okinawa narrow-mouthed toad (*Microhyla okinavensis*), some species, though few in number, are more closely related to groups in the Central Ryukyus (Matsui et al., 2005a, 2005b).

In the same fashion as the studies of potential sea turtle nesting sites in the Okinawa and Miyako Islands, a team of specialists was commissioned by the Okinawa Prefectural Board of Education from 1998 to 2000 to do a comprehensive and exhaustive survey of nearly all of the beaches on which sea turtles might land and nest. As a result, it was found that beaches with the highest frequencies of nesting are concentrated on the southern and northwestern shores of Iriomote Island, and that Ishigaki's northern and northeastern shores and Kuroshima's western shore had also high frequencies of nesting. In terms of nesting species, common green turtles were by far the most dominant, accounting for more than 80% of the total, followed by loggerhead turtles with around 15%, and only a few cases of hawksbill turtles making it up the beaches (Okinawa Prefectural Board of Education, 2001).

The Ishigaki Sea Turtle Research Group has been recording nest counts by species on Ishigaki since 1995, and their conclusions support the trends observed above (Tanizaki, 2008). It should also be noted that Kamezaki conducted a comprehensive study of sea turtle nesting in the Yaeyama Islands in the 1980's, and found that loggerhead turtles accounted for more than 60%, with common green turtles lagging far behind at less than 40% (Kamezaki, 1991). The fact that there is such a drastic difference in dominant species in the findings of studies conducted just over a decade apart using similar methods and covering the same region suggests that there are significant environmental, biological, and conservation-related implications involved, so this phenomenon deserves careful examination in the future.

The nesting sites of sea kraits were found in the region, and chiefly on the islands of Iriomote and Ishigaki. It is likely that they are from three species, the Erabu black-banded sea krait, blue-lipped sea krait, and yellow-lipped sea krait (Ota, 1995; Ota and Masunaga, 2005).

If we discount species that are obviously nonnative (Ota et al., 2004), there are no amphibians on Yonagunijima, but there are nine species of terrestrial reptiles (Maenosono and Toda, 2007). The Yonaguni tree lizard (*Japalura polygonata donan*), Yonaguni musk snake (*Elaphe carinata yonaguniensis*), and the Miyara's reed (or dwarf) snake (*Calamaria pavimentata miyarai*) are subspecies endemic to this island. While each of the last two snakes has a possible sister subspecies in Taiwan and mainland China (apparently close but separate subspecies belonging to the same species), populations of these species are not found in any other of the islands of the Yaeyama group, nor anywhere in else in the Nansei Islands northwards of the Miyako Islands (but regarding the Yonaguni musk snake, the nominate subspecies of the common musk snake [*Elaphe carinata carinata*] is also found on the Senkaku Islands: Ota, 2000a; Maenosono and Toda, 2007). The Yonaguni tree lizard has related subspecies (i.e. of the same species) spread out over a broad area, including the northern Taiwan (Yellow-mouthed tree lizard [*J. p. xanthostoma*]), a few other islands of the Yaeyama and Miyako Islands (the Sakishima tree lizard [*J. p. ishigakiensis*]), and the Okinawa and Amami Islands (Okinawa tree lizard [*J. p. polygonata*]), but the group most related has yet to be identified (Ota, 2003). Aside from these endemic subspecies, terrestrial reptiles native to Yonagunijima are shared exclusively with Iriomotejima and Ishigakijima only (one species), or with more islands but only of the Southern Ryukyus (three species), or with both Taiwan and many other islands of the Nansei Islands (two species: Ota, 2000a). In short, Yonagunijima shares characteristics with both Taiwan and Iriomote and the other Nansei Islands northwards, but at the same time Yonagunijima has maintained the degree of independence necessary for differentiation of endemic taxa to take place.

Sources indicate that sea turtles nested on Yonagunijima in the past, but the construction of breakwaters and other artificial alterations have resulted in the current situation in which, even if sea turtles do nest on the island, it is a rarity (Okinawa Prefectural Board of Education, 2001). There is also no evidence of sea kraits nesting on Yonagunijima.

There are no known amphibians on the Senkaku Islands, but six species of terrestrial reptiles have been recorded. When we exclude Ramphotyphlops braminus, which was probably introduced artificially (Ota et al., 2004), and a species in the genus Scincella whose specific identity has yet to be properly determined, the remaining four species are all common to Taiwan and mainland China. Just one of those (*Gekko hokouensis*), however, is shared also with other islands of the Nansei Islands (Ota, 2000a). The strong biogeographical affinity observed between the terrestrial reptiles of the Senkaku Islands and those of Taiwan and mainland China can be attributed to the fact that, unlike the remaining island groups of the Nansei Islands, which are located on the Ryukyu Ridge, these islands are located on the current continental shelf across the Okinawa Trough, and therefore it is thought that these islands, together with Taiwan, were part or almost part of the continent during a regressive period in the Late Pleistocene (Ota et al., 1993). Because these islands are surrounded on all sides by rocks of sandstone or lava, sea turtles cannot nest in this region and there are no reports of sea kraits nesting here either.

Yaeyama and Senkaku Islands: (iv) Insects

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Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

Yonagunijima is the westernmost island of Japan. It is known for its distinctive scenery, which is created by its water systems, sheer cliffs, and mountains. It has land-dwelling endemic species and subspecies of insects such as *Drilaster flavicollis*, *Neolucanus insulicola donan*, and *Aphaenogaster rugulosa*, in addition to species in the water systems that are disjunctly distributed or have their northern distribution limits here, including *Pseudagrion microcephalum*, *Laccotrephes maculatus*, and *Limnometra femorata*. The shore areas are inhabited by *Thetella elegans*, which is endemic to the Ryukyu Islands.

Iriomote Island is the only island not to feel the destructive effects caused by the construction of forest roads, and for this reason alone it is extremely valuable. Iriomote and Ishigaki share many of the same species in common. For example, of the 10 cicada species found on the Yaeyama Islands, *Platypleura yayeyamana* and four others are species or subspecies endemic to both islands. *Drilaster ohbayashii* and

Stenocladius yoshikawai are fire fly species endemic to both islands, while *Lucidina natsumiae* and one other species are seen only on Iriomote Island. *Prosopocoilus pseudodissimilis* and *Neolucanus insularis* are endemic species common to both islands, while *Dorcus amamianu*s *yaeyamaensis* is a subspecies endemic to Iriomote Island. Notable endemic aquatic insects include *Lethocerus deyrolli* and *Cybister limbatus* (both Endangered) and 12 endemic dragonfly species, all of which are endemic to both of these islands and classified as Near Threatened. Some grasshoppers worthy of mention are *Neophisis iriomotensis* (Iriomote and Ishigaki Is.) and *Diestrammena* sp. (endemic to both islands; inhabits forest beds and limestone caves, after Oshiro, 1986) There are very few populations of *Platypleura albivannata*, and they are extremely disjunct. As for other islands, Rhagophthalmus ohbai (an important example of disjunct distribution of a family, Endangered) also inhabits Kohamajima. Haterumajima is very flat and almost all of it has seen encroachment by development projects, but the presence of Ochlodes asahinai (Vulnerable) has been recorded there.

Camponotus sp., *Glenea masakii* and *Strongylium araii* are all species endemic to Uotsurijima of the Senkaku Islands. *Gonocephalum senkakuense* is found only on Yonagunijima and Uotsurijima, and *Psacothea hiralis yonaguniana* is a disjunctly distributed species. At the same time, *Ochetellus glaber*, *Pantala flavescens*, and other species with very broad distributions have been documented on these islands. The island of Kitakojima is inhabited by *Diestrammena* sp. (undocumented endemic species in the subfamily Aemodogryllinae) as well as *Cicindele yuasai okinawaensis*, which has been documented on Kitakojima as well as Okinawa Island and Iriomote Island.

Yaeyama and Senkaku Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Because the rivers of Iriomote Island flow from deep, sprawling subtropical forests, they are quite affluent for small island rivers and are relatively pristine in condition. This has contributed to the extraordinary diversity exhibited by the ichthyofauna of the island. In fact, over 400 species of fish have been reported in the Urauchi River alone. When one considers that only about 3,800 species of fish have been confirmed in the whole of Japan (Nakabo, 2000), it becomes clear just how rich in diversity this river is, and it need not be reiterated that this Class A river must be protected (Tachihara, 2005). The fish fauna therein contain many rare species, and there are many species that are found chiefly in this water system: Papuan black snapper (*Lutjanus goldiei*), lobed river mullet (*Cestraeus* plicatilis), *Mesopristes iravi* (nov.), silver grunter (*M. argenteus*), tapiroid grunter (*M. cancellatus*), half fringelip mullet (*Crenimugil heterocheilos*), Japanese lates (*Lates japonicus*), etc. In recent years, however, changes to water environments brought about by hotel construction and overuse by tourists has become a problem. The overexploitation of rivers in particular under the banner of ecotourism is becoming a particularly pressing issue. There are serious concerns over the effects of tourists feeding flagtails by hand and diving into the waters repeatedly throughout the day. The issue of overexploitation of rare fish by business operators is also growing in importance. Agricultural improvement projects are currently underway in the fallow fields on the east bank of the Urauchi River. It is urgent that such developments be monitored carefully. Many diverse and very rare species of freshwater fish occur in the rivers of Ishigaki Island, but the degradation of water quality caused by urbanization and excessive leisure-related exploitation is causing those numbers to drop year by year.

Yaeyama and Senkaku Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The northern part of Ishigaki Island is mountainous. The island also possesses relatively well-preserved river environments and natural shorelines. These sites are critical habitats for rare species endemic to Ishigaki, e.g. the Ishigaki freshwater crab (*Geothelphusa marginata marginata*). The Nagura-Amparu area stretching from the upper to lower reaches of the Nagura River and to Nagura Bay houses not only rare species but also the Japanese blue crab (*Portunus trituberculatus*) and other species that play important roles in maintaining aquatic environments in general (Shokita et al., 2003). Iriomote has multiple water environments of high quality, including the rivers (the Urauchi River system in particular) that nourish the endemic Shokita's freshwater prawn (*Macrobrachium shokitai*) and Iriomote freshwater crab (*G. marginata fulva*), as well as estuarine mudflats, mangrove forests, rocky splash zones of the coastal area, etc.

Relatively undisturbed shores and anchialine pool remain on Taketomijima, Kuroshima, Aragusukujima, Haterumajima, and Hatomajima, and as such these are important habitats for coconut crabs and anchialine crustaceans. Uotsurijima in the Senkaku Islands has the Senkaku freshwater crab (*G. shokitai*).

Yaeyama and Senkaku Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

About 45 species of terrestrial mollusks occur in the Yaeyama Islands (Minato, 1989), and many of them are endemic to this island group. The evergreen broadleaf forests covering the mountainous regions of Ishigaki and Iriomote Islands, as well as Yonagunijima, Haterumajima, and the limestone regions of the northeastern part of Ishigaki form important environments for a large number of endemic species.

The habitats of marine mollusks that live in the waters off the shores of the Yaeyama Islands comprise a diverse combination of environments, including mangrove forests, tidal mudflats, seagrass and algae beds, and coral and rock reefs. Ishigaki's Nagura region, Iriomote's Furumi region, together with Funaura, Urauchi, and Shirahama areas, nurture large, contiguous habitats that extend from mangrove marshes to mudflats and seagrass/algae beds. Each form unique and diverse mollusk fauna, and are therefore critical as habitats. To date, 281 species of mollusks have been reported in the mudflat areas of the Yaeyama Islands (Nawa, 2009). The majority consist of tropical species seen throughout the Indian and Pacific Oceans, with only a few temperate mainland coastal species. The northern limit of many of these tropical species is the Yaeyama Islands themselves. The terrestrial mollusks (mostly brackish water-dwelling species) exhibit high degrees of species diversity from the downstream reaches to estuarine (brackish) portions of the river systems of this region, especially in the south of Ishigaki and north of Iriomote, which makes the area highly important.

Endemic land snails such as *Nesiohelix solida* and *Euphaedusa senkakuensis* are distributed among the Senkaku Islands. Regarding the former, the only other places in which species of the same genus are found in the Ryukyu Islands are the Daitō Islands and on Okinoerabujima.

Yaeyama and Senkaku Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

The Yaeyama Islands: Ishigaki Island and Iriomote Island were formed from the same reef limestone that created the Sekisei Lagoon located between them. To the south of Iriomote is Haterumajima, and to the west is Yonagunijima. Within the Sekisei Lagoon, Kuroshima, Aragusukujima, Yubujima, and Kohamajima are situated near Iriomote Island, while Taketomijima is adjacent to Ishigaki Island. The major seagrass beds off Ishigaki Island are the beds growing off the coast of Nagura Bay, the beds that have developed in a steppingstone pattern from Urasoko Bay to the coral lagoons of the northeast coral reefs, and beds that grow in a belt-pattern in moats off the Shiraho coast, whose reefs function as a rich habitat for algae, making these areas important for the conservation of biodiversity. According to Yamaha Resort (1999), of the islands located within the lagoon, the area around Kohamajima has the largest seagrass bed, replete with diverse algal flora, making it an important area for conservation. Iriomote also has well-developed seagrass beds off its shores, with the exception of its southern coast, which is flanked by sheer cliffs. Studies of seagrass beds were conducted off the shores of Iriomote and Kuroshima due to their relevance to dugong (Kasuya et al., 2000; Toma et al., 1982). If one considers the study at Amitori Bay (Ministry of the Environment, 2004c), it becomes clear that all areas off Iriomote Island, except for the southern coast, are very important in terms of conservation.

Yonagunijima: The algal flora of Yonagunijima, which is well-positioned to benefit from the Kuroshio Currents that pass directly over it, has long been a subject of academic interest. Studies of the island's algae began with Yamada and Tanaka (1938), were continued by Tanaka and Itono (1972), and if one includes the data in Kamura's notes, 154 species occur here. There are five known species of seagrass (Tuda and Kamura, 1991). The topography of the coral reef from Hikā to the Irizaki Lighthouse is unique to Yonagunijima, as it houses communities of *Chamaedoris orientalis* and other notable species. The outstanding view provided by this coral-filled seascape is reason enough to demand measures for its conservation.

From its origin to its outflow regions (about a 50 km stretch with no effects from saltwater), the Tabarugawa River, which empties into Nanta Beach, contains very rare and diverse species of freshwater algae such as *Dichotomosiphon tuberosus*, *Caloglossa ogasawaraensis*, and Bostrychia simpliciuscula, in addition to providing habitats for species such as Compsopogon oishii and Hildenbrandia rivularis (Vulnerable). Its mangrove estuary is rich in mangrove algae (Bostrychia sp., Caloglossa continua, and Boodleopsis pusilla). The green laver-like algae growing at the upper reaches of the stream was found to be and presented as a new species, called "Ulva limunetica Ichihara et Shimada" (Ichihara et al., 2009). The algal macroflora of Tabarugawa rivals the flora of Okinawa's Sugā River in Motobu as described above, and therefore must be preserved.

The Senkaku Islands: The Senkaku Islands are located at the edge of the Kuroshio Current. The coral type off Uotsurijima, which is the largest of these islands, produces fringing reefs, and since this presents a difficult environment for seagrass to grow, there are no reports of seagrass in the area. The addition of the study of algae by Kawamura (1980) to that done by Nakayama and Yoshikawa (1973) leaves us with about 90 confirmed species, which is a comparatively small number for waters off the Senkaku Islands. Given the existing records, three species (*Valoniopsis pachynema*, *Rhizoclonium grande*, and *Chlorodesmis caespitosa*) in Uotsurijima could be selected as indicator species for conservation purposes. Since the islands are uninhabited at present, there seems to be little danger to algae posed by human intervention, but further research is still necessary.

Chapter 3. Identifying Priority Areas

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3.1. Regional conferences

In October of 2006, WWF Japan began a project designed to identify areas in the Nansei Islands that are particularly important in terms of biodiversity and that deserve priority from a conservation perspective (Biodiversity Priority Areas, or BPA's). As part of the Nansei Islands Biological Diversity Evaluation Project three regional conferences were held. These conferences were attended by researchers with expertise in each of the biological divisions, and individuals and NPO's engaged in conservation efforts in the respective regions. A list of attendees, including national and prefectural government officials who attended as observers, is provided in Appendix A.

First Regional Conference: September 8, 2007, Ginowan City, Okinawa Prefecture

Second Regional Conference: June 7—8, 2008, Amami City, Kagoshima Prefecture

Third Regional Conference: June 27—28, 2009, Naha City, Okinawa Prefecture

Organisms were separated into eight taxonomic groups at the conferences: mammals, birds, amphibians/reptiles, insects, fish, crustaceans, mollusks, and seagrasses/algae. The conferences consisted of deliberations and selection work regarding the identification of priority areas for each biological division (Taxon Priority Areas, or TPA's), and BPA selection methods and criteria. With regard to reef-building coral, a working group was formed separate from these conferences, which selected priority communities of coral.

The first conference focused on choosing indicator species for each taxonomic groups and on drafting maps of TPA's. The second conference consisted of the exchanging and sharing of views regarding how to select BPA's. The third conference consisted of final considerations for the purpose of determining BPA's.

3.2. Indicator species selection

Biodiversity is a concept that can be applied on many different levels: genetic species and ecosystems. The purpose of this project was to select diversity distribution maps on the taxon level. In drawing up the TPA maps for each taxa to serve as basic data sets, certain criteria were applied to select indicator species from among species in the eight taxonomic groups or taxa (with the exception of reef-building coral) listed in Endangered Wild Flora and Fauna in Kagoshima Prefecture: Fauna (Kagoshima Prefecture, 2003) and Endangered Wild Flora and Fauna in Okinawa Prefecture: Fauna, Revised Edition (Okinawa Prefecture, 2005) (the so-called “Red Data Books”; hereinafter “RDB's”), as well as species not listed in the RDB's but which researchers recommended. In an effort to select indicator species exhaustively from all areas and all habitats in the Nansei Islands, the following two steps were taken.

Step 1: The creation of matrices of inhabited areas/habitats

The Nansei Islands were divided into seven regions: the region covering the Ōsumi Islands and Akusekijima, the region encompassing Kotakarajima and Amami Islands, the Okinawa/Kerama Islands, the Daitō Islands, Miyako Islands, Yaeyama Islands and Senkaku Islands. Habitats were divided into three broad categories: land, rivers, and marine areas. Based on habitat information in the RDB's, matrices which contain data on the habitats of individual listed species were created. For species that crossover into multiple habitats, all pertinent information was entered. Species of insects and mollusks listed in the RDB's of Kagoshima Prefecture and Okinawa Prefecture exceed 200 in number, so only species that are at the higher levels of risk were included. For other taxa, all listed species were included.

Step 2: The application of criteria for the selection of indicator species

For species that inhabit the same areas or habitats and placed in the same matrix category, the following criteria were adopted: (1) endemic (sub)species, (2) species at their northern or southern distribution limits, (3) wide-area migratory behavior, (4) ecological relationship with insects and mollusks, and (5) other. Using these criteria, several species that ranked relatively highly were selected as candidates for indicator species. Furthermore, candidate species were reintegrated into their taxa, overlapping species were excluded, and scoring criteria were searched again so as to select several tens of indicator species for each taxa. At the same time, species not listed in the RDB's but that scientists recommended as worthy of inclusion were added. Considerations as to which species were to be included were factors such as whether they were keystone species, ecologically high-ranking species, genetically endemic species, species that use the pertinent areas as breeding grounds, socially important species, species dependent upon microenvironments, or novel species. Ultimately, about 300 indicator species in the eight taxa were selected for the Nansai Islands. A list of these indicator species is provided in Appendix B.

It should be noted that, while there are insects that arrived via ocean currents, many of them have adapted to diverse and highly specific environments, such as the hollows in old trees, rock crevices, and the heads of rivers. In addition, there are many species that exhibit low degrees of migratory behavior, so at forest edges or in areas populated by humans their habitats are easily separated or destroyed, and thus many of these are threatened species. For this reason, indicator species had to be selected at levels smaller than island groups.

3.3. Taxon Priority Area (TPA) selection and map-drafting guidelines

At the First Regional Conference held in September of 2007, TPA's were drawn onto 1/200,000 scale topographical maps. TPA's were evaluated based on whether the relevant area was a breeding or feeding ground for populations of the selected indicator species, whether it was a northern or southern distribution limit, and whether it encompassed a large region. For areas with deficient distribution and other data at the time of selection, there were cases in which areas were selected because they were deemed important judging from related information, and cases in which they were not evaluated. The shapes of TPA's (i.e., how they were delineated) were mostly based on catchment areas, the distribution of natural forests, areas in which the presence of species was confirmed in past studies, and similar criteria.

Social considerations, such as human impact, were not taken into account. Rather, selection was done from a purely scientific perspective. Nevertheless, TPA map-drawing criteria for all taxa were not strictly standardized, as each varies in terms of behavior characteristics, ecology, information available, etc. Below are the TPA map-drafting guidelines used for each taxa. TPA maps are shown in Appendix E. Ultimately, a total of 1,400 areas were selected for all taxa. As stated below, TPA for reef-building coral were selected separately.

(i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

The major distribution areas of indicator species and subspecies of mammals were drawn onto the maps according to the following guidelines. Generally speaking, mammals have larger body sizes than animals in other taxa as well as wider ranges of mobility. Therefore, the areas selected centered on locales where the particular animal was confirmed, or locales otherwise deemed important for the animal, but they were also defined so as to include a certain degree of peripheral space to account for mobility ranges. Areas of distribution were determined and filled in based on existing literature (scientific papers, reports, etc.), data that members had collected from field surveys they conducted themselves, and/or inquiries to researchers with pertinent expertise.

1) For a species with a wide range of mobility found only on one island but confirmed to inhabit broad sections throughout the island, the whole of that island was included. In addition, if the anticipated range of mobility exceeded the size of the island, i.e. its range was restricted by the island's size, the entire island was included.

2) Areas selected for arboreal bats and mice surround the locales where they were confirmed. Areas for cave-dwelling bats covered caves where they were confirmed living and breeding, but also included forested tracts thought to be feeding grounds. In some cases caves are located in populated communities. In addition to these, non-forested areas thought to be along flight routes were included. The most important breeding caves for the East Asian little bent-winged bat are very few in number, and the species does not necessarily require forests around its caves, so given the prospect of marking such caves with identifiable points and other indications which would probably tempt people's curiosity to encroach upon their habitats, it was decided that this species would not be selected in the current round.

3) Seagrass beds thought to play important roles in dugong habitats were selected, as records of sightings are sparse and fragmentary.

Important notes:

1) For the most part, habitats important for indicator species (subpecies) were recorded. However, there were cases such as Yakushima which, despite the pristine environment and presumed importance for mammals in general, did not include indicator species and could therefore not be included. Such circumstances have to be taken into account, so mention was made of them.

2) For the purpose of assessing biodiversity, mention was made of the current state of some rare species that were overlooked in area selection, disturbance to ecosystems caused by invasion by nonnative species, and the conservation of endemic species.

3) With many mammal species, surveys indentifying distributions are difficult, and therefore some areas that were not selected in the present survey still may contain distributions of indicator species. Furthermore, thorough surveys of mammalian fauna have not been conducted on many islands.

(ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

Indicator species were first selected based on criteria such as endemicity for endemic species and subspecies, whether the birds are resident or have breeding nesting sites in particular areas (birds migrating in the summer), and whether they are threatened or endangered. Then, the areas containing habitats or nesting grounds for these species were indentified. The basic sources of data utilized in this process were, A Check-list of Japanese Birds, Revised Sixth Edition (Ornithological Society of Japan, 2000), Endangered Wild Flora and Fauna in Kagoshima Prefecture: Fauna (Kagoshima Prefecture, 2003) and Endangered Wild Flora and Fauna in Okinawa Prefecture: Fauna, Revised Edition (Okinawa Prefecture, 2005), in addition to more recent findings of bird fauna in the relevant areas. From these, priority areas were sought. This data was further revised based on inquiries to specialists concerning recent changes to habitats caused by development projects, etc.

As forests serve as important habitats for many terrestrial birds, habitats were drawn using vegetation maps. The coasts that terns nest on and the rivers and ponds that the small blue kingfisher inhabits comprise small areas, so in many cases it was difficult to pinpoint their locations on maps. For this reason, such specific sites were included among those drawn in as priority areas.

Both inhabited and uninhabited islands are located in Okinawa Prefecture, and there are large discrepancies in the degree of thoroughness of studies of birdlife conducted on these islands. There have been no recent surveys of the Oki Daitō Island and the Senkaku Islands, for example, so one has no choice but to rely on older findings. Recent information is often unavailable for other islands as well.

Natural environments are continually being altered due to the effects of typhoons and development. Recent changes have been particularly significant. It is also likely that global warming in recent years has had an impact on bird habitats. For these reasons, systematic surveys should be conducted on islands which have not been studied in recent years.

(iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

Of the species and subspecies native to the Nansei Islands, the ones addressed here are primarily those listed on the most recent Red Lists of the Ministry of the Environment, Okinawa Prefecture, and Kagoshima Prefecture (published or revised in 2006, 2006, and 2003, respectively) as Endangered or Vulnerable, but also include species and subspecies which have declined in numbers in recent years but have yet to be included in these categories, as well as several species and subspecies added at the discretion of committee members because they define the ecological or biogeographical features of certain regions. Once this selection process was complete, the species and subspecies chosen were then divided into two groups based on their primary habitat types: the terrestrial group (all species and subspecies of amphibians, plus land- and terrestrial water-dwelling reptile species and subspecies) and the marine group (marine reptiles) before proceeding.

Concerning the former group, habitat sites in which species and subspecies have been confirmed since 1980 in the field by Ota, Toda, and Okada, archived specimens confirming habitat sites since 1980 in the National Museum of Nature and Science (Ota and Endo, 1999), the Okinawa Prefectural Museum (unpublished specimen catalogue), the Osaka Museum of Natural History (unpublished specimen catalogue), and habitat sites recorded since 1980 in the pertinent literature (see the bibliography under Maenosono and Toda [2007]), were all plotted by species and subspecies on maps of the islands. Next, the plots of individual species and subspecies were encircled so as to include tracts of important habitats (for example evergreen broadleaf forests, pristine mountain streams, etc.) that are more or less contiguous as determined from looking at vegetation maps and from directly observed findings. Lastly, if there were tracts in which recent studies have clearly shown the absence of habitation, they were excluded. The resulting habitat areas were drawn in on the maps.

Three species of sea turtles (the common green turtle, the loggerhead turtle, and the hawksbill turtle), all of which reproduce in Japan and are listed as threatened species on the Red Lists above, were chosen as marine reptile indicator species, and based primarily on findings from the field studies that Kamezaki has been involved with, as well as data from the relevant literature, areas encompassing nesting beaches thought at present to be particularly important for these species were drawn onto the maps.

(iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of Ryukyus)

The expanded and revised Checklist of the insects of the Ryukyu Islands (2002) contains about 8,200 species of insects. Furthermore, this catalogue listed up only species noted in the literature which were found in the Ryukyu Islands south of Tokara Islands (excluding Osumi Islands). Much data was unavailable during the compiling of this catalogue, there must have been many more species that have yet to be listed. Even so, there were about 1,500 species whose colloquial Japanese names include place names like Amami, Tokara, Okinawa, Yanbaru, Yaeyama, Minami, Ryukyu, Taiwan and others. The conceivable factors that produced the unique insect fauna are as follows. First, there are peculiar geographical circumstances: namely, the islands are fairly close to a continent. The east edge of the Asian continent comprises a belt that includes subarctic, temperate, subtropical and tropical vegetation extending from the northern to southern hemispheres (the “East Asia Green Belt”). This region is thought to have the highest level of biodiversity on earth. The Nansei Islands have repeatedly joined and left this green belt (see, for example, Kimura, 2002, ed. Kimura), and in the process benefited from supplies of migrating and immigrating insect fauna. The second reason for the uniqueness of the Nansei Islands’ insect fauna is that, after the island groups were formed, they were covered with subtropical rainforests, which remained for long periods of geologic time. Without these geographical and chronic factors, emigrant species and communities could not have evolved into distinct endemic species and subspecies.

If the world at large is to recognize the value of the Nansei Islands, it will be because of the “joy of life” offered by views of the wet subtropics, from their rainforests to their shores, as well as the “spiritual comfort derived from the fact of coexistence” (see Miyawaki, 1984, 2006, etc.). This is not simply a matter of nostalgia over the past. There is a quality to islands which, by seeing them with our own eyes, we realize what has been destroyed by volatile and hasty economic development, and what kind of future we are leaving. Furthermore, the physical scale of an island presents us with a microcosm that lets us explore new and truly sustainable forms of economic activity.

With these ideas in mind, the following criteria were employed to select indicator species. Note that there are cases in which one species or subspecies conforms to multiple criteria.

1) Species or subspecies and local communities listed in RDB’s. 2) Species thought to be located at their limits of distribution. 3) Communities in confined areas cut off by roads or urban structures. 4) Species or subspecies that require entire mountain streams or rivers. 5) Species or subspecies that require specific types of habitats, such as mountain stream heads, caves, springs, depressions in rocks on the coasts, etc.

Most of the insects selected were those that are generally well-known. Groups which are difficult to classify or identify were left out, as were species with no Japanese common names. Areas for conservation for the chosen indicator species and other notable species were identified or extrapolated based on catalogues, field guides, specimen data, and interviews with people who had collected specimens or observed them in the field. Sites connected with behavior patterns of adult insects (mating, egg-laying, feeding, resting, flying patterns, etc.), larvae habitats, and pupation sites were included in presumed habitats.

Important notes:

1) Even common species were included if they were deemed endemic to the Nansei Islands or unique to certain specific areas, species with low mobility (apterous or brachypterous), or if it was thought that communities of a particular insect had drastically fallen in numbers in recent years. This is the reason why many islands, including the Tokara Islands, were selected as priority areas.

2) For species and subspecies that live in human environments, farms or urban structures, backyards, natural formations of religious significance, springs, reservoirs, stone walls, and other such places are important environments. It is, however, difficult to pinpoint such locations on maps, in addition to the fact that people may alter them easily. For these reasons, the entirety of Naha City, Nago City, and other large urban areas were selected as sites for preservation.

(v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

The Ryukyu Island Arc, which is a chain of islands that extends from Tanegashima to Yonagunijima, and also known as the Nansei Islands, has natural environments that vary little by little, from island to island, together with latitude. At the same time, the Kuroshio Current, which cuts through the islands, functions as a kind of conveyer belt that carries fish of southern origin to the higher latitudes, and simultaneously serves as a barrier that prevents the invasion of fish from the Chinese mainland. The southern distribution limits of temperate fish and the northern distribution limits of tropical fish intermingle in complex ways in the Nansei Islands, giving rise to ichthyofaunas that are unique and highly diverse.

The following are the guidelines used to delineate priority areas for fish in terrestrial water sources. Many of the rare terrestrial water-dwelling fish to be found in the Nansei Islands are diadromous, and as such their distributions are assumed to vary widely from year to year. For this reason, the selection of "areas that need to be protected" was based on findings of studies conducted within the last ten years or so, and the distributions of individual species were indicated not by points, but by whole water systems. The rare fish selected here are all species listed as Threatened in the Red Data Books put out by the Ministry of the Environment, Okinawa Prefecture, and Kagoshima Prefecture. For the five species of low-mobility pure freshwater fish (Japanese silver crucian carp [*Carassius auratus langsdorfii*], Japanese rice fish, swamp eel [*Monopterus albus*], dojo loach, and Chinese fighting fish [*Macropodus opercularis*]), three approaches were taken in selecting priority protection areas: for fish inhabiting rivers, those water systems were selected; for fish inhabiting stagnant water sources such as ponds that are not located near the proximal rivers, those ponds, etc. were selected independently; for fish in stagnant water sources that are near rivers, the water systems with catchment areas encompassing them were selected.

Areas for marine fish, on the other hand, were considered based on the rarity of the fish and their importance for maintaining marine resources. At present, available data on marine ichthyofaunas is fragmentary. There is no data available to make comparisons of all of the Nansei Islands with a resolution compatible with the physiographic units (PGU's) adopted as the basic units in this project. For this reason, for priority conservation areas for fish in marine areas, we looked to Ecologically Critical Habitats (ECH's) that are important to fish throughout their lifecycles, such as seagrass beds, mangrove forests, coral communities, tidal mudflats, bay areas, and spawning grounds. Of these habitats, areas were selected based the following considerations: whether they are well-preserved, their size, and whether they have pronounced characteristics or significant importance for fish fauna. The various habitats mentioned above are closely related ecologically to coral reef areas, and marine fish often alter their habitats from one developmental stage to the next.

Researchers have noted the importance of seagrass beds (Nakamura and Sano, 2004; Horinouchi et al., 2005; Nakamura et al., 2006; Ota and Kudo, 2007; Nakamura and Tsuchiya, 2008), mangroves (Tachihara et al., 2003), and the breaker zones of mudflats and bays (Ohta, 1998) to juvenile fish in the Nansei Islands, with ichthyofauna reported in each of these habitats. Fish faunas adapted to specific environments, such as reef slopes, moats, and bays have also been observed in coral reefs (Nanami and Nishihira, 2002; Nanami et al., 2005; Nanami and Nishihira, 2007; Ota and Kudo, 2007; Shibuno, 2007). Some coral reef-dwelling fish are also known to form aggregations during spawning periods. These spawning aggregations gather temporarily during specific periods and at specific sites (spawning grounds) for the purpose of spawning (Johannes, 1978; Russell, 2001; Claydon, 2004; Hamilton et al., 2005). Fishermen are quite familiar with Chinese emperors (*Lethrinus haematopterus*), groupers (*Epinephelinae*), and other important marine resource species forming such spawning aggregations in the waters off the Yaeyama Islands. We considered the areas in which these aggregations are formed to be critical waters that should be protected, if only for their crucial role in the sustainable and effective utilization of resources.

(vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

Crustaceans (subphylum Crustacea) are a large group of arthropods (phylum Arthropoda). More than 67,000 species have been recorded to date. Among this group are the decapods (Malacostraca Decapoda), most of which consist of shrimps and crabs, constitute about 11,000 species worldwide, with about 2,300 of them found in Japan. Although no exhaustive studies on the decapod fauna of the Nansei Islands have been conducted to date, it is clear that the decapod fauna of the region exhibits high species diversity. Even now a considerable number of undescribed species have been discovered every year. Crustacea is the group that have adapted to wide range of microenvironments in the Nansei Islands, from dry land to coral rich waters off the islands' coasts (forests, lakes, swamps, rivers, underground water systems, mudflats, mangrove forests, sandy beaches, and coral reefs). In addition, temperate species and tropical species coexist on these islands through different combinations of the effects of the Kuroshio Current, climate, and geology. Moreover, the complex speciation processes caused by geographic vicariances from and connections with the mainland have resulted in a unique and diverse crustacean fauna of the region.

In delineating priority areas for crustaceans, we first chose indicator species from among all threatened species listed in the Red Data Books published by the Ministry of the Environment, Okinawa Prefecture, and Kagoshima Prefecture, then selected the main habitats (environments) of those species as "critical areas for conservation (areas subject to protection and conservation measures)". In selecting indicator species, we cover not only terrestrial water- and river-dwelling endemic species such as freshwater crabs, but also other representatives from a variety of different microenvironments, including splash zones, mangrove flats, and subterranean water systems. In terms of the lifecycles of the indicator species, there are non-diadromous species such as freshwater crabs that spend their entire lives exclusively in specific environments, and diadromous species, such as freshwater shrimp that live in rivers and coconut crabs that inhabit coastal areas, both of which require different habitat types in their life history (i.e. the ocean and rivers) (Shokita, 2003; Shokita et al., 2004). For the indicator species with diadromous life history, it took into account not only the main habitats of adults, but also neighboring environments as well (for example, if their adult habitats were rivers or subterranean water sources, we included entire water systems into the priority areas as well. If their adult habitats are coastal waters, we also included surrounding vegetation). In addition, we set extensively large priority areas for the place where the habitats of many indicator species are overlapping (such as Yanbaru on northern Okinawa and Iriomote Island) and where number of undescribed species have been discovered in recent years or remarkable crustaceans fauna exist (such as the bay environment on the eastern coast of Okinawa Island).

(vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

The chief distributions of indicator species and subspecies of mollusks were drawn into the maps according to the following guidelines.

1) The habitats of indicator species were divided up into the following environments: forests, rivers, marshes, lakes and ponds, mangroves, sandy beaches, tidal mudflats, rocky shores, seagrass beds, and coral reefs (moats).

The distributions of indicator species were determined based on survey data collected by the authors and relevant literature after reviewing vegetation maps and topographical maps, and then drawn onto topographical maps according to the environmental categories indicated in 1) above.

(viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

In order to study the establishment of conservation areas in the Nansei Islands, the relevant aquatic spermatophytes and macroalgae were divided into four categories depending on where they grow: 1) seagrasses (marine spermatophytes) and algae dependent upon saltwater, 2) spermatophytes that grow in brackish water (widgeon grass) and algae that grow in river mouths and mangrove swamps, 3) algae that are distributed from brackish to freshwater areas (*Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis*), and 4) algae that occur in freshwater environments (*Dichotomosiphon tuberosus*).

There are few endemic species of seagrass and algae in the Nansei Islands or the individual islands that constitute them, as the dispersal of species is driven by the warm Kuroshio Current that flows north along the islands, and there is no mechanism to isolate species. There are many shared species among the islands from Yonagunijima to the Amami Islands. The coasts of the Ōsumi Islands are “transit” points, so to speak, of tropical and subtropical species traveling farther north. Tropical and subtropical algal species (bubble green seagrass [*Boergesenia forbesii*], *Acetabularia ryukyuensis*, *Acrocystis nana*, and others) from Okinawa Prefecture’s Red Data Okinawa (2006), and temperate algal species seen from Kyushu, through the Ōsumi and Amami Islands, and as far south as the Okinawa Islands, where they have established their southern distribution limits (*Helminthocladia australis*, *Gloiopeltis furcata*, *Sargassum fusiformis*, *S. thunbergii*, etc.) were selected as indicator species. Rhodophytes (red algae) such as *Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis* that are found from brackish to freshwater environments, and *Dichotomosiphon tuberosus*, a freshwater alga dispersed in a discontinuous fashion throughout the globe and which is thought to have once been a marine alga that was subsequently landlocked (Arasaki, 1953; Yokohama, 1982) were each selected for their habitats. “Seagrass beds” form in bays as well as in the sand and gravel bottoms of coral moats (called *inō* in Okinawa). Seegrass beds play an important role in stabilizing sand and gravel seabeds, and have multiple functions as constituents of coral reef ecosystems. The following aquatic spermatophytes were selected as indicator species: widgeon grass, which grows in brackish water, the tropical and subtropical sickle seagrass (*Thalassia hemprichii*) and serrated ribbon seagrass (*Cymodocea serrulata*), both of which are important constituent species of seagrass beds, and the temperate eelgrass (*Zostera marina*) and dwarf eelgrass (*Z. japonica*).

Conservation areas were chosen based mainly on the 30 species of seagrass and algae selected as indicator species, but these choices were also made with a view to entire regions, including areas rich in species that were not indicators.

3.4. Identifying important coral communities

1. Convening of working groups

Unlike other taxa, the selection of important coral communities in the Nansei Islands did not involve choosing indicator species using RDB's. Instead, a group called the Nansei Islands Large-scaleReef Monitoring Team was set up within the Japanese Coral Reef Society's Conservation Committee to conduct a comprehensive survey of the Nansei Islands. Working groups convened four times over the duration of the project to study methods for selecting important coral communities and to actually select them. Participants are listed in Appendix C.

The Large-scale Reef Monitoring Team also studied underwater survey protocols for coral reef areas and monitored the chosen important coral communities based on these protocols (cf. "WWF Japan Nansei Islands Biological Diversity Evaluation Project Field Survey Report", issued separately).

Working group meetings (important coral community selection):

First meeting: September 22, 2007, Naha City, Okinawa Prefecture

Second meeting: November 25, 2007, Ginowan City, Okinawa Prefecture

Third meeting: March 19, 2008, Naha City, Okinawa Prefecture

Fourth meeting: April 12, 2008, Naha City, Okinawa Prefecture

2. Selection of important coral communities

The working group developed and employed a methodology for comprehensively and objectively evaluating coral communities in the Nansei Islands, which uses the following four indicators:

1) Evaluation by the Nansei Islands Large-scale Reef Monitoring Team of the Japanese Coral Reef Society's Conservation Committee

2) The results of coral coverage surveys conducted from 1989 to 1992 as part of the Environment Agency's Natural Environment Conservation Basic Survey

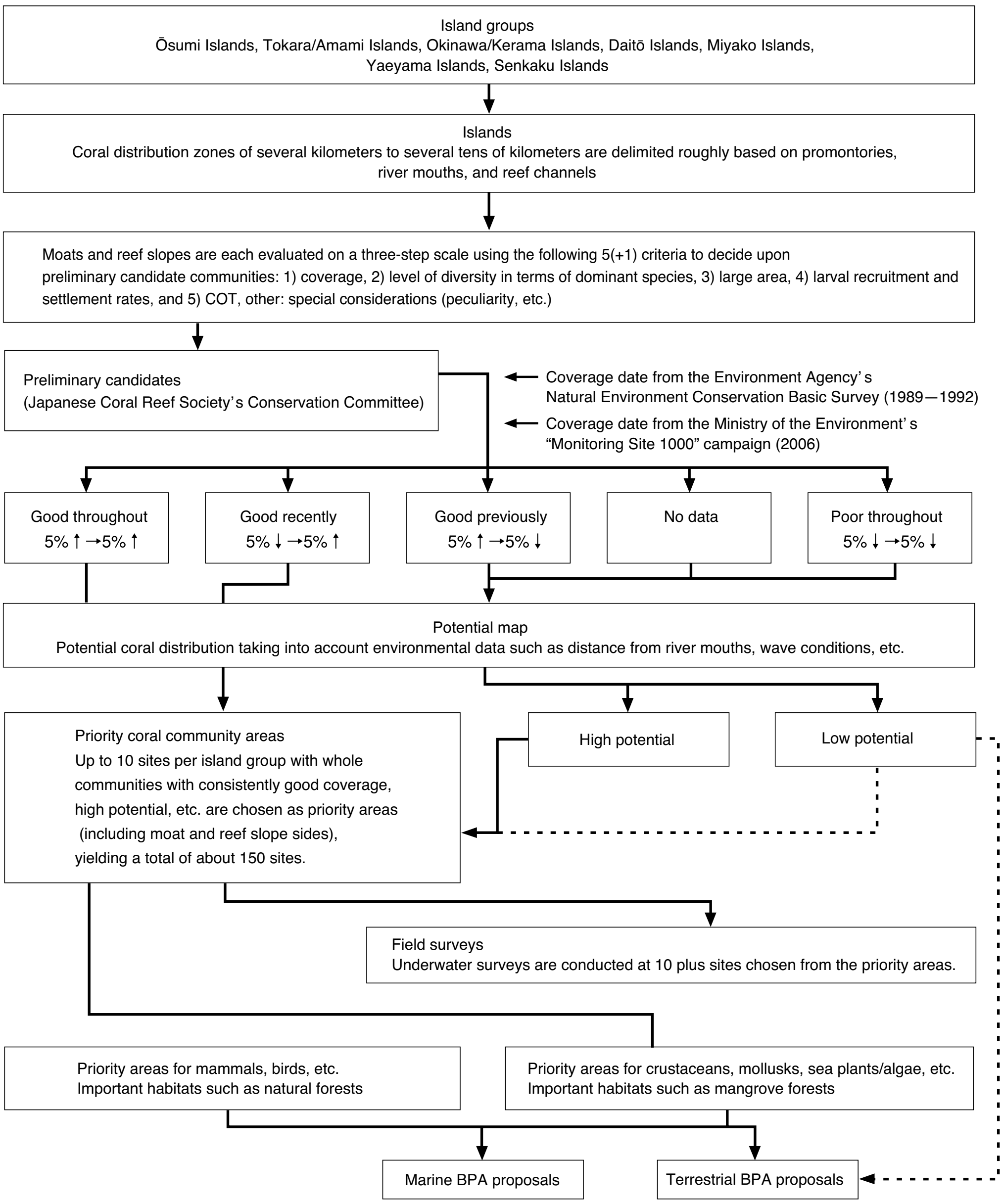
3) The results of a coral coverage survey conducted in 2006 as part of the Ministry of the Environment's "Monitoring Site 1000" campaign

4) Assessments of coral growth "potential" based on physical environment data analyses

Evaluations using the first indicator of the four relied heavily on information from local residents cooperating with the project who have detailed knowledge of the waters in question. Factors like degree of diversity of coral types, size of communities, damage from predation by the crown-of-thorns (COT) starfish (*Acanthaster planci*), and recruitment and settling rates of coral larvae were evaluated on a three-step scale. The coral communities evaluated were loosely drawn up in tracts of several square kilometers using gaps in reefs (channels), promontories, bays and other such topographical features as rough landmarks. The moats, reef flats, and reef slopes of each of these areas were then evaluated. For evaluating coral coverage, the criterion employed was whether or not the specified coral communities each had, in their entirety, at least 5 percent coverage during the 1989 to 1992 survey and at the time of the 2006 survey. The fourth indicator, namely the measure of coral's potential, entailed the development of software applications in cooperation with the National Institute for Environmental Studies specifically for this selection process. Specifically, physical environmental data on factors that affects coral community formation, such as ocean temperature, wave conditions, past typhoons, and distance from densely-populated areas and river mouths, are calculated from arbitrarily chosen points, thereby yielding and evaluating coral's "potential" (see 3.4.3).

Using these evaluation criteria, the selection process, which was performed on about 20 locations per island group from the Ōsumi to Yaeyama Islands, yielded a total of 154 priority coral community areas (Appendix F). Since there was insufficient data on the Tokara Islands and Senkaku Islands, they were excluded from selection.

Flowchart representing the process of selecting priority coral communities:



3. Characterization of coral reefs and coral communities in the Nansei Shoto

Yamano, Hiroya (National Institute for Environmental Studies)

Introduction

This report is to show results of development of a Potential Coral Habitats Evaluation tool in collaboration with the Biodiversity Evaluation project to illustrate the biodiversity priority areas (BPAs) of the Nansei Shoto Ecoregion directed by WWF Japan.

Present-day coral communities are disturbed by acute disturbances including Acanthaster planci outbreaks and coral bleaching. This means that the present coral communities may not represent the communities potentially established there. Thus in order to identify priority areas for coral communities, evaluation of long-term potential for coral habitats is needed in addition to understanding present-day status of coral communities. Physical environments such as wave energy exposure have been regarded as dominant factors that affect coral distribution (Fig. 1). So it would be possible to evaluate the potential for coral habitats based on physical environments. In this work, we report on the development of a Potential Coral Habitats Evaluation tool to characterize coral reefs and identify high potential areas for coral habitats in the Nansei Shoto (Fig. 1). The overall flowchart is shown in Fig. 2.

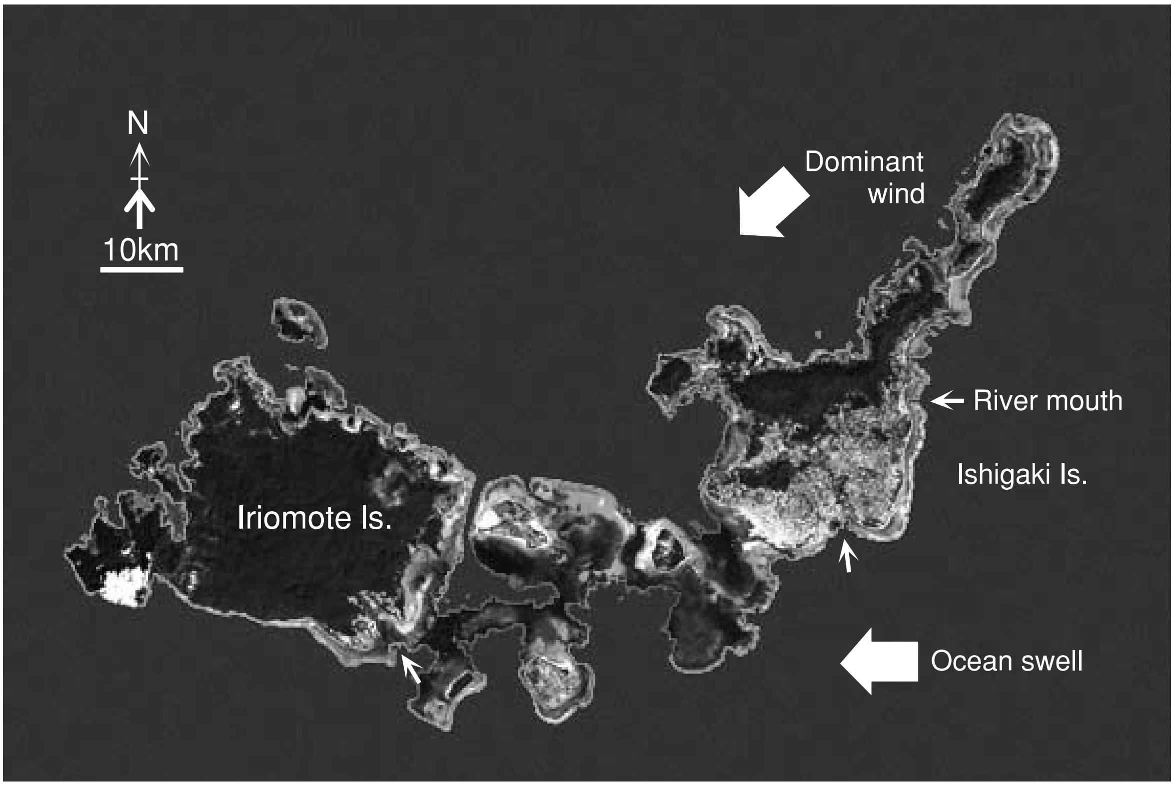
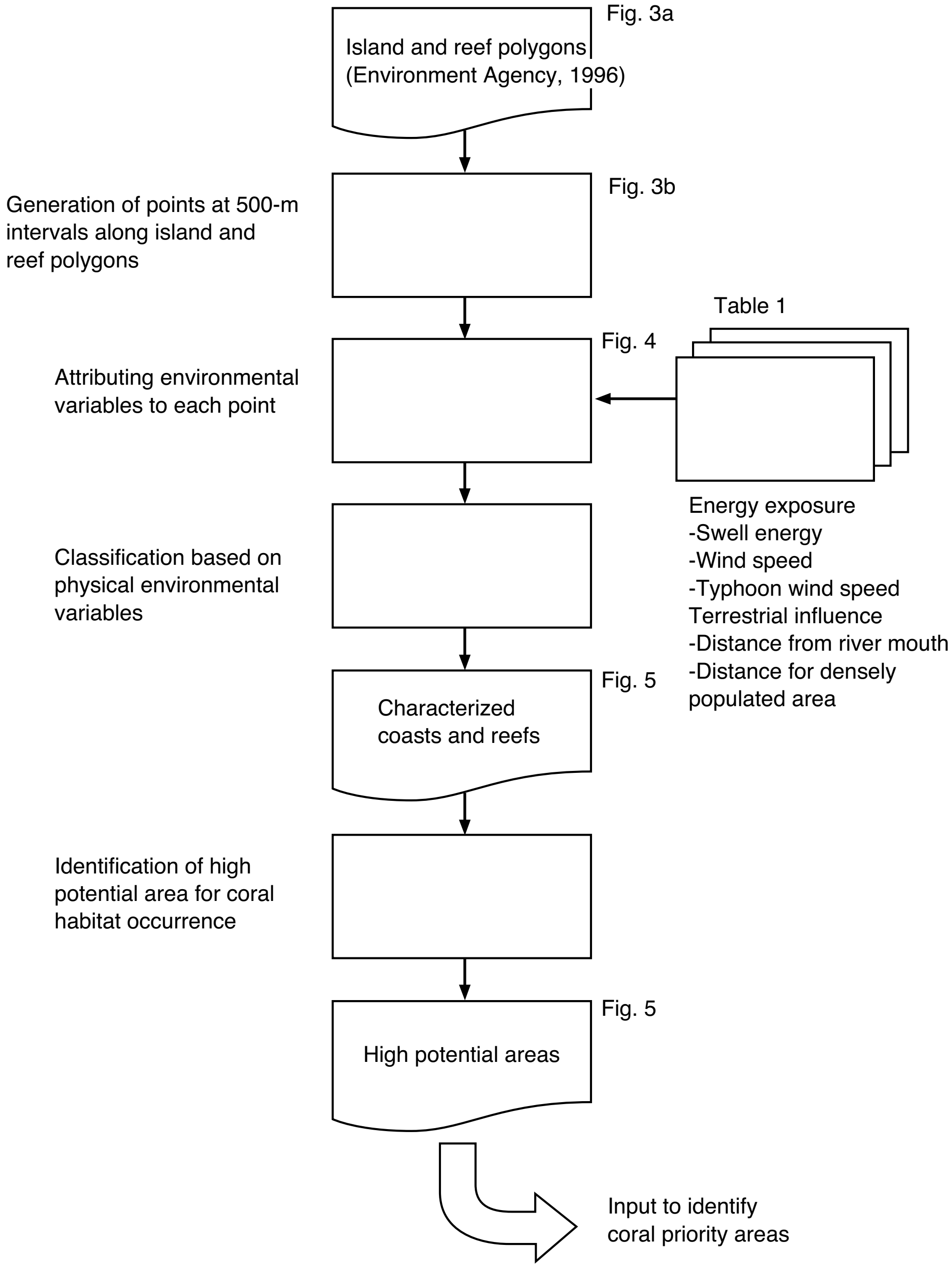


Fig. 1. a) Location of the Nansei Shoto, Japan. b) Coral reef distribution is constrained by physical environment. Well-developed coral reefs occur at high-energy sites facing to dominant swell and winds, while less developed coral reefs are found in leeward sites or sites affected by river discharge.

Fig. 2. Flowchart of this work.



Selection of physical environmental variables

We selected physical environmental factors that are assumed to have significant effect on coral distribution (Table 1).

Table 1. Physical environmental variables used in this work.

	Item	Value	Source
Energy index	Swell	Monthly swell energy	ECMWF
	Wind	Monthly wind speed	Japan Meteorological Agency
	Typhoon	Sum of typhoon (wind speed >17 m/sec) wind speed	AMeDAS, JMA
Terrestrial influence	River discharge	Distance from river mouth	
	Anthropogenic influence	Distance from densely populated area	Land-use map

ECMWF: European Centre for Medium-Range Weather Forecasts

Attribution of physical environmental variables

We assumed that corals were mainly distributed along the coastline and reef crest. For the whole Nansei Shoto, we generated points at 500-m intervals along the island and reef polygons (Fig. 3) that were prepared by Environment Agency (1996) and provided by the Biodiversity Center, Ministry of the Environment, Japan (http://www.biodic.go.jp). Then physical environmental variables shown in Table 1 were attributed to each point.

For energy indicators (swell, wind and typhoon), annual means of vertical vector values (swell energy, wind speed, and typhoon wind speed) against the surface shape of the polygons were attributed to each point (Fig. 4). If the points were situated in leeward or protected parts of energy exposure, null values for the energy indicators were attributed (Fig. 4). For terrestrial influences (river discharge and anthropogenic influence), distance from the sources (river mouths and densely populated areas, respectively) to each point was calculated, and the distance values were attributed.

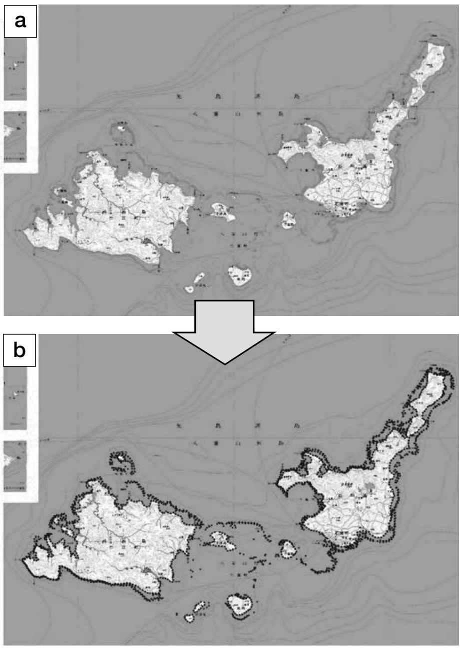


Fig. 3. a) Island and reef polygons (Environment Agency, 1996). b) Points generated at 500-m intervals. Examples from Ishigaki Island.

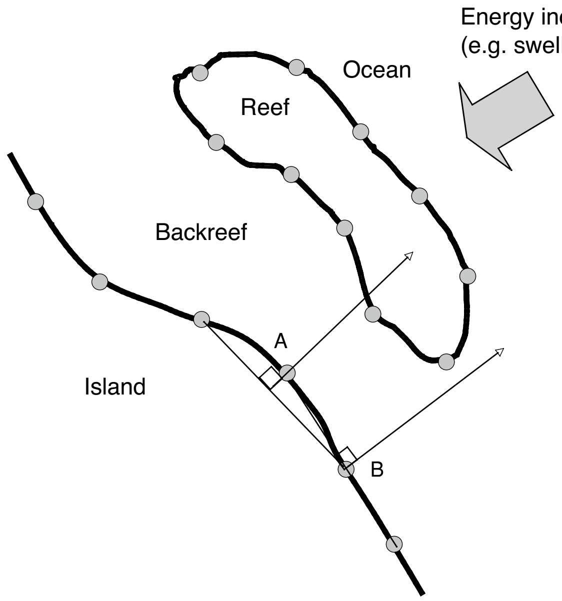


Fig. 4. Attribution of energy index. Vertical lines are set at each point, and if the lines are intercepted by other polygons, the point is regarded as protected, and null value is attributed (point A). Otherwise, energy index such as swell energy values are attributed (point B).

Characterization

First, based on the energy indicators, points with null energy values (hereafter, inner bay and backreef points) and points with positive values (hereafter, oceanward points) were classified. Then, for the inner bay and backreef points, further classification was achieved by using distance values; 1 km from the sources to the points. Accordingly, four classes were identified for the inner bay and backreef points (Fig. 5). For the oceanward points, median values for energy indicators in the whole Nansei Shoto were used. Based on swell energy and wind speed, the points were classified into three; large energy points (larger values for both swell energy and wind speed), medium energy points (larger values for either swell energy or wind speed), and small energy points (smaller values for both swell energy and wind speed). Further they were classified into two based on median values for typhoon wind speed in the whole Nansei Shoto. Accordingly six classes were identified for the oceanward points (Fig. 5).

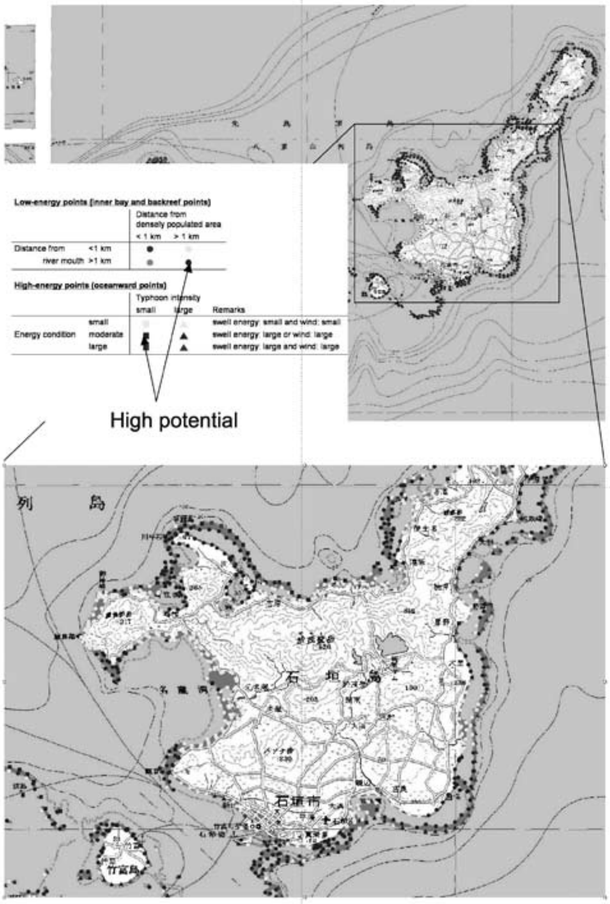


Fig. 5. Characterized points by physical environmental variables. In the inner bay and backreef points, points with less terrestrial influence are regarded as high potential areas. In the oceanward points, points with medium energy and low typhoon intensity are regarded as high potential areas. An example from Ishigaki island.

Evaluation of potential for coral habitats

We defined the high potential areas as points with small terrestrial influences for the inner bay and backreef points and as points with medium energy (larger values for either swell energy or wind speed) and small typhoon influence for the oceanward points (Fig. 5).

Conclusion

As a result of this work, large-scale characterization of coastal environment, as well as large-scale evaluation of the potential for coral habitat occurrence, was made possible (Fig. 5).

Our tool can provide general evaluation at a large spatial extent, and could be used for other applications including identification of suitable environment for coral transplantation and understanding the development pattern of coral reefs. Further, it could be applied to other coastal environments such as seagrass beds.

Appendix

-A poster that was presented in the 11th International Coral Reef Symposium

3.5. Selection of Biodiversity Priority Areas (BPA's)

BPA's were selected using GIS data, such as that from existing vegetation maps, in addition to TPA and priority coral community data. Although the Nansei Islands consist of small islands scattered widely over the ocean from the Ōsumi Islands to the Yaeyama Islands, the actual area encompassed by landmasses and shallow sea areas is extremely small. Thus, for the selection process, criteria were studied that would meet the scale (1:200,000) requirements for mapping. Furthermore, given that there is a great deal of species endemicity from island to island, methods for selecting BPA's in ways that distinguish between regions properly were also studied. The procedures for determining BPA's are outlined below.

1. Basic guidelines for BPA selection criteria

Tatsuo NAKAI (Kokushikan University)

1-1. Overlay method

The number of times TPA's overlap is an indicator of the degree of biodiversity at the taxon level, and this can be used as a basis for determining areas high in diversity (i.e. the overlay method). This method served as the main tool in the selection process.

1-2. Habitat method

When one thinks of BPA's not as administrative regions but as ecoregions, a concept that takes into account ecological functions and processes, one must consider not only the mere distributions of the different taxa, but also the distributions of the habitats in which they live. More specifically, in selecting BPA's for this project, with the exception of sea plants and algae, the taxa considered were all animals. Put in different terms, terrestrial plants were not taken into consideration. Nevertheless, it is extremely important to understand distributions of vegetation as habitats for these animals, and it is also reasonable to consider the diversity of plant species as integral to those habitats.

For these reasons, in addition to the overlay method described in 1-1 above, a method referred to here as the "habitat method" was employed. Terrestrial and marine habitats deemed critical for the preservation of biodiversity were selected, and the areas they encompassed were termed "Ecologically Critical Habitats" (ECH's). Then, the numbers of ECH's and TPA's occurring within a certain unit area were counted, and these figures served as one of the basic data sets for BPA selection.

In setting the unit areas for this counting process, it is important to consider the ecosystems within these areas. On land, for example, unit areas should be established with a view to the intertwining spatial structures of habitats, which include factors such as watersheds and similar systems, elevation, the distribution of geological features, etc.

With such considerations in mind, for terrestrial areas, watersheds were made unit areas, and the numbers of ECH's and TPA's occurring within them were counted. It should be noted that in Ryukyu limestone zones, because there are few or no developed surface rivers, subterranean water systems were taken into consideration to the extent that data collection was possible. In the initial phases of the project, we studied the possibility of including habitats distributed in mosaic patterns (natural spring sites, small streams, small patches of forest as seen at utaki and around estates, etc.) as elements for evaluation, but since homogeneous data encompassing the entirety of the Nansei Islands could not be collected, this idea was abandoned for the time being. However, despite being small in area and functioning as a habitat for only certain taxa, mosaic areas, where diverse habitats exist within a certain scale in terms of area, could also be considered areas important for conservation of biodiversity. Using the habitat method, vegetation on which there is extensive nationwide data made it possible, at least to a certain degree, to evaluate these mosaic habitats. Nonetheless, it is still necessary to study ways to evaluate mosaic habitats such as natural springs, small streams, utaki forests, etc. in the selection of BPA's encompassing even smaller areas.

For marine areas, specifically the shallow waters which this project addressed, the involvement of environmental components from the ocean such as wave conditions, and of environmental components from land, namely terrestrial water sources and the sediment they carry, means that habitats exhibit a belt-like configuration that more or less runs parallel to the coastlines (Figure 1). This belt configuration is modified by the presence of topographical formations such as bays and rivers, and as a consequence raises the level of diversity in habitats occurring within certain areas. In this respect, the application of the habitat method is more appropriate to marine areas than the overlay method. Since the coral reefs in the relevant areas are composed of fringing coral, the expanses of shallow seas on the islands extend at most about one or two kilometers from the coastline, and therefore are more linear than planar. For this reason, physiographic units (PGU's), which approximate catchment areas on land, were adopted as units of area. PGU's are particularly effective in delineating coral reef areas, and because promontories, water channels, reef flats (reef crests), and other topographies control the seawater flow patterns, semi-enclosed aquatic systems are formed, which in themselves can be thought of as ecological units (Nakai, 2007).

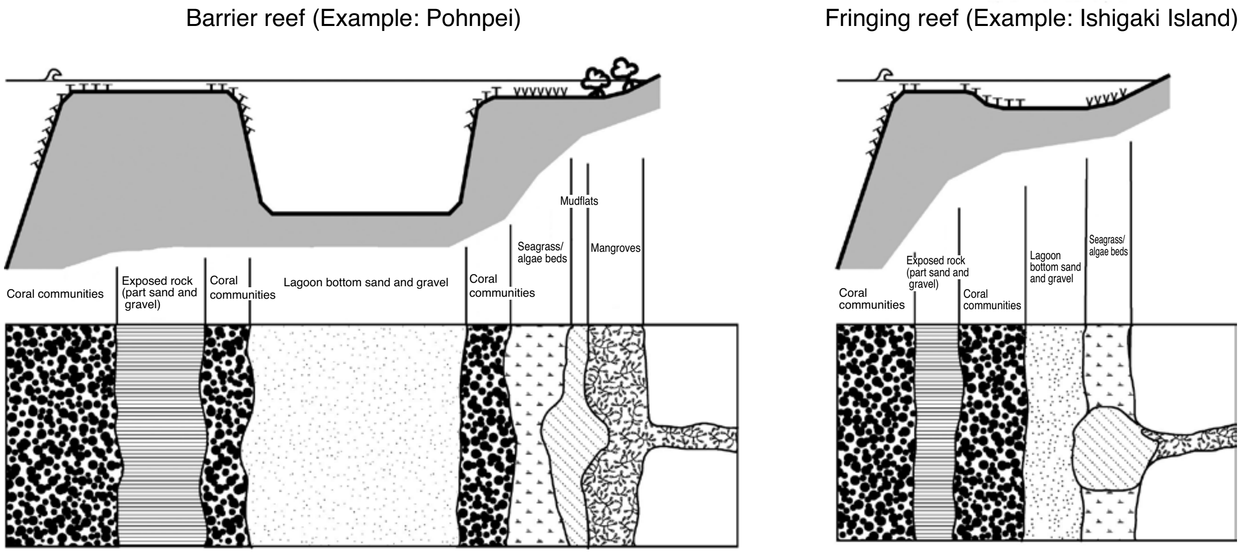


Figure 1. Coral reef landscape component (habitats) belt layouts (Nakai, 2007)

1-3. Area divisions in the BPA selection process (evaluation of endemic species)

Hidetoshi OTA (University of Hyogo)

The genesis and history of the Nansei Islands have led to a large degree of biota heterogeneity among the islands and island groups that constitute them. Furthermore, some of the islands and island groups, including the smaller ones, have endemic species and subspecies that only occur on those islands, and the frequency of their occurrence is not necessarily in accordance with the high level of diversity of the biota as a whole. For this reason, if the BPA selection method attempted in this project were to be applied to all of the Nansei Islands uniformly, there would be a risk of unduly omitting areas with high rates of endemicity, which is one of the most characteristic features of the terrestrial biota in the Nansei Islands, as noted above. One cannot doubt the scientific significant of treating the Nansei Islands uniformly, eliminating other factors, and comprehensively and unconditionally narrowing areas down strictly to those with a high rate of occurrence of BPA's. However, in order to ensure that the results of this project have a direct effect on future biodiversity conservation strategies, it is necessary to make sure that, amidst the high degrees of heterogeneity, certain areas are not excluded in the analysis process, namely areas with high levels of endemicity which should be given priority from a conservation perspective.

Given these considerations, in selecting terrestrial BPA's, a method was employed that uses overlaps observed in the distribution of endemic species, endemic subspecies, and genetically specialized groups of some terrestrial vertebrates, insects (especially beetles), terrestrial crustaceans, and terrestrial mollusks, of which there is a relative wealth of knowledge, to divide the Nansei Islands into 13 areas (endemicity areas).

2. Details of the selection procedures

Based on the principles expressed above, we first made two distinctions: terrestrial and marine. The selection procedures used for each are described below. The technical methods for data extraction using GIS (geographic information systems) software are shown in Appendix D.

2-1. Terrestrial areas

The chief method used was the overlay method, but it was augmented by the habitat method. In other words, BPA's were selected by identifying primarily areas with a high degree of biodiversity, but also catchment boundaries with relatively pristine and diverse vegetation.

2-1-1. Overlay method

1) Using GIS, overlay processing was performed on TPA maps of eight taxa (mammals, birds, amphibians/ reptiles, insects, fish, crustaceans, mollusks, and freshwater algae). Reef-building coral were not included. For groups with species such as sea turtles for which both terrestrial and marine environments are important, as well as groups such as mammals, seagrass and algae which have both land- and marine-dwelling species, the marine areas were excluded from the extraction process.

2) Areas were demarcated into strata according to the number of overlaps and drawn onto the maps (see Appendix G).

2-1-2. Habitat method

1) Catchment boundaries were shown with GIS, and maps of the watersheds of all areas were created. The catchment boundaries were gleaned from topographical maps. Limestone areas, however, often lack surface water (rivers), and terraces make it difficult to discern, so catchment boundaries were set using existing data on subterranean water sources to the extent possible.
2) Using GIS, watershed maps (unit area) were superimposed onto eight types of TPA maps and the following four kinds of ECH maps. The number of occurrences of TPA's and ECH's were calculated for each watershed, and maps were created based on those numbers (see Appendix H).

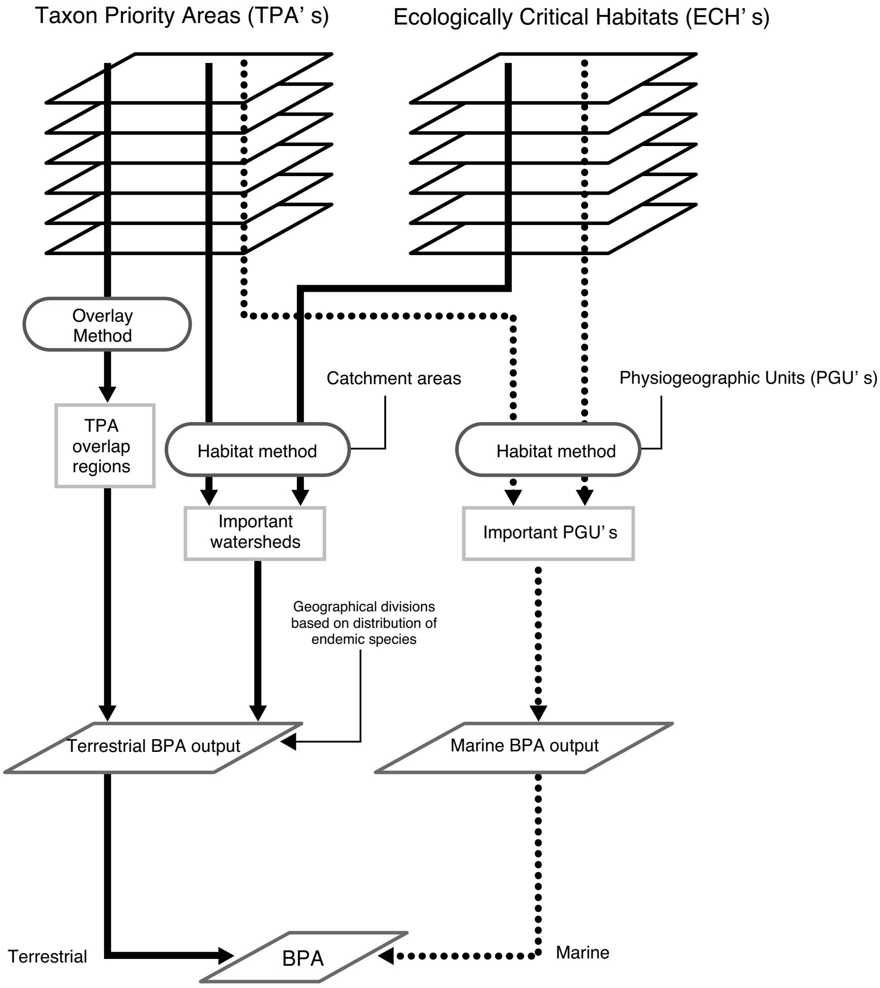
Ecologically Critical Habitats (ECH's):

I. Natural vegetation in *Fagetea crenatae* regions (pristineness level of 7 or higher)
II. Natural vegetation in *Camellietea japonicae* regions (pristineness level of 7 or higher)
III. Secondary vegetation in *C.japonicae* regions (pristineness level of 7 or higher)
IV. Riverbank, moor, salty marshland, and dune vegetation

Note: All were gathered from vegetation maps from the Environment Agency's Natural Environment Conservation Basic Survey by Minstry of the Environment.

2-1-3. Terrestrial BPA selection (integration of the overlay and habitat methods)

1) Regions in which the number of overlaps in the TPA maps for the eight taxa is equal to or greater than m in the overlay method, they are classified as BPA_{L1}.
Furthermore, the TPA's of all taxa are joined, and the resulting area becomes IA. The number of overlaps m is the minimum value such that the ratio of BPA_{L1} to IA does not exceed 30 percent.
2) Regions in which the number of occurrences is equal to or greater than n in the habitat method, they are classified as BPA_{L2}. The number of overlaps n is the maximum value such that the ratio of the union of BPA_{L1} and BPA_{L2} (BPA_L) to IA exceeds 30 percent.
3) The addition of the regions yielded after the above operations were performed on each of the 13 areas that were demarcated based on the distinctiveness (endemicity) of biota from island to island or among island groups in the Nansei Islands, and the regions yielded after performing the operations without those distinctions, give us the terrestrial BPA's (BPA_L).



Note: The bases for dividing the Nansei Islands into 13 areas based on overlaps observed in the distribution of endemic species, endemic subspecies, and genetically specialized groups of some terrestrial vertebrates, insects (especially beetles), terrestrial crustaceans, and terrestrial mollusks are as follows.

Area ID	Area name	Basis for division
1	Ōsumi Islands	Unlike most other islands in Nansei, many species are shared with Kyushu, though there is some endemicity seen in mammals, reptiles, amphibians, and beetles.
2	Northern Tokara Islands (Nakanoshima)	Some genetically peculiar species of reptiles
3	Southern Tokara Islands (Takarajima/Kotakarajima)	Endemic species and specialized groups of reptiles and crustaceans
4	Amami Islands (Amami Ōshima)	Endemic species and subspecies of mammals, birds, reptiles, amphibians, and beetles
5	Tokunoshima	Endemic species and subspecies of mammals, reptiles, and beetles
6	Okinoerabujima	Genetically specialized groups of reptiles; endemic species and subspecies of beetles, crustaceans and terrestrial mollusks
7	Yoronjima/ Okinawa Islands/ Kerama Islands	Endemic species and subspecies in many taxa; possibly necessary to make further divisions
8	Kumejima	Endemic species and subspecies of reptiles, beetles, and crustaceans
9	Daitō Islands	Although these islands exhibit a low level of diversity overall, there are endemic species and subspecies of mammals, reptiles, beetles, and terrestrial mollusks.
10	Miyako Islands	Endemic species and subspecies of reptiles, amphibians, crustaceans, and terrestrial mollusks
11	Yaeyama Islands (Ishigaki/ Iriomote)	Endemic species and subspecies of mammals, reptiles, amphibians, and beetles
12	Yonagunijima	Endemic species and subspecies of reptiles, beetles, and terrestrial mollusks
13	Senkaku Islands (Uotsurijima)	Endemic species and subspecies of mammals, beetles, and crustaceans

Divisions by Hidetoshi Ota (University of Hyogo)

2-2. Marine areas (shallow waters)

The habitat method was used for choosing BPA's. Using PGU's as basic units, BPA's were selected by identifying areas with relatively diverse habitats such as mangrove forests, natural shores, critical coral communities, and seagrass beds, in addition to taxa diversity.

2-2-1. Habitat method

1) PGU's were determined from topographical information on promontories, bays, water channels, reef crests, and water depths, as well as from aerial photographs showing micro-landform configurations on coral reefs, which reflect the predominant movements of ocean waters. The borders off the PGU waters were based on ancillary 20-meter depth lines shown on government-issued topographical maps (1:200,000). At locales where it was difficult to extrapolate the 20-meter depth line, or in cases in which the 20-meter depth line is closer to the shore than reef edges, a line offshore equidistant from the reef edges was treated as the PGU border. Because of the steep gradient in sea depth off both the northern and southern parts of the Daitō Islands, the depth of 200 meters was adopted as an outer boundary line.

While Sekisei Lagoon and Nakagusuku Bay do boast considerable areas, the same basic methodology was employed for reasons of consistency. That said, there are cases of highly valuable communities of flora and fauna adapted to environments extending from the inner reaches of bays all the way to ocean waters, and therefore future considerations should include ways of assessing "super units" that encompass all such areas.

2) Using GIS, TPA maps of six taxa (mammals, birds, amphibians/reptiles, fish, crustaceans, and mollusks; insects were not included) and the following five kinds of ECH maps were superimposed upon PGU's. The number of occurrences of TPA's and ECH's in each PGU was calculated, and maps were created based on those numbers (see Appendix H).

Ecologically Critical Habitats (ECH's):

I. Coral communities (reef slopes); important communities selected in this project

II. Coral communities (reef flats and moats); important communities selected in this project

III. Seagrass/agae beds; important beds selected in this project

IV. Mangrove forests; gathered from the vegetation maps from Natural Environment Conservation Basic Survey by Ministry of the Environment

V. Natural shores (one kilometer or more in length); gathered from the Environment Agency's Natural Environment Conservation Basic Survey by Ministry of the Environment

2-2-2. Marine BPA selection

Regions in which the number of occurrences is equal to or greater than u are classified as marine BPAm. Furthermore, all PGU regions with occurrences of one or more are considered priority marine waters, the area of which is IA. The number of occurrences u is the maximum value such that the ratio BPAM to IA exceeds 30 percent. The land Biodiversity Priority Areas (BPAL) and marine Biodiversity Priority Areas (BPAM) determined through the above procedures together become the Biodiversity Priority Areas of the Nansei Islands (see Appendix I).

The numbers of occurrences in BPA’s in the Nansei Islands derived from the superimposition method and habitat method in this project are listed below.

Area ID	Area name	Terrestrial BPA		Marine BPA
		Overlay method: No. of TPA occurrences	Habitat method: No. of TPA+ECH occurrences	Habitat method: No. of TPA+ECH occurrences
0	Nansei Islands overall	4	10	5
1	Ōsumi Islands	3	8	*
2	Northern Tokara Islands	3	8	*
3	Southern Tokara Islands	3	6	*
4	Amami Islands	5*	10	*
5	Tokunoshima	4	9	*
6	Okinoerabujima	3	8	*
7	Yoronjima/ Okinawa Islands/ Kerama Islands	4	10	*
8	Kumejima	4	9	*
9	Daitō Islands	5*	10	*
10	Miyako Islands	3	8	*
11	Yaeyama Islands	6*	11*	*
12	Yonagunijima	5*	10	*
13	Senkaku Islands	4	7	*

*Terrestrial BPA’ s selected are the result of the joining of areas yielded from the application of selection criterion values for the Nansei Islands as a whole with the areas yielded from the application of selection criterion values to each of the 13 areas. For this reason, regions with asterisks next to criterion values denote the application of the application of selection criterion values for the Nansei Islands as a whole.
*Corresponding divisions or demarcations were not used for marine areas, so uniform criteria (5 occurrences) were applied to all regions of the Nansei Islands.

3. Considerations important to BPA selection

The selection of BPA’s in this project does not necessarily mean that these areas should be established as protected areas to be enforced by laws and regulations. Furthermore, it should in no way be inferred that areas not selected as BPA’s are good places for development projects. The BPA maps should not be used for such purposes. For the purposes of preserving individual areas or developing plans on how to utilize them, more detailed and thorough field surveys, as well as a better understanding of social factors and environmental impact, are absolutely essential.

The current project represents an experimental attempt to select BPA’s by chiefly evaluating centers of biodiversity in terms of various taxa and habitats while also taking the Nansei Islands' centers of endemism into consideration, and by utilizing scientific data that encompasses all of the Nansei Islands. In the discussions that took place in this project, many issues related to the identification and selection of priority areas arose. The most prominent issues are outlined below.

・Weighting the data

In the current project, no weighting of the data based on considerations such as differences among taxa, data reliability, species scarcity, or endemicity was done in the selection and evaluation processes. If one were to select TPA's in a manner that is more area-specific, it would be necessary to weight any data on the species and environments to be protected, keystone species, ecological functions, etc. In addition, the present project contains instances where the boundaries of priority areas were drawn in an accurate and scientifically rigorous manner based on the latest distribution data, but also instances where data was insufficient so that boundaries had to be drawn in a rough fashion, leaving a certain degree of buffer area. Weighting based on data reliability is an issue worthy of further study. It was also pointed out that there were many areas not designated as TPA's because there was not enough scientific information available to determine their importance, and we were not able to make the distinctions between such areas and those of low importance or priority.

・Establishing contiguity between land and sea

Because the paradigms used in the selection process were ecoregions or bioregions, a conscious effort was made to create geographical divisions determined from the movement of water: namely, catchment areas on land and PGU's in shallow ocean waters. This made it possible to discuss the relationship between terrestrial and marine areas that are connected through the movement of water. The movement of water is closely related to human wastewater, sediment, and organisms that traverse terrestrial and marine areas. Accordingly, areas with terrestrial and marine BPA's adjacent to one another become extremely important as complete systems that link land with the ocean. Even in cases in which hinterlands of marine BPA's are not included among terrestrial BPA's, the conservation and management of those hinterlands are vital to the conservation of their adjacent marine BPA's. Ways of indicating this on BPA maps should be studied in the future. When dealing with island ecosystems, perspectives that see land and ocean in an integrated manner are important.

・Evaluating areas in which natural restoration and the establishment of corridors are possible

There have been instances of scientists measuring the area (landmass) of a relevant region in terms of the minimum area required by keystone species or populations being protected, measuring degrees of disjunction, and evaluating areas in which populations of indicator taxa had recovered through the effective eradication of nonnative species. However, in part because no dataset could be obtained that was comprehensive enough to contribute to such evaluations in the Nansei Islands, areas in which natural restoration and the establishment of corridors are possible were not considered in this project.

・Improving and updating the database

The geographical information database, in which basic data on the various taxa used to select BPA's is stored, should be updated. In addition, it is necessary to add features such as logs of areas for which the problem of insufficient data has been resolved, access dates, update histories, etc. By creating and maintaining a database with these capabilities, more reliable BPA maps could be produced. Such a database would have the potential to become a repository of findings from different kinds of monitoring surveys conducted by a variety of parties, it could contribute to the strategic and effective elimination of data deficient areas and subjects.

・Indicator species selection methods

Matrices were created in this project so that indicator species could be chosen from various areas and habitats of the Nansei Islands with as few omissions as possible, but when one looks carefully at individual islands and microenvironments, it becomes clear that some areas were omitted as TPA's because the relevant indicator species was not selected. Indicator species selection methods that properly correspond to the scale of the areas subject to conservation efforts should be adopted accordingly.

・The validity of the scopes of BPA's

In this project, parameters were set so that about 30 percent of the total area of TPA's for all taxa would be selected as the BPA's of the Nansei Islands, and maps were created based on this. However, there is no absolute foundation behind this choice of 30 percent. Opinions among attendees of the conferences differed as to the validity of the scope of areas to be demarcated as BPA's. The selection in this project was done with a view to maintaining processes that guaranteed traceability, based on objective and scientific data and without societal concerns. For this reason, it is possible that areas in urgent need of protection have been omitted.

Accordingly, in determining how to designate individual areas as priority areas, the BPA selection approach and maps can serve as useful sources of information, but they alone are not sufficient. It is also necessary to take into account socioeconomic factors, which entails balancing the choices of species groups to be protected with the interests of the owners of land containing environments they inhabit, and to study zoning strategies that involve strict protection, sustainable use, etc. For reference purposes, maps are shown in Appendix J in which the BPA selection parameter of 30 percent of all priority areas that was used in this project has been changed to 10, 20, 40, and 50 percent, respectively.

Chapter 4.
The present and future of priority areas in the Nansei Islands

Chapter 4. The present and future of priority areas in the Nansei Islands

4.1. Overlaps of Biodiversity Priority Areas (BPA's) with protected areas/national forests

For this project, we took into account factors such as diversity at the taxon level, the distribution of endemic species inhabiting the islands, pristine vegetation, the presence or absence of shore environments, catchment areas, etc., and set parameters so that more than 30 percent of the total area comprising the TPA's for all taxa would be selected, and based on that proceeded to determine the Biodiversity Priority Areas (BPA's) of the Nansei Islands.

After calculating the coverage of BPA's by existing protected areas and national forests, it was found that about 40 percent of terrestrial BPA's and 50 percent of marine BPA's had been designated as protected areas or national forests (see Table 1, Table 2, and Appendix K). When viewed by region, most of the BPA's of Yakushima, which has been designated as a World Natural Heritage Site, and of the Yaeyama Islands, which were expanded through the creation of the Iriomote-Ishigaki National Park in August of 2007, are part of designated protected areas or national forests. In nearly all other regions, in contrast, this overlap is less than 10 percent, indicating a regional bias in official protection status. Although this report is not meant to suggest that BPA's are areas that immediately need to be protected through legal measures, when the Committee to Review Candidates of World Natural Heritage was convened by the Ministry of the Environment and the Forestry Agency in 2003 and the Nansei Islands area was chosen as a candidate site, one issue pointed out was that not enough of the area has been turned into protected areas, an observation that was confirmed in this project as well.

It is hoped that these BPA maps will be utilized by government officials as they establish or expand protected areas and promote the sustainable use of nationally-owned forestland, and that even for important areas in which the protected area designation is not applied, management plans will be drafted with the participation of parties involved in this project.

Table 1. Overlaps of Biodiversity Priority Areas (BPA' s) with protected areas/national forests in the Nansei Islands (land)

Land		Area (km^2)					
Area ID	Area name	BPA	Terrestrial (BPA/land area %)	Priority area IA (BPA/IA %)	BPA ∩ Protected area (Protected area/BPA %)	BPA ∩ National forest (National forest/BPA %)	BPA ∩ (Protected area ∩ National forest) (Protected area & national forest/BPA %)
0	Nansei Islands overall	1762.9	4707.9 (37.4%)	3992.1 (44.2%)	578.5 (32.8%)	372.5% (21.1%)	694.3 (39.4%)
1	Ōsumi Islands	250.3	1026.5 (24.4%)	548.0 (45.7%)	199.3 (79.6%)	141.4 (56.5%)	199.3 (79.6%)
2	Northern Tokara Islands	38.8	92.8 (41.3)	76.7 (50.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
3	Southern Tokara Islands	6.8	8.4 (80.6%)	7.9 (85.1%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
4	Amami Islands	341.3	878.3 (38.9%)	801.0 (42.6%)	35.7 (10.5%)	11.2 (3.3%)	45.4 (13.3%)
5	Tokunoshima	106.9	248.1 (43.1%)	245.4 (43.6%)	32.1 (30.0%)	6.4 (6.0%)	36.1 (33.8%)
6	Okinoerabujima	34.0	93.7 (36.2%)	88.5 (38.4%)	0.0 (0.0%)	3.1 (9.1%)	3.1 (9.1%)
7	Yoronjima/ Okinawa Islands/ Kerama Islands	415.3	1371.3 (30.3%)	1279.3 (32.5%)	66.0 (15.9%)	39.8 (9.6%)	105.7 (25.5%)
8	Kumejima	48.2	61.0 (79.0%)	58.8 (82.0%)	0.0 (0.0%)	5.2 (10.8%)	5.2 (10.8%)
9	Daitō Islands	34.1	42.6 (80.1%)	42.6 (80.1%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
10	Miyako Islands	91.6	292.1 (31.3%)	278.9 (32.8%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
11	Yaeyama Islands	363.3	558.5 (65.0%)	531.0 (68.4%)	245.4 (67.6%)	163.6 (45.0%)	297.7 (82.0%)
12	Yonagunijima	28.9	29.0 (99.8%)	29.0 (99.8%)	0.0 (0.0%)	1.8 (6.2%)	1.8 (6.2%)
13	Senkaku Islands	4.0	5.5 (71.9%)	5.0 (80.4%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)

Table 2. Overlaps of Biodiversity Priority Areas (BPA' s) with protected areas in the Nansei Islands (ocean)

Ocean waters		Area (km^2)			
Area ID	Area name	BPA	Marine area (BPA/marine area %)	Priority area IA (BPA/IA %)	BPA ∩ Protected area (Protected area/BPA %)
0	Nansei Islands overall	748.8	2264.4 (33.1%)	2177.2 (34.4%)	361.6 (48.3%)
1	Ōsumi Islands	3.4	117.0 (2.9%)	112.7 (3.0%)	0.0 (0.0%)
2	Northern Tokara Islands	0.0	13.3 (0.0%)	1.6 (0.0%)	— (—%)
3	Southern Tokara Islands	0.0	12.2 (0.0%)	8.2 (0.0%)	— (—%)
4	Amami Islands	129.9	286.2 (45.4%)	272.8 (47.6%)	90.5 (69.7%)
5	Tokunoshima	0.0	53.1 (0.0%)	51.0 (0.0%)	— (—%)
6	Okinoerabujima	0.0	26.5 (0.0%)	19.4 (0.0%)	— (—%)
7	Yoronjima/ Okinawa Islands/ Kerama Islands	248.0	837.1 (29.6%)	819.8 (30.2%)	28.6% (11.6%)
8	Kumejima	12.2	63.5 (19.1%)	63.4 (19.2%)	0.0 (0.0%)
9	Daitō Islands	0.0	10.9 (0.0%)	7.9 (0.0%)	— (—%)
10	Miyako Islands	5.1	246.5 (2.1%)	225.6 (2.3%)	0.0 (0.0%)
11	Yaeyama Islands	350.1	571.4 (61.3%)	570.3 (61.4%)	242.4 (69.2%)
12	Yonagunijima	0.0	14.1 (0.0%)	14.1 (0.0%)	— (—%)
13	Senkaku Islands	0.0	12.6 (0.0%)	10.6 (0.0%)	— (—%)

Note: The rates of coverage by protected areas were derived by first aggregating the protected areas (i.e. National Parks, Quasi-National Parks, Wilderness Areas, Nature Conservation Areas, Wildlife Protection Areas, Natural Habitat Conservation Areas, wetlands registered for protection under the Ramsar Convention, World Natural Heritage Sites, and Protected Water Surfaces) and then calculating the ratios of parts of BPA covered by protected areas to the BPA, for both terrestrial and marine surface areas. Similarly, ratios to BPA of overlapping national forests, as well as of the union of protected areas and national forests, were calculated. The data on protected areas was obtained from the Ministry of the Environment's Natural Environmental Information GIS, the MPA database, and the Ministry of the Environment's International Coral Reef Research and Monitoring Center. National forest data was obtained from the Land Use Control Back-up System.

4.2.Current state of the taxa and pending issues

In the following pages we address the state of conservation of the Nansei Islands and pending issues as they relate to the taxa evaluated in this project (i. mammals, ii. birds, iii. amphibians and reptiles, iv. insects, v. fish, vi. crustaceans, vii. mollusks, viii. sea plants and algae, and ix. coral).

1. Ōsumi Islands

Ōsumi Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

In recent years, Yakushima has been facing several problems, such as disturbances to ecosystems caused by an increase in the nonnative raccoon dog (*Nyctereutes procyonoides*), predation of seedlings in habitat forests by Yakushima deer, whose numbers have soared, and damage to fruit-bearing trees caused by the Yakushima macaque. In addition to hunting pressure and the eradication of nonnative species, the need for the establishment and expansion of natural forest ecosystems through the promotion in habitats of mixed forests with coniferous and broad-leaved species must be addressed. Similar kinds of conservation are also needed on Tanegashima and Mageshima. On Kuchinoerabujima, human settlements have become habitats of the Erabu flying fox, and it is hoped that the animal can continue to live in harmony with people. There is very little data available on bats on the islands scattered throughout this region. The Mishima Islands, which comprise Takeshima, Iōjima, and Kuroshima, is the northern boundary of the Kuroshio Current. Kuroshima in particular still has many natural forests, but there is almost no available information on mammals on the island.

Ōsumi Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

There were once major logging operations exploiting Japanese cedar (*Cryptomeria japonica*) natural forests on Yakushima, but a large section of the island, from the central to the western part, are protected by overlapping designations as a National Park, a World Natural Heritage Site, and a Wilderness Area, within which there is no development activity. However, after being listed as a World Heritage Site, Yakushima saw an increase in the numbers of sightseers and other visitors, which has created the problems such as the need to construct facilities to accommodate these visitors, and general overuse. Furthermore, better strategies need to be employed which strike a balance between the interests of the residents and local industry with the efforts at natural conservation. There is a certain amount of data on birds in forests, but there is still a relative paucity of data on birds at the island's river mouths, seashores and farmland.

Tanegashima does have Wildlife Protection Areas on its northern and southern parts, but there is still a need for conservation measures that link important habitats for birds, which in addition to these protected areas include forests, marshlands, and shorelines. The whole of Kuchinoerabujima is a Wildlife Protection Area, and part of it is a Natural Park Special Protection Zone. All of Mageshima is likewise a Wildlife Protection Area, but most of it is privately owned by a company, and it faces a host of problems related to major alterations to the environment, as logging and quarrying operations are underway on the island.

Surveys of bird fauna and observation records for the Ōsumi Islands are all from 2001 or earlier, and although no major changes are thought to have taken place, they do not represent the current situation. New studies are necessary in order to create updated lists of birds and to ascertain information on habitat locations and populations. There is a particular need for studies of recent trends of species which have been recorded in the past but for which there are almost no recent records, such as the Ryukyu robin and the Izu thrush on Yakushima, and the Japanese robin on Tanegashima.

Ōsumi Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

With the exception of very small uninhabited islands and rock reefs, there exist one or more reports or distribution records concerning amphibians and reptiles on the Ōsumi Islands (Maenosono and Toda, 2007). That said, even in the case of larger islands that generate a relatively high level of scientific and lay interest, as do Yakushima and Tanegashima, there have been almost no comprehensive studies conducted of the intra-island distributions or intra-island populations of noteworthy species accorded special statuses. The demarcation of distribution ranges that was conducted in this project relied on scant field observation data and the checking of the types of habitats that such species would live in from maps. More efforts are required in order to raise the level of accuracy of data through studies that are more systematic and comprehensive.

Regarding sea turtles, levels of interests among local residents are high on Yakushima and Tanegashima, which harbor relatively large beaches. Kamezaki and members of the Sea Turtle Association of Japan that he heads are conducting ongoing research through direct observation and interviews with others, and the quality of data gathered by them is considered high. Aside from these efforts, there are islands on which the landing and nesting of at least loggerhead turtles has been confirmed (for example Kuchinoerabujima; Ota, unpublished data), but information is very far from complete.

Of amphibians and reptiles in this island group, there is nothing to suggest that any whole taxon is facing an immediate threat to its continued survival. Nevertheless, there are grounds for concern at the level of individual populations on specific islands —for example the Japanese pond turtle population on Tanegashima— due to the effects of shrinking terrestrial water sources and deteriorating water quality. There are also more than a few islands on which there are concerns over direct predation by nonnative species and disturbances to ecosystems. On Yakushima, for example, recent years have seen the expansion of the habitats of raccoon dogs, which were intentionally released on the island, and on Iōjima, Indian peafowl (*Pavo cristatus*), which were released by a tourist attraction that once operated on the island, have thrived and now densely populate nearly the entire island (Ota, unpublished data). We can assume that these nonnative species prey on many amphibians and reptiles, leading to serious concerns about predation pressure.

Ōsumi Islands: (iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of the Ryukyus),
Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

Because Yakushima has been registered as a World Heritage Site, there are now concerns over development in the areas stretching from the shores to the forest edges. Full-scale studies of insects on Tanegashima have yet to be conducted. Mageshima has many rivers, which is uncharacteristic for a small island, and the people responsible for protecting the nature and the fishing industry of the island have reported many species of flora and fauna there. However, a quarrying enterprise by a developer (which owns 99 percent of the island in terms of area) has caused tremendous devastation, leaving the island’s environment in a critical situation. The issue needs to be addressed urgently.

Ōsumi Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

In addition to being part of the Kirishima-Yaku National Park, two areas of Ōsumi (excluding Sakurajima and Cape Sata: 170.9 hectares) have been designated as Marine Park Zones. The Marine Park Zone designation provides for the protection of scenery and ecosystems, as well as systems regulating the hunting, capture or collection of designated plants and animals. The species protected are mainly those that are highly valued for their exotic beauty, such as butterflyfish (the same applies to regions below).

Ōsumi Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

At present, no comprehensive surveys have been conducted on the crustacean fauna of the Ōsumi Islands. As it stands, we only have incomplete records of the collection of specimens of rare species (indicator species used in this project). Survey data of shores and adjacent areas (tidal mudflats at river mouths and rocky splash zones) is particularly deficient, thus further studies and research need to be performed at an early date.

Ōsumi Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

On Yakushima, important habitats for terrestrial mollusks coincide with a National Park, a natural World Natural Heritage Site, and a Wilderness Area. Most of Tanegashima, however, does not enjoy such legal protections, which is why there are concerns over worsening forest environments caused by farmland development and other projects.

Research into population data for terrestrial water-dwelling and marine mollusks on both Yakushima and Tanegashima has not advanced sufficiently. For this reason, the identification of important shore areas remains incomplete.

Ōsumi Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

The coral reefs at Sumiyoshi listed as a priority conservation area in this project extend from the inner reaches of a small bay (the Sumiyoshi Fishing Port) to the waters off the Ōsumi Peninsula. The Hamanochō River flows on the outside of the port's right shore and washes over the reef flat into the sea.

It is likely that the position of the river mouth and the direction it dictates have been altered because of the construction of the fishing port. One significant concern is the impact on organisms that live in intertidal zones from the outflow of rivers over coral reefs during heavy rains. Data on the effects of organisms during such events and their capacity to recover must be collected. At present, there do not appear to be any problems posed for other important conservation areas.

Ōsumi Islands: (ix) Coral

Takeshi MATSUMOTO (Yakushima Marine Organism Research Workshop)

Due to the large-scale bleaching event that struck the Ōsumi Islands in 1998, shallow communities of table coral were devastated. However, there have been no bleaching events since and no apparent damage by crown-of-thorns starfish, and the reefs are steadily recovering.

Over the course of a project designed to further conservation activities of Marine Park Zones conducted in fiscal 2002, a survey of crown-of-thorns starfish revealed neither its presence nor evidence of predation thereof.

According to the “Monitoring Site 1000” survey conducted in 2004, out of 19 sites, those with coverage ratios exceeding 40 percent totaled eight: Yakushima’s Shitogo, Senroku, Yudomari, Mugio, Nanase, and the area below the administrative building, and Kuchinoerabujima’s Nemachi and Iwayadomari. Shitogo, Yudomari, Mugio, Nanase, and the area below the administrative building were areas particularly devastated by the 1998 bleaching event, though they are steadily recovering. At Shitago, staghorn coral (*Acropora formosa*), which was not frequently observed at Yakushima, has grown into several communities of 20 to 30 centimeters, which is just one sign among many of the recruitment of new coral. At Yudomari, Mugio, and Nanase, *A. hyacinthus*, which thrived in the past, has also recovered and is continuing to grow.

No major changes were observed off Mageshima, Tanegashima’s Urata district, Kuroshima, Iōjima, or Takeshima.

2. Tokara and Amami Islands

Tokara and Amami Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

The Erabu flying fox and other small entomophagous bats (a few) have been recorded on the Tokara Islands, but many details remain unclear. There have been no studies of mammals on Yokoatejima, which is situated to the west of the midpoint between Takarajima and Amami Ōshima. In addition, with the exceptions of Amami Ōshima and Tokunoshima, thorough surveys of mammalian fauna on the Amami Islands have not been conducted, with few such surveys having been undertaken even for Amami Ōshima and Tokunoshima, meaning that information is scarce. As mammals depend heavily on forests, there are concerns over forestry activities with regard to trees at felling age, and therefore future strategies must be developed to mitigate this trend. Tokunoshima has a particularly large share of forest-dwelling indicator species, but large-scale projects to expand farmland have led to the cutting off of forests between the northern and southern parts of the island, which in turn has caused the disjunction of habitats. Moreover, the growing impact of tourism and incidents of traffic accidents also merit study.

The Javan mongoose (*Herpestes javanicus*) was first introduced to Amami Ōshima (specifically the present-day Naze district of Amami City in its central region) in 1979. It went on to inhabit about 60 percent of the island. The Javan mongoose poses a threat to the habitats of many of the indicator species indicated above and many other native species belonging to other taxa. Projects aimed at eradication are currently underway under the Invasive Alien Species Act, and as a result, population densities of this species have dropped significantly. Consequently, there are visible indications of improvements in populations of native species, including some indicator species. The impact of feral dogs and cats on native species is also quite substantial. Furthermore, a subspecies of the Japanese weasel (*Mustela itatsi itatsi*) has become feral on the islands and poses a threat to native biota. At the same time, the devastation to ecosystems (including vegetation) brought about by the increase in feral goats around the coastal areas of Amami Ōshima in particular cannot be ignored. These developments underscore the need for comprehensive strategies to deal with such "domesticated" animals as well.

Tokara and Amami Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

All of the islands in the Tokara Island group have been designated as Wildlife Protection Areas, and therefore it is fairly safe to assume that no major environmental alterations have occurred. There have been short-term surveys of specific birds on Nakanoshima, Tairajima, Suwanosejima, and Yokoatejima, but it does not appear that surveys of other islands have been conducted, a situation that will hopefully be remedied in the future.

The mountainous parts of Amami Ōshima are covered by evergreen broadleaf forests. The majority of this land is privately owned, with national forests constituting only a relatively small portion. For many years the construction and improvement of general utility and forest roads has continued, accompanied by the continual felling of forestland and exploitation of lumber in the form of woodchips. There can be no doubt that the extent to which continual logging affects bird fauna and biodiversity in general must be studied and measured. At the same time, there is the problem of nonnative mongooses and feral dogs and cats preying upon native species. In this respect, efforts to eradicated mongooses are underway.

There are almost 20 Wildlife Protection Areas within the island of Amami Ōshima, but none of these areas scattered across the island exceeds 500 hectares. There are one or two Wildlife Protection Areas centered around the forested areas of Kikaijima, Tokunoshima, and Okinoerabujima. Yoronjima lacks protected areas.

Studies of rare species conducted by the Ministry of the Environment and other parties continue on Amami Ōshima. In addition, wild bird data gathered by the Amami Ornithologists' Club continues to accumulate. Nonetheless, information on other islands remains scarce.

Tokara and Amami Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

Northern Tokara: Just as with the case of the Ōsumi Islands, with the exception of tiny uninhabited islands and rock reefs, one or more reports or distribution records concerning amphibians and reptiles on the northern half of the Tokara Islands have been published (Hikida et al., 1992; Ota et al., 1994), but also like the Ōsumi Islands, even for relatively large islands such as Nakanoshima and Suwanosejima, there have been no comprehensive intra-island distribution or population studies of noteworthy species and populations (Hikida et al., 1992; Ota et al., 1994). More efforts are needed in order to improve the quality of data through studies that are more systematic and comprehensive.

The Japanese weasel was introduced to nearly all of the main islands that make up Northern Tokara in the latter half of the 20th century in an attempt to control rats that were damaging agricultural crops. Since then it has established itself on almost all of the islands. As a result, with the exception of Kuchinoshima, lizards on all of the islands, particularly Plestiodon species populations for which there is strong evidence of genetic specificity and biogeographic importance (Motokawa and Hikida, 2003; Honda et al., 2007), have now disappeared (Akusekijima and Tairajima) or are in imminent danger of disappearing (Hikida et al., 1992 ; Ota et al., 1994).

Southern Tokara: Since the islands that make up Southern Tokara are extremely small and the environments within the islands are relatively homogenous, it is likely that the habitats of various species (including indicators) more or less cover the entire island on which they are distributed. Unlike the islands of Northern Tokara, introduced Japanese weasels have not thrived, and perhaps for this reason, there is a high population density of terrestrial species, especially lizards. However, the Tokara habu and the Erabu black-banded sea krait, the latter of which is one of the two sea snakes to land on the islands for nesting, are being captured for commercial purposes, and at least in some years, in staggering numbers (Ota, unpublished data). Further research on the implications of this exploitation for the survival of the communities of these two species is urgently needed.

Northern Amami: For the amphibians and reptiles of this region as well, with the exception of very small uninhabited islands and rock reefs, one or more reports or distribution records have been published for each island (Maenosono and Toda, 2007). However, even in the case of larger islands that generate a relatively high level of scientific and lay interest alike, such as Amami Ōshima and Tokunoshima, there are few findings available that are rooted in comprehensive studies conducted of the intra-island distributions or intra-island populations of noteworthy species with special statuses. The demarcation of distribution ranges that was conducted in this project relied heavily on limited field observation data and the confirmation of the types of habitats that such species are expected to live from maps. More work must be done to improve the scope and accuracy of available information through studies that are more systematic and comprehensive.

Regarding sea turtles, levels of interests among residents of inhabited islands are high. Kamezaki and members of the Sea Turtle Association of Japan that he heads continue to conduct research via direct observation and interviews with others, and the quality of data obtained by them is thought to be relatively high. As for uninhabited islands, information is either nonexistent or very incomplete.

Of the islands in this region, Amami Ōshima and Tokunoshima have particularly complex topographical features, and have traditionally had lush forests in addition to relatively rich terrestrial water environments, most notably networks of mountain streams. However, considerable human intervention in the form of logging and alteration of water environments has taken place, resulting in concerns over the survival of many endemic species that depend upon such environments (Ota, 2000b). Moreover, mongooses released onto Amami Ōshima have settled there, leading to serious concerns over the impact of predation by them on native species (Ota and Okada, 2002). In fact, five species of amphibians and reptiles, namely Ishikawa's frog (*Rana ishikawae*), the Otton frog, the Amami tip-nosed frog, the Akamata, and the Ryukyu brown skink, have all but disappeared from areas in which mongooses have lived for long periods of time, and these are just the affected species we know of, which is one reason that mongoose control strategies have become such an urgent issue (Watari et al. 2008). Similarly to the islands of Northern Tokara, the Japanese weasel, a nonnative predator, has established a presence on Kikaijima as well, and populations of the Okinawan five-lined skink, which was once thought to be a subspecies endemic to this island (*Plestiodon marginatus oshimensis*), as well as many other species of amphibians and reptiles documented on this island in the scientific literature (Maenosono and Toda, 2006), have been threatened to the point that we need to reconfirm that populations still exist (Ota, unpublished data).

The presence on many sandy beaches of artificial installations of various sorts (tetrapod piles, seawalls, revetments, etc.) to mitigate natural disasters and prevent erosion of the sand, as well as factors associated with the islands' use as tourist attractions and resorts that directly interfere with nesting females and hatchlings (campfires, car headlights, ruts from car tires, etc.), have prompted fears of deterioration in quality as nesting beaches for sea turtles (Kamezaki et al., 1994).

Southern Amami: The vegetation landscapes covering all of Okinoerabujima and Yoronjima, with the exception of human settlements, are each fairly homogeneous. From this we can assume that the terrestrial reptile faunas are more or less distributed evenly within each island. In contrast, it is likely that the distribution of amphibians are largely influenced by surface water of artificial origins such as reservoirs, as both of these islands have foundations of highly permeable Ryukyu limestone, a fact which limits natural sources of surface water, which is vital to amphibian reproduction. Nevertheless, information rooted in direct observation is minimal, and thus systematic, comprehensive surveys are necessary. Regarding sea turtles, Kamezaki and members of the Sea Turtle Association of Japan that he leads are conducting research through direct observation and interviews with others. The landing and nesting data from this research is quite reliable.

The Japanese weasel, a nonnative predator, was introduced to Okinoerabujima and Yoronjima in the middle of the 20th century and subsequently thrived in the wild, and as with Kikaijima, many terrestrial reptiles are now threatened to the point that they can rarely be found. On Yoronjima in particular, predation pressure from Japanese weasels, along with the concurrent sharp decrease in rice paddies with the sudden modal shift in agriculture, are thought to have caused reported cases Okinawa green tree frog populations disappearing (Nakamura et al., 2009). At present, the most important issues to ensure the survival of amphibian and terrestrial reptile populations found on these two islands are the eradication of Japanese weasels and the preservation of terrestrial water habitats.

Not unlike the islands of Kita Amami, there is also an urgent need for protections to maintain the quality of beaches on which sea turtles nest in this region as well. As for the Erabu black-banded sea krait, there are no indications of plans that would significantly alter nesting caves or surrounding environment for the time being, and as long as that is the case the current conditions for the animal will likely remain unchanged.

Tokara and Amami Islands: (iv) Insects

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Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
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Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

Toshima Village's "Prohibiting of Collection" ordinance has been well-received. The small islands adjacent to Amami Ōshima, separated by inner seas, should be treated as constituting a single ecosystem. The mountainous areas of Amami Ōshima have been cleared through quarrying and logging. It is the responsibility of researchers to inform as many people as possible about the fragility of subtropical island ecosystems. The preservation of natural coastlines is also an important issue. On Yoronjima, it is necessary to protect the trees remaining around artificial ponds, caves, and other such places that serve as habitats for local populations. On Tokunoshima and Kikaijima there are concerns over the impact of farmland development and chemical spraying.

Tokara and Amami Islands: (v) Fish

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Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Kagoshima Prefecture has enacted the "Kagoshima Prefectural Ordinance to Protect Rare Wildlife", which forbids the capture of the Ryukyu ayu, tropical carp-gudgeon, mud gudgeon, and Rhinogobius sp. However, merely forbidding the capture of these species is an insufficient protection strategy. On Amami Ōshima, one can see numerous examples of how artificial constructions have altered habitats. A river improvement project is currently underway even at the Yakugachi River, which is the largest habitat for the Ryukyu ayu (Niimura, 2002). In addition to aggressive habitat conservation measures, in some cases protection strategies that involve nature restoration projects may even be needed. Nonnative mosquitofish and tilapia introduced from overseas, as well as domestic nonnative fish such as the carp and common minnow (Tokunoshima) have gained a foothold and pose a threat to native species such as Japanese rice fish and *Rhinogobius* sp. (Sawashi, 1995; Yonezawa et al., 2003).

The Amami Islands are protected as a Quasi-National Park. At the same time, five areas (446 ha) have been designated as Marine Parks. The highly tranquil inner bay regions of Amami Ōshima's Ōshima Strait and Kasari Bay are important nursery zones for commercial fish such as the leopard coralgrouper (*Plectropomus leopardus*) and humphead wrasse (*Cheilinus undulates*), while also harboring a diverse variety of small fish in the Apogonidae and Gobiidae families.

Tokara and Amami Islands: (vi) Crustaceans

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Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

No exhaustive studies of the crustacean fauna of the Tokara Islands have been conducted to date. The only available information is in the form of fragmentary collection records. Survey data for coastal areas (mudflats at river mouths and splash zones) is particularly deficient, and thus further research is necessary at an early date.In the Amami Islands, there are concerns over the impact of road expansion projects near coastlines, river improvement projects, and road (forest access roads) construction on Amami Ōshima and Kakeromajima.

There is very little known about the crustacean fauna of Tokunoshima, or of smaller islands such as Ukejima and Yoroshima, a situation which will hopefully be remedied through surveys and research in the future.

Ground water pollution has become a cause for apprehension on Kikaijima, Okinoerabujima, and Yoronjima. There is also concern over the impact of the underground dam that is currently under construction in Okinoerabujima.

Tokara and Amami Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

On Akusekijima, logging activities have disturbed the habitats of Yakuchloritis hoshiyamai and other endemic species of terrestrial mollusks (Environmental Protection Division, Living and Environmental Affairs Department, Kagoshima Prefectural Government, 2003). Furthermore, collection pressure caused by collectors has become a source of concern (Environmental Protection Division, Living and Environmental Affairs Department, Kagoshima Prefectural Government, 2003). Research into marine mollusks in the Tokara Islands has so far been insufficient.

Habitats in important areas for terrestrial mollusks on the Amami Islands are steadily degrading. Road construction and other projects on Amami Ōshima and Tokunoshima have caused habitats (forests) to either disappear or become increasingly disjunct. On Kikaijima and Okinoerabujima, farmland development projects have resulted in the disjunction and aridification of habitats.

Important areas for marine mollusks have seen considerable, ongoing degradation of habitats. On Amami Ōshima for example, mudflats are being reclaimed every year by the construction of roads to provide shorter routes, harbor expansion, and the construction of gently sloping revetments. As important habitats for mudflat-dwelling mollusks continue to shrink, more and more local populations are disappearing. Furthermore, development of watershed areas has caused an influx of dirt, sand and gravel into mudflats, leading to deterioration of the habitat environment.

Tokara and Amami Islands: (viii) Seagrasses/Algae

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Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

Future studies are necessary, as data is deficient for all islands in this region except for Amami Ōshima

Problem 1: Some areas experience abnormally large occurrences of collector urchins (*Tripneustes gratilla*) (the moat in Amami Town's Ōhama Beach Park and Yamato Village's Kuninao Shore), leading to known cases of deforestation or "urchin barrens" (Kamura et al., 2008). Most algae find it hard to grow in such places, as the substrate becomes covered by crust-like non-articulated coralline algae. The dead coral on the reef edge in front of Ōhama Beach Park (table Acroporidae judging from the shape) is covered by non-articulated coralline algae. There are concerns that overpopulation by collector urchins may devastate algae and seagrasses. Because collector urchins are high-priced as cuisine, it is necessary to consider utilizing them effectively as a resource.

Problem 2: The widgeon grass growing in the brackish waters off Uken Village's Yadon district is the only bed on Amami Ōshima. The shrinkage of brackish water areas caused by reclamation and potential water quality degradation in the future may cause local extinction (Kamura et al., 2008).

Tokara and Amami Islands: (ix) Coral

Katsuki OKI (Tida Planning)

The coral communities in the shallow areas on the reef flats and slopes off Amami Ōshima were disrupted during the widespread bleaching event of 1998. The Ōshima Strait on the south of Amami Ōshima with the large coral communities that were present then is a ria coast. The rise in sea temperatures was mitigated, and there was relatively little death to these coral communities through bleaching, but beginning in 2001 there was an explosion in the population of crown-of-thorns starfish that inflicted catastrophic damage on these coral communities. Crown-of-thorns starfish population explosions subsequently occurred in the north and central regions as well, causing predation damage to the communities that were beginning to recover from the bleaching event. In 2008 the starfish population explosions ended, and at present the coral communities are recovering, particularly on the reef edges and slopes facing the Pacific.

In Wase of Amami City (F3), the effects from bleaching and crown-of-thorns starfish were relatively small, leaving healthy communities that are also quite diverse. At Amami Ōshima's Ōshima Strait (F4), efforts to control crown-of-thorns starfish have facilitated the growth of coral communities (Angyaba) and an increase in the recruitment of new coral, but table-shaped Acroporidae have been affected by "white syndrome", and some areas have seen a yearly decrease in the coverage of live coral (Derikyonma). At Aze (F7) the branching table coral covering the moat is preserved by the regular eradication of crown-of-thorns starfish. The coral communities at Wanjo (F8) have been also protected through measures to eradicate of crown-of-thorns starfish. There are many small communities of Acroporidae coral that have are recovering in the waters off the Pacific side of Amami Ōshima (S1, S2, and S3). The summer is prone to swells, which may have been a factor in mitigating bleaching and the occurrence of large populations of crown-of-thorns starfish. Recovery was observed at reef slopes on the East China Sea side after the 1998 bleaching event, but coral communities were subsequently disrupted by crown-of-thorns starfish predation. As with F4, recovery was seen at the Ōshima Strait (S4), but at Derikyonma (F4-4), table Acroporidae were struck by white syndrome. To date, white syndrome has not affected other sites. At Asari Bay (S7), inner bay-dwelling coral communities are being protected, yet recruitment levels of new coral are low. Off Okinoerabujima (S9), Acropora hyacinthus communities at the top of reef slopes are subject to conservation measures.

As part of the Amami Islands Development Project begun in fiscal 2005 in the Amami Islands, a total of 81 coral reef sites have been subject to monitoring: 53 at Amami Ōshima, four at Kikaijima, nine at Tokunoshima, nine at Okinoerabujima, and six at Yoronjima. In addition, projects established along local administrative lines have also been instituted to eradicate crown-of-thorns starfish at a total of 39 sites, most of which are coral protection zones established by those administrative bodies.

Comparative assessments of coral communities of the Tokara Islands (including the Amami Islands) with the other islands of the Nansei Islands based on indicator groups selected in this project could not be performed, hence they were excluded. Nevertheless, surveys were conducted in fiscal 2005 as part of the "Monitoring Site 1000" survey.

The Tokara Islands comprise 12 islands spread across roughly 160 kilometers that are situated between Tanegashima/Yakushima and Amami Ōshima. Of these islands, living coral populations are distributed on six islands: Kuchinoshima, Nakanoshima, Tairajima, Kogajajima, Kodakarajima, and Takarajima. Reef-building coral have been observed in all of these areas (Nakai and Nojima, 2004).

According to a survey conducted in 2005 on Takarajima, Kodakarajima, Akusekijima, Suwanosejima, and Nakanoshima, Takarajima is home to the most developed distributions of reef-building coral, among which large communities of *A. hyacinthus* and species of the genus *Pocillopora*, as well as the massive *Faviidae* and *Porites* species spanning more than two meters in diameter, have been observed. Communities of mixed coral species stood out at Akusekijima, while on Suwanosejima and Nakanoshima, encrusting coral was more prominent. The average coral coverage at the time of the survey was 20.5 percent (Ministry of the Environment, 2006).

3. Okinawa and Kerama Islands

Okinawa and Kerama Islands: (i) Mammals

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Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

The Yanbaru area occupies a central role in discussions on conservation. However, significant issues currently remain, such as coordinating compromises with those in the forestry industry, conservation on the military base, and strategies after the military base reverts to Japanese authorities. The impact of nonnative species, which includes both predation and competition, is assumed to be large. The small Asian mongoose (*Herpestes javanicus*), which has invaded the entire island of Okinawa, exerts considerable predation pressure on native species. Much like Amami Ōshima, there are eradication projects underway in the Yanbaru area which are founded in laws concerning nonnative organisms. In addition to the mongoose, the effects of predation by feral cats are considerable. There are also concerns over the preservation of indicator rat species given the competition with black rats (*Rattus rattus*). In marine areas, in addition to red soil erosion, seawall construction, and reclamation projects, the military base construction off Henoko has presented major tangible problems. There have also been cases of disruption of bat caves caused by human entry (including educational field trips) as well as the reclamation of bat caves themselves. Studies of the distribution of mammals for most areas have been insufficient, though data on rats and arboreal bats in Yanbaru is particularly lacking. Surveys on small bats on the surrounding islands are almost nonexistent.

Okinawa and Kerama Islands: (ii) Birds

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Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

Forestland has declined as a result of the expansion of residential areas on the island of Okinawa, a trend that has forced birds to ever-shrinking habitats to the north of the island and other relatively uninhabited areas. Even Yanbaru on the north of Okinawa Island has seen the development of dammed reservoirs and forest access roads, leading to the disjunction of bird habitats. One representative example is the Okinawa rail which, like other species, have experienced steady decreases in population and distribution area. The same can be said for surrounding islands, where beaches are being altered and forest access roads are being constructed for the purposes of development of the tourism and forestry industries.

The construction of forest roads in Yanbaru not only makes the encroachment of mongooses and feral cats that prey upon birds easier, it results in roadkill. Populations of the large-billed crow (*Corvus macrorhynchos*) have increased in recent years, a phenomenon which is thought to have played a part in decreases in populations of not only the Okinawa rail, but many other birds and small animals.

Given this situation, many have called for measures to protect the Okinawa rail. Many local residents have taken an interest and have donated money to protect the rail and restore its population numbers. It should be noted, however, that these efforts have been for the protection of the Okinawa rail alone, and as such they lack the broader objective of maintaining species diversity in Yanbaru and protecting the ecosystem as a whole. The Okinawa rail must be thought of as symbolic of the dangers that many diverse species in Yanbaru are facing.

Much of the coast in this region has been subject to reclamation projects, and many precious mudflats have been lost. The Manko Tidal Flat is registered under the Ramsar Convention, and largely NPO-led protection efforts by citizens are underway. The reclamation that has already begun at the Awase Tidal Flat has caused a political fight between conservationists and reclamation proponents.

There are massive U.S. military installations in the central and northern part of Okinawa Island, but the only scientific data we have on birds living on them is from one study by Higa et al. (1992). Further research, including studies and surrounding islands such as Tonakijima, is necessary.

It is also necessary to not consider distributions observed at a certain point in time to be static. Rather, we must view the movement of populations as being more dynamic, with distributions expanding and shrinking over time, and new species such as the light-vented bulbul (Pycnonotus sinensis) spreading out and settling.

Okinawa and Kerama Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

The Okinawa Islands (excluding Kumejima): As is the case with the Amami Islands, with the exception of few uninhabited islands and rock reefs, one or more studies on the amphibians and terrestrial reptiles in this region have been published for each island (Maenosono and Toda, 2007). However, again not unlike Amami Ōshima and Tokunoshima, even in the case of Okinawa Island itself, where there is much scientific and lay interest in the wildlife there, there is little comprehensive and reliable population and distribution data on noteworthy species and subspecies on the island. The demarcation of distribution ranges of indicator species on each of the islands that was conducted in this project mostly relied on scant field observation data and the checking of the types of habitats that such species would live in from maps. More efforts are required in order to raise the level of accuracy of data through studies that are more systematic and comprehensive.

Regarding the landing and nesting of sea turtles, levels of interests among residents of inhabited islands are high. Kamezaki and members of the Sea Turtle Association of Japan that he heads continue to conduct research via direct observation and interviews with others. As for other islands, including uninhabited ones, systematic surveys are being conducted by the prefectural government and local researchers (Kikukawa et al., 1996, 1998; Okinawa Prefectural Board of Education, 1996), and the quality of that data is relatively high.

The northern part of Okinawa Island (known as “Yanbaru”) has particularly complex topographical features, and has traditionally had lush forests in addition to relatively rich terrestrial water environments, most notably mountain streams. However, as is the case with Amami Ōshima and Tokunoshima, considerable human intervention in the form of logging, forest access road construction, as well as alteration of water environments through dam construction, has taken place, and this has resulted in the shrinkage and disjunction of populations of many endemic species that depend upon such environments, threatening their survival (Ito et al., 2000; Ota, 2000b). Furthermore, nonnative and predatory mongooses released onto the southern part of Okinawa Island in the 1910’s have spread throughout the island, including the northern part, and in recent years there have been serious concerns over the impact of predation by not only mongooses, but also by feral cats, which have also become more common in the northeastern part of the island (Ogura et al., 2002; Jogahara et al., 2003). The most important issue for the protection of the diversity of amphibians and terrestrial reptiles in the area is how best to protect the remnant forests, including those that are in the U.S. military bases for which control will likely revert to Japan in the future. Then, it will become a matter of effectively eradicating mongooses and feral cats and preventing them from invading the area again.

Zamamijima, Akajima, and Keramajima, which are all part of the Kerama Islands, have been invaded by the nonnative and predatory Japanese weasel. Preyed upon by these weasels, the Okinawan five-lined skink, Okinawa pitviper (*Ovophis okinavensis*), and many other populations of amphibians and reptiles documented on these islands in the scientific literature (Maenosono and Toda, 2006), are thought to have already disappeared (Toyama, 1996; Ota, unpublished data).

As for sea turtles, on many sandy beaches there are more than a few things associated with the islands' use as tourist attractions and resorts that directly interfere with nesting females and hatchlings (interference through visual stimuli via campfires and car headlights, as well as physical interference, such as off-road vehicles compressing the sand and leaving tire ruts). Increased interference has prompted concerns over the deterioration in quality as nesting beaches for sea turtles (Kikukawa et al., 1999).

The Erabu black-banded sea krait, which is among the sea kraits that land and nest on Kudakajima, has long been trapped by local residents for food and such. However, in recent years, especially after the construction of seawalls and revetments, there have been anecdotal reports that number of Erabu black-banded sea kraits landing has decreased drastically (Ota, unpublished data). More detailed studies are urgently needed in order to confirm or ascertain the extent of this.

Kumejima: Although Kumejima is a relatively small landmass, because of the population and habitat studies of Kikuzato's stream snake and Ryukyu black-breasted leaf turtle that have been conducted a number of times, we have a generally better picture of the distribution patterns of rare species than other islands (Okinawa Prefectural Board of Education, 1993; Ota and Hamaguchi, 2003). Nevertheless, there have been changes that, just as with other islands, make the further collection of quality data an absolute necessity. For example, surveys conducted up to 1992 failed to confirm Kikuzato's stream snake in a certain area, leading to the belief that it was unlikely that the animal lived there, but subsequent surveys found relatively high population densities of the snake in the same area (Ota, unpublished data).

The area around Mt. Uegusukudake, which serves as a habitat for Kikuzato's stream snake, in addition to many rare species and indicator species, has a Protection Area established through the Ministry of Environment's Law for the Conservation of Endangered Species of Wild Fauna and Flora, but it still does not cover enough area (600 ha, 255 ha of which is under strict controls as a "Managed Area"). The area around Mt. Āradake near Kumejima's southeastern tip, which is clearly disjunct from the area around Uegusukudake, also retains good environments. It is strongly hoped that this area, together with the beaches nearby where sea turtles land and nest, be designated as a Protection Area and Managed Area. The influx into habitats of red soil attributable to rampant development in the form of farmland, residential land, and water conduits adjacent to existing Protection and Managed Areas, and the reproduction and spread of predatory and highly invasive nonnative species such as the American bullfrog, Asian tree frog (*Polypedates leucomystax*), tilapia, bluegill (*Lepomis macrochirus*), are issues that should be dealt with urgently.

Okinawa and Kerama Islands: (iv) Insects

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Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

In Kumejima, the mountainous area is intolerably dry. It is our hope that attempts are explored to restore a sense of depth to Kumejima and to repair and protect the ecosystems in a manner that brings pride to its residents. Its peculiar insect fauna condenses many of the characteristics of the Central and Southern Ryukyus, and the presence of unique species such as the Kumejima fire fly holds the promise of elucidating the relationship between the Nansei Islands and mainland China, which is just one reason that the ecosystems of Kumejima are important. Kerama Islands should be entirely protected. Marine leisure activities have recently become popular on these islands, but there are concerns over the development of the marine areas.

The web of prefectural roads and forest access roads being constructed in Yanbaru area of the Okinawa Island and the felling of its trees for woodchips not only causes direct destruction and disjunction, it leads to the degradation of the biota by facilitating invasion by nonnative species (decrease or replacement of native species), makes it easier for people to capture or collect wildlife illegally, and causes many, urgent and serious problems. Some beetles, such as the Yanbaru long-armed scarab beetle, which lives exclusively in the hollows of old trees, are in critical danger of extinction. Yanbaru's low-lying but thickly canopied evergreen forests of *Castanopsis sieboldii*, *Quercus glauca* var. *amamiana* and others, its mountain streams, rocks, fallen trees, moss, fallen leaves, cracks in boulders, and other environments that stay moist even in times of low rainfall (lecture by Kazuo Minato), all have nurtured a rare, precious and rich endemic insect fauna. However, dam construction is destroying the island's unique stream morphology, and the expansion of farmland has created problems associated with red soil, and these are dealing a serious blow to stream-dwelling insects. The blindingly bright lights of the golf courses built in Nago City and Onna Village have disrupted the physiology and behavior of plants and insects alike, and their effects are geographically widespread. Clearing the best-preserved area to build a graduate school is a folly that should be averted by any means. Tropical and subtropical forests are easy to destroy but difficult to restore (Miyawaki, 1985). The protection of these ecosystems is an issue that justifys the very value of the Okinawa Islands.

The inland area of Motobu Peninsula also faces the problem of golf courses and expanding farmland. Mt. Katsuodake, Mt. Oppadake, and Mt. Yaedake have seen the construction of roads and camping grounds, and the planting of the decorative inumaki (*Podocarpus macrophyllus*) in attempts to attract tourists. Small mountains have been destroyed through the quarrying of limestone near the southern coast. The karst plateau stretching from Yamazato to Ufudō has been protected through the efforts of community residents, but trees have been felled in the area around the Nakijin Gusuku castle remains in order to exploit the area for tourism, causing aridification in the cleared areas. Even in narrow spaces such as the Shigemagawa River and the tip of Cape Bise, the currently remaining water systems and natural forests must be urgently protected.

In the central and southern areas, urban expansion, road construction, and cemetery construction are taking place at a breathtaking pace, and what few habitats that remain are rapidly dwindling. Considered the serious effect of the developments on the environment, in order to protect the scattered habitats, the entire area was designated for conservation. Even if populations disappear from a certain place, as long has habitats remain nearby, there is the possibility of natural reintroduction (Haruhiko Fujii, private correspondence). Almost no natural shoreline is left in the central and southern areas. The distributions of insects that inhabit rocky shores and mudflats are at single points and along lines. The disjunction of just one of these could lead directly to a species disappearing from a region. Shorelines are the termini of species in ocean current vectors, and thus are critical for the development of island ecosystems. Now, the most pressing issue is the protection of the Awase Tidal Flat.

Okinawa and Kerama Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

The shore areas of Okinawa have been designated as a Quasi-National Park, while the three zones (493 ha) in the Okinawa and Kerama Islands have been designated as Marine Parks. Furthermore, in two marine areas, off Nakijin and Haneji respectively (totaling 425 ha) in the northern region of Okinawa Island, a four-month (August to November) self-enforced blanket ban by fishermen has been imposed that prohibits the catching of spangled emperors (Lethrinus nebulosus) in order to protect immature fish (Ebisawa, 2007).

Okinawa and Kerama Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

Development has proceeded rapidly around the rivers and shores of Okinawa Island, and it is necessary to protect the few remaining habitats at all costs. The long-legged freshwater crab used to be seen in the Motobu Peninsula, but it has not been recorded for some years now (Shokita, personal communication). The changes in the natural environment on Okinawa Island have been progressed rapidly; we need to monitor their condition with extreme caution.

The river environments of the Kerama Islands and Kumejima, in addition to being very small to begin with, have been affected by river improvement projects and road construction, contributing to an ongoing decline in quality.

Okinawa and Kerama Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

Road construction and other projects in the Kerama Islands have caused important terrestrial mollusk habitats (forests) to either disappear or become increasingly disjunct. Furthermore, aridification is occurring.

Marine mollusks living along the coastlines of the Kerama Islands have also seen the rapid degradation of their habitats in recent years. Sand for construction (artificial beaches, etc.) has been dredged from the waters between the Kerama Islands and Chībishi on a massive scale, contributing to the erosion of the coastlines of the Kerama Islands. The influx of dirt, sand and gravel from the land continues to affect marine areas. There is also cause for concern due to the unchecked hunting of large gastropods that live in tidal moat flats, seagrass and algae beds by collectors.

Important habitats for terrestrial mollusks in the Okinawa Islands are also continuously degrading. In the northern part of the island (Yanbaru), forest access road and dam construction have led to the disappearance or disjunction of important terrestrial mollusk habitats (forests). On the Motobu Peninsula, rock quarrying has caused habitats (forests) to shrink.

Important habitats for marine mollusks in Okinawa have deteriorated considerably. In the central and southern regions of Okinawa Island, tidal mudflats continue to be reclaimed, causing the widespread loss of important habitats for mudflat-dwelling mollusks. As a result, more local populations have disappeared. The habitats of the mudflats on the north of Okinawa Island have been devastated by sediment runoff. Large-scale mudflat reclamation projects are being planned for the Haneji Inland Sea's Goga Tidal Flat and Naha City's Ōmine shore, which are important habitats. Construction is already underway on a reclamation project at Nakagusuku Bay's Awase Tidal Flat. Critical habitats for terrestrial mollusks as well are deteriorating as a result of river improvement projects and sediment pollution.

Okinawa and Kerama Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

Conservation status and issues regarding seagrass beds off Okinawa Island:

・In order to protect seagrass beds because of the various roles that seagrass beds play, regardless of their size, in supporting marine resources, they must be given the utmost priority among coastline environments. The locales with major seagrass beds are listed as either "Priority One among natural habitat areas to aggressively protect" or "Priority Two among natural habitat areas to conserve and protect" in Okinawa Prefecture's Guidelines for the Preservation of Natural Environments (1998), from which we must reaffirm the importance of guidelines for protecting these natural environments and respect such guidelines. It is unfortunate, however, that waters harboring these habitats are often targeted for reclamation and similar projects.

Major alterations to the natural environment by way of the reclamation and harbor improvements in tidal mudflats and coral reefs began with projects spanning the 1950’s and early 1960’s at Naha City’s Naminoue and the vast mudflats stretching from the Wakasa coastline to Tomari (the mudflats where *Pseudodichotomosiphon constricta* was discovered), and led to the region becoming the commercial urban center that it is today. Beginning in 1970, the rapid coastline reclamation projects gained further momentum, and since then the reclamation and harbor improvement works have only continued to reduce the area covered by mudflats and coral reefs, which has corresponded to the accelerated decline in the area covered by seagrass beds.

・Issues regarding the Sugā River in Motobu Town

This river is protected as a Natural Monument by the Japanese government, and while it sustains many species of flora and fauna, its hinterland is a quarry, and thus after it rains the river sometimes turns deep red from the runoff of red soil. It is clear that the hinterland quarry is expanding, so naturally there are concerns over the potential degradation of the biota from further red soil contamination. Since *Bostrychia simpliciuscula* and *Caloglossa ogasawaraensis* distributed from the brackish water area to the upper reaches of the river need clear freshwater, the influx of red soil in the river and the contamination and accumulation thereof pose a threat to their survival. The chronic red soil sediment and ensuing contamination has implications for the survival of organisms living in affected rivers and coastlines. Furthermore, the submerging of entire rivers by dam construction poses a serious threat. Solutions to the red soil problem have yet to be devised.

・Issues regarding Dichotomosiphon tuberosus

As the growth of this species depends upon springs flowing from raised coral reef substrates, hence the deterioration of water quality or the conversion of paddies into residential land around and near spring areas may cause habitats to disappear (Kamura, 1998). The progressive use the plateau and the construction of roads in Nanjo City have caused the spring water supporting the rare rhodophyte *Thorea gaudicaudii* (a nationally designated natural monument) to become opaquely white, which inhibits the growth of this species and in some cases has caused its disappearance (Kamura, 1998)

The Kerama Islands constitute a Quasi-National Park, and part of Akajima is registered under the Ramsar Convention. These islands are arguably the most famous tourist destinations in Okinawa, and through harbor construction and beach improvement projects, the marine environments have been altered considerably. It is necessary to assess the extent to which the changes to the waters off the coast have impacted the biota.

Conservation status and issues on Iheyajima and Izenajima:

・Destruction of mudflats and coral reefs via reclamation along the coastlines: conversion of farmland, construction of harbor and related facilities, and construction of sports facilities

・Interviews have yielded information suggesting that, because channels were created running parallel to the shoal beds off Iheyajima and Izenajima, currents have become faster, leading to a decline in seagrass beds.

・More surveys and research are needed to gather more data on algal flora.

Conservation status and issues on Kumejima:

Issues on Kumejima include dredging and reclamation along Kumejima's coastal areas, the loss of the island's only mangrove swamp due to reclamation, and construction of fish farms in its mudflats. On land, the conversion of rice paddies to millet farms have led to the loss of buffer zones, resulting in muddied water flowing directly into the sea and adding to chronic concerns over the impact that these factors have on the shore areas.

Okinawa and Kerama Islands: (ix) Coral

Eiji YAMAKAWA and Tomofumi NAGATA (Okinawa Environmental Research & Technology Center),
Kazuhiko SAKAI (University of the Ryukyus)

In the waters off Okinawa Island, the runoff of red soil accompanying shoreline and hinterland development, the population explosions of crown-of-thorns starfish that have continued since the 1980's, and the widespread bleaching event of 1998, all came to bear and inflicted massive damage to coral reefs and have been an ongoing source of concern over their potential deterioration. Recently (2008), however, coral communities with high coverage levels have been observed to the northeast and southern portions of Okinawa Island, which is evidence that coral communities are recovering at some reefs.

Coral reefs over a broad area around Okinawa Island are being monitored regularly through the Ministry of the Environment's "Monitoring Site 1000" initiative.

Northeast of Okinawa Island: Communities of blue coral (*Heliopora coerulea*), *Porites cylindrica*, and another massive *Porites* species were confirmed at Ōura Bay (F1), though there are development plans for this area that are cause for concern.

The reef slopes stretching from the northern (S1) to northeastern (S2) part of Okinawa Island boast a relatively high level of coral coverage for the island.

South of Okinawa Island: A large community of *Pavona clavus* was found at Yokohishi on the southern part of Miyagijima (F2). At Awase in Nakagusuku Bay (F3), a large *Acropora pulchra* community was confirmed, but development is underway, leading to concerns over the potential impact on the coral. At the moat in the waters off the Kyan Fishing Port to the south of Okinawa Island (F4), communities comprising mainly *Montipora digitata*, *P. cylindrica*, and branching Acroporidae have been recorded.

The moat off southern Naha's (F5) airport area has a community dominated by *A. formosa*. There are development plans for this area as well, also prompting concerns over the impact on the coral.

In waters off Ginowan to the west of Okinawa Island (F6), there are sporadic occurrences of sites with high coverage by coral communities, sites with coverage in relatively deep waters, and sites with high degrees of species diversity. There are development plans affecting the waters off Urasoe, sparking concerns over the impact on the coral.

The reef slopes stretching from the east of Ikeijima (S3) to the southeast of Okinawa Island (S4) do not enjoy high levels of coverage, but there are many new table coral recruitment groups, which is a good indicator of the recovery of coral communities. Extensive communities with high coverage rates and high species diversity levels have been found on the reef slopes on the south of Okinawa Island (S5). The reef slopes off southern Naha's (S6) airport area exhibits large table Acroporidae communities. Up until 1997 there was a high-coverage, high-species-diversity community at the reef slopes off the west of Okinawa Island (S7), but coverage levels still remain low after declining from the effects of bleaching and crown-of-thorns starfish predation.

Northwest of Okinawa Island: The moats around the Cape Bise area of the Motobu Peninsula (F7) exhibit scattered and localized communities with high levels of coverage. The moats around Okuma to the northwest of Okinawa Island (F8) had communities with high coverage levels in the 1990's, but coverage levels remain low after dropping off due to the effects of bleaching and crown-of-thorns starfish predation.

There are localized communities with high levels of coverage and species diversity at the reef slopes around Sesokojima and Minnajima off the Motobu Peninsula (S8). The reef slopes around Okuma to the northwest of Okinawa Island (S9) had communities with high coverage levels in the 1990's, but coverage levels remain low after dropping off due to the effects of bleaching and crown-of-thorns starfish predation.

Areas around Kerama: The areas around Kerama saw explosions of crown-of-thorns starfish populations beginning around 2002 which decimated the coral. However, the concerted and strategic measures taken by local residents to eradicate the starfish have resulted in well-preserved coral communities within some conservation areas, and it has been noted that these areas are now important as sources of coral larvae to other areas around Okinawa Island.

Coral reefs around Akajima and Chībishi are being monitored regularly through the Ministry of the Environment's "Monitoring Site 1000" project.

Kerama: The inland sea of the Kerama Islands (Zamamijima and Tokashikijima: F9) has been relatively undisrupted by human intervention, so healthy coral communities can be seen. The reef slopes off the Kerama Islands (S10), including Chībishi, nurtured communities with high levels of coverage and species diversity even after the rise in ocean temperature in 1998, up until massive predation by crown-of-thorns starfish. There are, however, still some high-quality coral communities left, especially in the conservation zones.

Kumejima, Agunijima, and Tonakijima: At some moats around Hatenohama to the east of Kumejima (F10), high-coverage communities consisting of species in the genera Acropora, Montipora and others have been sighted.

Communities with high levels of species diversity and coverage were present at the reef slopes off Kumejima, Agunijima, and Tonakijima (S11) in the 1990's, but subsequently declined as a result of bleaching. These coral communities are currently recovering.

Izenajima and Iheyajima: There were communities with both high levels of species diversity and coverage at the reef slopes off Iheyajima and Izenajima (S12) during the 1990's, but they declined due to the effects of bleaching and crown-of-thorns starfish predation, though they are now recovering. There are development plans in the works for Nohojima, causing concerns over the potential impact on the coral.

4. Daitō Islands

Daitō Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

Because of the unique history of these islands, the natural environments originally present here have already changed, and many species are now extinct. At the present time, areas that could potentially function as animal habitats are limited to dolines (or sinkholes), hagu (narrow, circular windbreak forests remaining at the islands' perimeters), and the areas around marshes. Surveys conducted have concentrated on Kita Daitō and Minami Daitō, and as a result there is no data available for Oki Daitō.

Daitō Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

Since people began to settle on the Kita and Minami Daitō Islands in 1900, primitive forests have been converted into farmland, and small lakes and marshes have been reclaimed. Despite this, as early as the 1920's there were concerted efforts to plant forests, along with educational programs to raise people's awareness of natural conservation and to take action. At present, Wildlife Protection Areas have been established, mainly around the lakes and marshes in the central region, which has helped to preserve the ornithological fauna.

Minami Daitō Village has worked to develop the area in such a way that the entire village ostensibly functions as a natural museum of the whole island, utilizing the island's natural attractions as resources for tourism and giving visitors to the island a view of nature as it is. It offers canoes for lakes and marshes, and guided tours of the water channels that connect them. While this does help people feel a deeper connection with aquatic environments and allow them to view birds up close, it also poses the risk of disturbing wintering birds and birds that are there to nest. One can see in this situation the problem of striking the right balance between nature conservation and ecotourism.

There has been a relative abundance of studies conducted of Minami Daitō Island (e.g. Takehara et al., 2004), but not as many have been done on Kita Daitō. Kita Daitō is only about 10 kilometers away from Minami Daitō, and lies within the range of flight of almost all of the birds on Minami Daitō. For this reason, one might be tempted to think that the two islands can be grouped together as one large habitat for the same birds, but this is not necessarily true. The Daito scops owl, which lives on Minami Daitō, has in the past been found on Kita Daitō as well, but in recent years the bird has not been confirmed there (Takehara and Nakamura, 2001). Year-round surveys of bird fauna are necessary.

Oki Daitō Island is located about 150 kilometers south of Minami Daitō. At present, it is under the control of the U.S. military, which forbids access to it. As an island so isolated from other landmasses, researchers would be extremely interested in learning about the bird fauna there, but because the island serves as a shooting range for the U.S. military, there is little doubt that the bird fauna has been affected. Nevertheless, the island's biota still merits studies.

Daitō Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

With the exception of rocky areas with little vegetation, the mourning gecko can be found throughout the Daitō Islands. Hence, we feel the demarcations of its habits used in this project are valid. However, the frequencies with which different clones have been found vary greatly. In order to protect clone diversity, it is necessary to ascertain the geographical distributions of each clone as well as their relative population densities. The impact of this gecko sharing many of its habitats with the nonnative bisexual common house gecko (*Hemidactylus frenatus*) should be studied from a variety of perspectives and the necessary steps should be taken.

Daitō Islands: (iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of the Ryukyus),
Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),

Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

The prohibition ordinance of insects here is seen as a major step forward. At the same time, however, there should also be regulations that strictly prohibit bringing insects and other small animals sold as pets into the islands. If the “island-wide museum” initiative is to succeed, it should be understood by the relevant authorities that planting tropical plants and trees that are aesthetically pleasing to tourists and drying out the grounds around shrines by clearing fallen leaves and branches will lead directly to the extinction of endemic species.

Daitō Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Surveys of the subterranean water systems on the islands have so far been insufficient, and there is a possibility that anchialine fish will be discovered in the future. Careful studies of freshwater sources on the Kita and Minami Daitō Islands are needed, especially when considering what they could potentially teach us about the dispersal abilities of diadromous fish.

Daitō Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

In recent years, land improvement projects have been implemented around cave areas on Kita Daitō Island and Minami Daitō Island, and as a result some caves have already disappeared. There are other situations which require immediate attention, such as instances of surface wastewater flowing into groundwater in caves, as well as caves being inhabited by nonnative organisms such as the cane toad and soft-shelled turtle. Furthermore, major harbor construction and road expansion projects are underway, which are cause for concern over the alterations to coastal environments and the felling of forests along the coasts.

There is no current information available on Oki Daitō Island.

Daitō Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

Priority habitats for terrestrial mollusks in important habitats in the Daitō Islands have been steadily deteriorating. The forests which currently harbor endemic populations of terrestrial mollusks are few and fragmentary, limited to the remaining forested portions circulating the islands and the areas around shrines. These forested areas are also being rapidly split apart by agricultural improvement and harbor construction projects.

Daitō Islands: (ix) Coral

Tadashi KIMURA (Japan Wildlife Research Center)

The Daitō Islands, which comprise Kita Daitō Island, Minami Daitō Island, and Oki Daitō Island, are located roughly around the same altitudes as Okinawa Island and the Ogasawara Islands, situated about 400 kilometers east of Okinawa Island and 1,110 kilometers west of the Ogasawara Islands. The distance separating Kita Daitō Island and Minami Daitō Island is about eight kilometers. The maximum ocean depth between the two is about 2,700 meters. Oki Daitō Island is about 160 kilometers farther south of both. All three islands formed from coral reefs generated on landmasses that were raised from depths of 1,000 to 2,000 meters from the ocean bed, and are bordered by the seas on all sides by steep precipices, having no gently sloping sandy beach coasts of the type seen on Okinawa Island. The Kita and Minami Daitō Islands are both surrounded by fairly weak fringing coral reefs forming a spur and groove system. Out to a depth of 20 meters, the slope of the seabed is fairly gentle, but after that it plunges to depths of up to 2,000 meters. The largest of the islands is Minami Daitō, with an area of 30.7 square kilometers and a circumference of 20.8 kilometers. This is followed by Kita Daitō with an area of 11.9 square kilometers and a circumference of 13.5 kilometers. Oki Daitō, the smallest of the three, is 1.2 square kilometers and 4.5 kilometers in circumference.

Prior to 1998 there were high-coverage colonies of mainly branching coral off the northern coast of Minami Daitō, but most of them died during the major bleaching event. Furthermore, beginning around the year after the bleaching event, that coral has suffered from predation by small groups of crown-of-thorns starfish.

In 2001, there was only about 10 percent overall coral coverage around Kita Daitō and Minami Daitō, but since then many recruited acroporid coral colonies have been observed (Nonaka and Kajiwara, 2004). According to observations made in 2007 (Kimura and Hayashibara, 2007; Ministry of the Environment, 2008), few large coral colonies were seen at depths shallower than 10 meters off Kita Daitō and Minami Daitō. Small, scattered colonies of cauliflower corals (*Pocillopora*) and *acroporids* were observed clinging onto rock foundations, and at this depth coverage was about 10 to 20 percent.

At depths exceeding 10 meters, many soft corals and mat corals such as *Porites*, *Montipora*, and *Favia* species occurred off the northern and eastern coasts of Minami Daitō, with coverage rates as high as 40 to 50 percent, depending on the location. There were relatively few acroporid colonies overall. Colonies of thick-branched cauliflower corals that appeared to have died several years ago were found in places, and there were some locations where it appeared that there had been considerable distributions of branching corals such as these.

At around a depth of 20 meters off the eastern coast of Minami Daitō, which has relatively high levels of coverage, small groups of crown-of-thorns starfish could be seen piled on one another in small areas feeding on coral communities, despite it being daytime.

The distinctive and precious communities of reef-building coral off the Daitō Islands exhibit features that are between those of the fringing reefs off the Ryukyu Islands and the coral communities typical of oceanic islands, as seen off Ogasawara.

5. Miyako Islands

Miyako Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

At the time of this study, no caves in which Rhinolophus pumilus miyakonis dwell could be confirmed, and thus the species was not selected. Further habitat and population studies are needed.

Miyako Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

No habitats appear to be in danger of destruction from development projects at the present time, but it is nevertheless necessary to maintain conservation efforts, be they at the marshes on Ikemajima or the Mt. Ōno Forest area on Miyakojima.

The bird fauna of the islands neighboring Miyakojima has been researched by local birdwatchers, but future studies are needed of Taramajima and Minnajima, which are considerably distant from Miyakojima.

Miyako Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

Many of the native amphibians and terrestrial reptiles can be seen with great frequency in the area spanning from the Miyakojima City Botanical Garden, which is located near the center of Miyakojima and has a relative abundance of trees, to the Mt. Ōno Forest. The coastal skink is frequently seen in the central part of the western coasts, and for this reason the area shown on the map is thought to be appropriate. However, many of the indicator species in this project have been seen sporadically in other locations (Yohena et al., 1998), so one cannot discard the possibility that localized areas of high diversity exist elsewhere.

The amphibians and terrestrial reptiles on Miyakojima, some of which are indicator species, have exhibited sharp drops in population densities over the past 20 or so years, and this is seen as cause for alarm. For example, in the area spanning from the Miyakojima City Botanical Garden to the Mt. Ōno Forest mentioned above, census results suggest that in the period from 1989 to 2007, population densities of the Miyako toad and the Sakishima rice frog have dropped to one tenth of previous levels or below, and the Miyako grass lizard, the Sakishima smooth skink (*Scincella boettgeri*), Kishinoue's giant skink (*Plestiodon kishinouyei*), and others have dropped to at least one fifth (Ota, unpublished data). The survival of these species in this area is increasingly critical. Likely reasons include predation pressure by nonnative Japanese weasels and Indian peafowl, and for amphibians, predation on their eggs and juveniles by the carp, tilapia, paradise fish, and other nonnative fish that have been released into the ponds and swamps in considerable numbers in recent years. Urgent conservation measures, which include the eradication of nonnative species, are desperately needed.

As for sea turtles, just as with other regions, steps need to be taken to address the falling quality of nesting beaches due to human intervention (the installation of tetrapods, revetment construction, etc.) (Okinawa Prefectural Board of Education, 1998). It has been found that the loggerhead turtles that nest on Miyakojima’s Yoshino Coast migrate to Vietnam and nest there as well (Sadoyama et al., 1996), meaning that concervation steps such as bycatch prevention strategies covering migration routes, not just nesting shores, should be studied in the future. Studies of nesting sites, nesting species, and landing frequency must also be conducted for sea kraits. Because the Erabu black-banded sea krait is also caught for commercial purposes, surveys should also cover the impact of fishing on their numbers as well as the survival of populations.

Miyako Islands: (iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of the Ryukyus),
Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

Recently, the introduction of tropical trees and flowers has caused insect habitats to rapidly disappear, and the more public the place, the more serious the problem is. The restoration of mixed forests of native trees such as the Ryukyu pine (*Pinus luchuensis*) and *Celtis boninensis* (extant in parts of the Mt. Ōno Forest) could become an issue to be addressed through public works, and the restoration and maintenance of mosaic ecosystems is, to a certain extent, possible through individual effort. A better understanding of the insect fauna of Miyakojima would not only be useful in revising the “eradication by seawater inundation” hypothesis, it would also greatly contribute to research into how the Ryukyu Arc was formed.

Miyako Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

Fish habitats are undergoing radical changes, so it is necessary to implement measures to protect them as soon as possible. Furthermore, research into subterranean water veins is lacking. Future studies would likely result in the discovery of anchialine fish.

Miyako Islands: (vi) Crustaceans

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Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The main threats to Miyakojima's anchialine environments are: 1) the filling in of caves (grotto wells) in land improvement projects, 2) the burying of springs by gravel sediment, 3) the disjunction or alteration of subterranean water veins through mining or underground dam construction, 4) predation and competition with native species by nonnative organisms, and 5) groundwater pollution by garbage dumping, household wastewater, and agricultural chemicals and fertilizers (Shokita, 1996; Fujita, 2007).

Miyakojima's coastal environments have large-scale developments of resorts in recent years, threatening to destroy or disjoin habitats. The completion of bridges that connects Miyakojima to the small surrounding islands will facilitate developments of more tourist attractions, so the impact of tourism must be monitored carefully well in the future.

The anchialine pools of Taramajima have all been designated as cultural properties of Tarama Village, and the areas around caves (at least) are in good condition (Fujita and Sagawa, 2008). However, it is still necessary to monitor subterranean water samples in order to check for water pollution attributable to water quality changes (particularly salinity levels) brought upon by overexploitation or to chemical fertilizers used on farms. Along the coastline, the sandy beaches, rock reefs, and coastal forests have been well-preserved (the road encircling the island was built in a manner that preserved the forests). To the authors' knowledge, there have been no studies conducted of the decapods of Minnajima, which is located to the north of Taramajima, hence it is hoped that detailed surveys be performed in the future.

Miyako Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

Habitats in important areas for terrestrial mollusks on the Miyako Islands are rapidly deteriorating. Causes include road construction and farmland expansion, which have caused forestland to shrink and habitats to become increasingly disjunct, as well as the aridification associated with these disturbances. Collection pressure caused by collectors has likewise become a source of concern.

Important areas for marine mollusks have seen considerable, ongoing degradation of habitats. At Yonaha Bay, for example, mangrove forests, and seagrass and algae beds have fallen victim to reclamation projects in recent years, and important habitats of mollusks have disappeared. The pollution of seagrass and algae beds at Yonaha Bay by dirt inflow has also caused a significant level of habitat deterioration.

Miyako Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

Some of the reasons for the decrease in coverage area by seagrass beds are land reclamation, expansive harbor and seawall construction, and other water channel-altering construction projects associated with building a fishing port. In addition to potential damage to seagrass beds because of Miyakojima's location in the path of major typhoons, there is serious concern that structures along the coastline (reclaimed land, bridge columns after the completion of the Irabu Bridge) could change the flows of water, causing gravel beds to be disturbed.

The environments within Yonaha Bay (a Wildlife Protection Area covers the bay and surrounding areas) have deteriorated considerably because of fishing port construction and the inflow of muddy water when it rains. Part of the coastline of Shimojishima was reclaimed for the construction of Shimojishima Airport, but the neighboring island of Irabujima was designated as a Prefectural Natural Park, and has been kept in good condition.

Miyako Islands: (ix) Coral

Kenji KAJIWARA (Miyako City Hall)

Overall, the Miyako Islands do not have extensive reefs. At 19.6 square kilometers (Marine Park Center, 1994), the coral reef coverage area is relatively small compared to the size of the islands (eight inhabited islands totaling 226 km2, 2007). There are almost no large reefs around the islands, but the Yabiji patch reef group to the north of Ikemajima comprises about 100 fairly coalescent patch reefs of various sizes and is one of the more well-known coral reefs of the Miyako Islands. The Miyako Islands are relatively flat, with no significant rivers or steeply inclined wastewater channels, so red soil runoff rarely occurs.

Just like the rest of the Nansei Islands, the Miyako Islands saw a population explosion of crown-of-thorns starfish in the 1980's, which decimated coral communities (though there are no detailed records). Beginning in February of 2004, an explosion of crown-of-thorns starfish populations occurred once again, but their distribution has been localized. The explosion is still ongoing as of September, 2009, and while efforts to remove the starfish are underway, these efforts have been plagued by monetary and organizational problems, in addition to unfavorable sea conditions. As a result, they have not helped the conservation effort as much as had been hoped for, and several sites in Yabiji and reefs off the south and east of Miyakojima have suffered devastating predation damage.

The area from Ōura Bay on the western shore of Miyakojima to Yonaha Bay is covered by shallow beds of sand and mud, and there are almost no reef-building coral. There are many underwater caves off the western shore of Shimojishima, making this area a popular diving spot, but it consists of contiguous bare rock reef slopes, with a reef-making coral coverage rate of less than 5 percent. In fact, there are no reports of coral distribution with any significant coverage (e.g. 25 percent or more) off the western coast of Shimojishima even before the explosion of crown-of-thorns starfish populations in the 1980’s or the 1998 bleaching event.

The places where one can see many corals with high levels of coverage are on the reef slopes off the northern to eastern shores of the island and reef patches, which consist mostly of branching acroporid corals: namely, the southwest of Yabiji Kanamara (S2), the reef slopes from Ikemajima to Ōgamijima (S3), off Miyakojima’s Takano Fishing Port (S4), and around Shiratorizaki at the north of Irabujima (S7). (However, beginning in 2008, S4 has suffered serious predation damage by crown-of-thorns starfish, and as of September, 2009, the population explosion is continuing.)

To the west of Miyakojima’s Karimata area (S8), which is the northernmost tip of the western shore, branching acroporid-dominated coral communities have grown from a roughly 10 percent coverage level to one of more than 40 percent in the past five years. Similarly, the coral of Sumutubiji (S1) on the west side of Yabiji and the reef patches off the port of Nagayama on Irabujima have gradually grown in coverage, from 40 percent to 50 percent in branching and table acroporid-dominated coral communities in the same period of time. It is thought that the coral communities at these sites were devastated by the population explosion of crown-of-thorns starfish in the 1990’s and the bleaching event of 1998, causing a drastic shrinkage in coverage, but that they have been quickly recovering since.

The area to the southeast of Miyakojima from the Yoshino Coast to the Aragusuku Coast (F3) and off Ueno’s Hakuai Fishing Port (F4) is covered by sandy beds where mass-like and branching Porites species grow. Coverage is between 10 and 50 percent. They are resistant to the effects of high ocean temperatures and predation by crown-of-thorns starfish, and communities enjoy fairly stable distributions.

According to the Marine Park Center (1994), the south and north sides of Taramajima and Minnajima, respectively, have branching *Porites* corals with 50 percent or higher coverage rates, but other information is very scarce. According to a diving company operator in Tarama Village, there are medium to high levels of acroporid coral coverage on the north sides of both of these islands (Miyako F5, S9, S10).

Since there are few people and organizations researching coral reefs in the Miyako Islands, records of coral reef conditions are scant. Even now, monitoring is done fairly infrequently and at a limited number of sites. Improving the coral reef monitoring systems is one of the more important issues in the Miyako Islands, especially given the necessity of monitoring for the purposes of dealing with crown-of-thorns starfish.

6. Yaeyama and Senkaku Islands

Yaeyama and Senkaku Islands: (i) Mammals

Kimitake FUNAKOSHI (The International University of Kagoshima),
Masako IZAWA (University of the Ryukyus),
Fumio YAMADA (Forestry and Forest Products Research Institute, Kansai Office),
Shintaro ABE (Naha Nature Conservation Office, Ministry of the Environment),
Yukari HANDA (Amami Mammalogical Society)

The natural environment has been altered considerably. The changes that have taken place as a result of the rapid growth of the tourism industry in particular, such as development, encroachment by people, and a drastic increase in the number of cars, have become serious problems. A major debate is taking place over the conservation of bats and the construction of a new airport on Ishigaki Island. There is a relative wealth of studies of Ishigaki and Iriomote Islands, but surveys of the mammals such as the Iriomote cat in the mountainous regions of Iriomote Island and the bats that dwell in the caves that spot the island of Ishigaki have yet to yield sufficient data. Survey data is lacking for other islands in the region. Surveys cannot be conducted on the Senkaku Islands because of political issues, so there is practically no data available, but there are concerns that feral goats have destroyed much of the vegetation there. Aside from Uotsurijima, available information on the Senkaku Islands is nonexistent.

Yaeyama and Senkaku Islands: (ii) Birds

Kazuo NAKAMURA (Part-time Lecturer, Graduate School of Okinawa University),
Kenji TAKEHARA (Misaki Special Needs Education School of Okinawa Prefecture),
Shinichi HANAWA (WWF Japan)

Much of Iriomote Island has been designated as either a Wildlife Protection Area or Special Protection Zone. The Amparu Tidal Flats of Ishigaki Island are registered as protected wetlands under the Ramsar Convention. However, Ishigaki, Iriomote, and many other islands have felt the overwhelming effects of development in recent years, with the construction of resort hotels, dams and roads, and logging to create grazing land. There has also been a tremendous increase in the number of tourists and new residents.

At present, the Wild Bird Society of Japan and other groups are spearheading efforts to survey and protect birds, but as these efforts have mainly focused on Ishigaki Island, studies of birds on the other islands of this region, including Iriomote, have not produced sufficient results. Comprehensive surveys covering all of the islands need to be conducted in order to get a more complete picture of the bird fauna in this region.

Because the Senkaku Islands are the subject of a territorial dispute, field studies are currently not feasible. It is hoped that the dispute can be settled so that comprehensive surveys may be performed.

Yaeyama and Senkaku Islands: (iii) Amphibians/Reptiles

Hidetoshi OTA (University of Hyogo), Naoki KAMEZAKI (Sea Turtle Association of Japan),
Mamoru TODA (University of the Ryukyus),
Shigeru OKADA (Kagoshima Environmental Research and Service)

The Yaeyama Islands (excluding Yonagunijima): With the exception of a few uninhabited islands and rocky reefs, one or more studies or distribution reports on the amphibians and terrestrial reptiles in this region have been published for each island (Maenosono and Toda, 2007). However, even in the case of Ishigaki and Iriomote, which are the largest islands of this group and where there is much scientific and lay interest in the wildlife, there is only a limited amount of comprehensive and reliable population and distribution data on noteworthy species and subspecies on these islands. Even the demarcation of distribution ranges of indicator species on each of the islands that was conducted in this project relied on limited field observation data and the confirmation of the presence of the types of habitats that such species would live in from maps. More efforts are required in order to raise the level of quality of the data through studies that are more systematic and exhaustive.

Of the islands in this region, Ishigaki and Iriomote Islands have particularly complex topographical features, as well as relatively rich terrestrial water environments, most notably networks of mountain streams. These two islands, and the coral reef-rich waters between them, are part of the Iriomote-Ishigaki National Park (20,569 ha). Part of a mountainous forest in the central part of Ishigaki Island (9.0 ha) has also been designated as a Natural Habitat Conservation Area under the Law for the Conservation of Endangered Species of Wild Fauna and Flora (relevant species: Platypleura albivannata). Despite this, because of the construction of paved roads, there are many instances of amphibians and terrestrial reptiles being run over by cars, especially on Iriomote and Ishigaki. This, together with the expansion of land used by people in the form of farmland, residential areas, and facilities for tourists, has generated deep concerns over the shrinkage and disjunction of habitats of amphibians and terrestrial reptiles selected as indicator species in this project. Furthermore, the invasive nonnative cane toad has spread, especially on Ishigaki, where it inhabits nearly the entire island (Ota et al., 2004). Kuroshima, Kohamajima, and Aragusukujima have dense populations of Indian peafowl (Tanaka and Takehara, 2003; Tanaka, 2004), and Haterumajima now has high population concentrations of Japanese weasels (Ota, 1981, unpublished data). There are serious concerns over the impact of these species on native amphibians and terrestrial reptiles through predation and competition.

As for sea turtles, on many sandy beaches there are more than a few things associated with the islands' use as tourist attractions and leisure destinations that directly interfere with nesting females and hatchlings (interference through visual stimuli via campfires and car headlights, as well as physical interference, such as off-road vehicles compacting the sand and leaving tire ruts) that are cause for concern. The construction of breakwaters in the surrounding areas, and seawalls and revetments on the beaches, has resulted in a decline in the beach widths and lowering of beach elevations, raising concerns over the deterioration in quality as nesting beaches for sea turtles (Okinawa Prefectural Board of Education, 2001). Concerning sea kraits, the Erabu black-banded sea krait in particular is fished for commercial purposes, so surveys should also cover the impact of fishing on their numbers as well as the survival of populations.

Yonagunijima: Mt. Urabudake, which is located slightly east of the center of the island, and the surrounding areas have relatively dense evergreen broadleaf forests, in which, along with the marshes and streams at the foot of the mountain, one can see many terrestrial reptiles fairly often. In addition, in the hilly region extending from this area to Mt. Kuburadake, which is located slightly southwest of the island's center, and in the north side of this area, there are patches where terrestrial reptiles can be frequently seen (Ota, unpublished data). Based on this, we can conclude that the areas selected in this project more or less cover areas high in diversity. It should also be noted that there has recently been a marked increase in logging in the evergreen broadleaf forests of Mt. Urabudake. This, together with the impact of the increase in numbers of the nonnative predatory Indian peafowl (Tanaka and Takehara, 2003), has prompted concerns.

The Senkaku Islands: Even Uotsurijima, which is the largest landmass and has the highest elevation of the Senkaku Islands, is only 3.8 square kilometers in area, and its highest point is 362 meters. All species of terrestrial reptiles found in this region inhabit Uotsurijima. Goats introduced to this island in 1978 by a private political group have since thrived and in recent years have reached a high population density. As a result, vegetation has been destroyed, and this has also caused the runoff of red soil during times of rain (Yokohata, 2003; Yokohata et al., 2009). The most important and urgent steps to take for protecting this area are field surveys and the thorough eradication of feral goats based on these results.

Yaeyama and Senkaku Islands: (iv) Insects

Masako YAFUSO (Retired from Faculty of Agriculture, University of the Ryukyus),
Kenichi WATANABE (Yaeyama Agricultural High School),
Seiki YAMANE (Faculty of Science, Kagoshima University),
Kunihiko MATSUHIRA (Kagoshima Prefectural Institute for Agricultural Development),
Yoshiyuki MAEDA (Hookaen Nursery), Kazuki YAMAMURO (Amami Mongoose Busters)

Many aspects of Yonagunijima, from its inland areas to its water systems and shores, are worthy of note. However, roads in the inland regions have caused forests to become drier. The roadside concrete ditches are deep, and rainwater quickly runs into them. Preventing the further aridification of the island's forests by remedying the concrete ditch problem and other steps is an issue of the utmost urgency. The insect fauna of Iriomote, Ishigaki, and surrounding islands is highly endemic, but many constituent members are threatened with extinction. Development should be limited to what the natural environment can tolerate, and more innovative ideas must be implemented.

Others have pointed out the destruction of vegetation by goats on the Senkaku Islands, making these islands of the highest priority in terms of conservation. A transnational survey group should be formed as quickly as possible to study the islands.

Yaeyama and Senkaku Islands: (v) Fish

Katsunori TACHIHARA (Faculty of Science, University of the Ryukyus),
Itaru OTA (Okinawa Prefectural Fisheries and Ocean Research Center),
Toshihiko YONEZAWA (Kagoshima Environmental Research and Service)

The Iriomote and Ishigaki region has been designated as a National Park. Furthermore, eight areas in Yaeyama (1106.5 ha) have been designated as Marine Parks. Aquatic surfaces protected by the Fisheries Resource Protection Law include Ishigaki's Kabira (275 ha) and Nagura (68 ha) areas. Of these, the capture of all flora and fauna, including fish, is forbidden in Nagura (Okinawa Prefecture's Fisheries Coordination Regulations). Furthermore, in five marine spawning areas (680 ha), a three-month (April to June) self-enforced blanket ban by fishermen has been imposed that prohibits the catching of the Pacific yellowtail emperor (Lethrinus atkinsoni). Because of the political situation, the waters off the Senkaku Islands have not been researched adequately, and thus available information is extremely limited (Okinawa Prefectural Department of Agriculture, Forestry and Fisheries, 1982). This is one of the marine areas for which it is hoped that detailed scientific studies will be conducted in the future.

Yaeyama and Senkaku Islands: (vi) Crustaceans

Yoshihisa FUJITA (Marine Learning Center/Part-time Lecturer, University of the Ryukyus),
Hiroshi SUZUKI (Kagoshima University), Tohru NARUSE (University of the Ryukyus),
Shigemitsu SHOKITA (University of the Ryukyus, Emeritus)

The southern area of Ishigaki Island has been subject to considerable development, so nearly all of the priority conservation areas are concentrated in the north. However, even in the north, new residential areas are being built for people who have relocated to the island, and resorts are being developed, so the situation must be monitored carefully.

National Parks and Protection Areas have been established on Iriomote Island, with the result that the environments on it are relatively well-preserved. That said, the number of visitors (tourists) grows year by year as the island grows in popularity as a destination for ecotourism, and there are concerns caused by overuse and excessive collection (by enthusiasts). Roads are being expanded and seawalls are being constructed along some of the coastal areas, a situation that requires attention.

Recent surveys have demonstrated cases of old wells and anchialine pools on Taketomijima, Kuroshima, Aragusukujima, Haterumajima, and Hatomajima being filled by dirt and gravel, leaving no water (interviews with local residents revealed that removal of the obstructing dirt and gravel restores the water). Studies of crustaceans on Kohamajima have been inadequate and thus further surveys and research are necessary.

Uotsurijima, a member of the Senkaku Islands, is home to the endemic Senkaku freshwater crab, but for political reasons surveys in recent years have been difficult, so the species' current status is unknown.

Yaeyama and Senkaku Islands: (vii) Mollusks

Jun NAWA and Taiji KUROZUMI (Natural History Museum and Institute, Chiba)

Parts of Ishigaki and Iriomote Islands have been designated as a Special Protection Areas as part of the National Park, but most of the habitats important to terrestrial mollusks on the Yaeyama Islands have steadily degraded. Road construction and farmland development projects on Ishigaki and Yonagunijima have caused habitats (forests) to rapidly shrink and become increasingly disjunct. Trees have been cut down to make room for road expansion and resort development in many areas along Iriomote Island's periphery, which has resulted in the shrinking of habitats of terrestrial mollusks.

Ishigaki's Nagura-Amparu Wetlands have been designated as a Class I Special Zone of the National Park, but nearly all areas that serve as habitats important to marine mollusks are rapidly deteriorating. Off Ishigaki Island, the influx of dirt into the tidal flats has caused a decrease in mollusk habitats. Important mollusk habitats are rapidly shrinking on Iriomote Island due to road expansion projects that have destroyed mangrove forests and to the influx of dirt into mudflats. A major dredging project is underway for a waterway in the tidal mudflats at Iriomote's Shirahama, resulting in the continued disappearance of seagrass beds, which are important habitats for mollusks. Critical habitats for terrestrial water-dwelling mollusks on Ishigaki and Yonagunijima are rapidly degrading due to river improvement projects and dirt inflow, resulting in a gradual loss of species diversity.

Important habitats for terrestrial mollusks on the Senkaku Islands are rapidly deteriorating. On Uotsurijima, there are concerns over dwindling populations of endemic terrestrial mollusks caused by the destruction of forests by feral goats (Okinawa Prefecture's Department of Cultural and Environmental Affairs, Nature Conservation Division, 2005).

Yaeyama and Senkaku Islands: (viii) Seagrasses/Algae

Shintoku KAMURA (Okinawa Environmental Research & Technology Center),
Ryuta TERADA (Faculty of Fisheries, Kagoshima University), Minoru YOSHIDA (Kaiyu)

Conservation status and issues off the Yaeyama Islands: Ishigaki is notable for its many sources of red soil that flow into the seas. Addressing the red soil problem is crucial. There are hotels on the coasts of Ishigaki and Iriomote that are already under construction, and more being planned. For this reason, it is our belief that conservation-related manuals that address both land and marine issues should be considered, developed, and created as quickly as possible.

Conservation status and issues off Yonagunijima: The gravel beds of the moats of the reefs in the waters off the Hikā district had, in 1972, scattered seagrass beds of mainly Thalassia hemprichii, but when observed in 1997, parallel dikes designed to control the waves during typhoons had been constructed in the moats at heights so high that one could no longer see the lagoons (called pishi). It is unclear whether the changes to tidal flow were the reason, but the seagrass beds had disappeared.

It is not known whether these seagrass beds have since recovered, but the moats are rich in algae. There were seagrass beds of *T. hemprichii* on the gravel bottom of the well-known Nanta Beach in Sonai Town, but they had declined after the construction of the harbor.

One of the concerns regarding the conservation areas of the Tabarugawa river system is the management of the upper reaches of the river, which is essential. There is a quarry close to the river's hinterland, and there are fears that it may be expanded.

Yaeyama and Senkaku Islands: (ix) Coral

Minoru YOSHIDA (Kaiyu)

The waters around the Yaeyama Islands are home to Japan's largest area of coral reefs, among which is the Sekisei Lagoon. The marine organisms, which include corals, are extremely diverse. The many beautiful underwater seascapes make it one of Japan's most popular areas for diving. Population explosions of crown-of-thorns starfish during the 1980's left coral communities devastated, but they have been steadily recovering since. Nevertheless, since the bleaching event in 1998, multiple sources of disturbance, including repeated bleaching events, crown-of-thorns starfish population explosions, chronic environmental degradation, have caused considerable overall damage to reef-building coral.

Representative of the blue coral communities of Shiraho (F2), Ishigaki's moats (F1, F3) feature distinctive corals in localized spots with high levels of coverage. The Sekisei Lagoon (F4) is already located in an area of ocean covered by sand and gravel, but during the bleaching event of 2007 the corals that until then had high coverage levels in reef patches were significantly damaged. In many areas, the corals in the moats and lagoons have not recovered to the coverage levels seen several decades previous.

The reef slopes along the north side of the Yaeyama Islands (S2, S3, S4, S6, S8) are dominated by mature acroporids, and healthy coral communities with high coverage levels over large areas can be seen even now, which is evidence that waters off Yaeyama are important as a source of coral larvae. The reef slopes located on the dynamic topography of the south side (S1, S7) comprise a richly diverse mix of different corals, dominated by acroporids but also featuring *Porites* species and others, although in most places coverage is lower than on the north side of the islands.

Massive populations of crown-of-thorns starfish have been confirmed throughout the waters off the Yaeyama Islands. Various aggressive steps to eradicate the starfish are being taken, but more and more areas have reached the point to where starfish eradication alone cannot protect the corals. In the future, it will be necessary to switch to an approach designed to designate smaller areas more strategically and consistently maintain healthy coral communities within them.

Priority areas were selected in this project, but due to the factors stated above, some coral communities have disappeared, while others have steadily recovered. We have seen in the past marine areas in which the underwater views and environments have changed dramatically in the span of a few years, so an adaptive approach, i.e. one in which the selected areas can be revised, is necessary.

In terms of the protections accorded the coral reefs off the Yaeyama Islands, eight areas have been designated as Marine Park Zones within the Iriomote-Ishigaki National Park, and one area has been designated as a Nature Conservation Area (Marine Special Zone) protected under the Nature Conservation Law. In addition to these, there are two aquatic surfaces protected under the Fisheries Resource Protection Law. Since, as seen here, there are more designated conservation zones than other marine areas, the conditions necessary for protection are in place. There are, however, many problems as well. For example, area at hand is vast, which is not conducive to fine-tuned or area-specific strategies, and the seasonal winds in winter make conservation activities all but impossible on the north side.

In part due to special political circumstances, there is little research and data concerning the Senkaku Islands. For this reason, those islands were left out of the selection process. It is hoped detailed scientific studies can be conducted in the future.

4.3. The status of the Nansei Islands as they relate to legal systems

The following pages address the present and future of biodiversity preservation in the Nansei Islands from a legal standpoint. Three main aspects, namely international conventions, domestic laws and their effects, and administrative ordinances, will be examined in chronological order according to when they took affect regarding natural environments and their protection.

International conventions

The Convention on International Trade in Endangered Species of Wild Fauna and Flora

The oldest international convention protecting wildlife ratified by Japan is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Convention No. 25 of 1980) (hereinafter “CITES”). Japan officially became a party to the convention in November of 1980, but there were domestic laws in effect at the time of ratification, namely the Law for the Regulation of Transfer of Birds in Danger of Extinction (Law No. 49 of 1972) and the Law for the Regulation of Transfer of Species of Wild Fauna and Flora in Danger of Extinction (Law No. 58 of 1987). These two would later be merged into the Law for the Conservation of Endangered Species of Wild Fauna and Flora (Law No. 75 of 1992), which is described below.

In 1986, these laws contained lists of 35 species and subspecies of birds, including the Okinawa rail and Okinawa woodpecker. They were referred to as “specially-protected birds” and thus accorded legal protection. Recently, the World Conservation Congress, which is held every four years by the International Union for Conservation of Nature (IUCN; founded in 1948) will coincide with the Conference of the Parties to the Convention on Biological Diversity to be held next year, so conservation measures are being strengthened for the dugong, which is a Natural Monument in Japan and is also protected by CITES. Furthermore, at the Conference of the Parties to CITES to be held next year, the United States is expected to submit a proposal to regulate under CITES trade in “precious coral”, which is popularly used in jewelry, on the grounds that it has been depleted through overexploitation. If the trade regulations are approved, special measures such as checks on the volume that can be traded and the issuance of export permits will become necessary.

The Ramsar Convention

The Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Convention No. 28 of 1980) (hereinafter the “Ramsar Convention”), was drafted in 1971 in order to preserve the ecosystem in wetlands that serve as important habitats of waterfowl, recognizing that they are at the top of the food chain. It entered into force in 1975. The initial draft of the Convention did not include provisions for amendments. To rectify this problem, the Protocol to Amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat, which added Article 10 bis (which laid out rules governing amendments added between Article 10 and Article 11) was drafted in Paris in 1982. In Japan, this Protocol is Convention No. 8 of 1987.

Beginning with the registration of Manko in May of 1999, the Nagura-Amparu Wetlands, the marine areas off the Kerama Islands, and the streams and wetlands of Kumejima have been designated and subject to conservation efforts.

The Convention on Biological Diversity

Unlike CITES and the Ramsar Convention, which regulate specific actions and specific habitats, the Convention on Biological Diversity (Convention No. 9 of 1993) was created to expand the framework of wildlife conservation and protect the overall diversity of Earth’s organisms. A signing ceremony for the Convention was held at the United Nations Conference on Environment and Development (the “Earth Summit”) in June of 1992 in Rio de Janeiro. The convention was opened for signatures that June for a period of one year, during which 168 countries and organizations signed it. It went into effect in 1993, which is the year it was ratified in Japan. As of 2009 there are 192 party states plus the EC. Party states are obligated to draft and act upon national strategies or national plans whose purpose is to protect and promote the sustainable use of biodiversity.

Japan drafts or revises a national biodiversity strategy every five years. The First National Strategy for the Conservation and Sustainable Use of Biological Diversity was drafted in 1995, but it contained no descriptions of concrete conservation measures applying to the Nansei Islands. The Second National Strategy for the Conservation and Sustainable Use of Biological Diversity of 2002 made mention of the importance of the island ecosystems of the Nansei Islands, and proclaimed the need to protect specific species, including the Iriomote cat, the Amami rabbit, Okinawa woodpecker, and dugong, which were mentioned by name. The document also made mention of international coral reef initiatives. The creation of a Coral Reef Ecosystem Conservation Action Plan has begun. The Third National Strategy for the Conservation and Sustainable Use of Biological Diversity, which was revised in 2007, goes so far as to outline action plans for biodiversity conservation. It describes current trends in biodiversity, identifies issues, prescribes concrete measures, states by name which government ministry or agency is responsible for which step, and even includes timetables. It states, for example, “Removal projects targeting nonnative species will proceed, with priority to the habitats of rare species, National Parks, Forest Reserves, and other areas important for conservation. For example, the small Asian mongoose, which threatens rare species on Amami Ōshima, shall be eradicated from that island with Fiscal 2014 as the targeted deadline. In addition, methods for removing the common raccoon, the largemouth bass, and various other species shall be studied, and local governments shall be recruited to carry out removal projects. (Ministry of the Environment, Ministry of Agriculture, Forestry and Fisheries).”

At present, the Ministry of the Environment is studying the prospect of making the Third National Strategy for the Conservation and Sustainable Use of Biological Diversity a statutory plan under the Basic Act on Biological Diversity, which is described below.

The Cartagena Protocol

Studies were done on procedures for the transport, handling, and use of living organisms modified through biotechnologies that pose a potential threat to biological diversity within the framework of the Convention on Biological Diversity. The resulting supplement to the Convention, the Cartagena Protocol on Biosafety (also simply known as the “Cartagena Protocol” or “Biosafety Protocol”), went into effect in 2003. This international Protocol requires exporting countries to provide the proper information to importing countries whenever exporting genetically modified crops or other organisms, and obtain prior agreement from the importing countries.

The corresponding domestic law in Japan is the Law concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (Law No. 97 of 2003) (hereinafter the “Cartagena Law”), which went into effect in 2004. The Cartagena Law regulates the use of organisms genetically modified through biotechnologies. Okinawa has seen a rise in the number of biotechnology-related companies, sparking concerns over the risks posed by the release into the wild of living modified organisms.

World Heritage Convention

The Convention Concerning the Protection of the World Cultural and Natural Heritage (Convention No. 7 of 1992), the purpose of which is to protect and preserve the common cultural and natural heritage of humanity from deterioration and destruction by establishing international mechanisms for cooperation and assistance, was adopted by the General Conference of UNESCO in 1972, and went into effect in 1975.

As of October of 2008, 185 countries were parties to the Convention. Japan joined the Convention in 1992, becoming the 125th country to do so. Yakushima, which was placed on the list in 1993, and in part due to the Jōmon Sugi, a tree thought to be about 7,200 years old, the island has become a well-known natural World Heritage Site. There are efforts underway to have the Nansei Islands listed as a World Heritage Site in the near future.

Domestic laws

Wildlife Protection and Hunting Law

The oldest legal framework for conservation in Japan is the Wildlife Protection and Hunting Law (Law No. 32 of 1918) (hereinafter the "Wildlife Protection Law"). The purpose of the law was to protect wildlife and regulate the hunting thereof in Japan. The Wildlife Protection Area system was established as a concrete measure to protect wildlife through an amendment, Law No. 217 of 1950. Law No. 23 of 1963 also amended the original Wildlife Protection Law and formalized the Wildlife Protection Project Plan System.

In 2002, the language of this law was modernized, and its name was changed to the Law concerning the Protection of Wildlife and Proper Regulation of Hunting (Law No. 88 of 2002). One of the changes was the inclusion of the protection of biological diversity among its stated purposes.

Kagoshima Prefecture set forth its 10th Wildlife Protection Project Plan, which is to span a five-year period beginning in April of 2007. Okinawa Prefecture likewise laid out its 10th Wildlife Protection Project Plan, to last five years beginning in April of 2008. The latter provides for the establishment of new Wildlife Protection Areas. Okinawa is also pushing ahead with attempts to transfer the control of the Wildlife Protection Areas at Mt. Yonahadake, Mt. Nishimedake, Mt. Ibudake and Sate, which serve as habitats to internationally and domestically important species such as the Okinawa woodpecker and Okinawa rail, to the national government, making them National Wildlife Protection Areas, in order to better protect wildlife and natural habitats.

For wetlands to be registered under the Ramsar Convention described above, they must already be designated as Special Protection Zones within National Wildlife Protection Areas, National Parks, or Quasi-National Parks, and be subject to the conservation and management provided by those designations. The Manko Tidal Flat was designated as a Wildlife Special Protection Zone in 1997 by the Japanese government.

Law for Protection of Cultural Properties

The second oldest domestic conservation law was the now-abolished Law for the Preservation of Historic Sites, Places of Scenic Beauty and Natural Monuments (Law No. 44 of 1919). It is the predecessor of the current Law for Protection of Cultural Properties (Law No. 214 of 1950), which absorbed and replaced it.

The Law for Protection of Cultural Properties protects plants, animals, and minerals that are considered to be of significant scientific or academic value for Japan by legally designating them as Natural Monuments. Natural Monuments that are of special value globally or nationally are given the Special Natural Monument designation.

For example, the Amami rabbit was designated as a Natural Monument in 1921, but was subsequently made a Special Natural Monument in 1963. It was then designated as a National Endangered Species of Wild Fauna and Flora under the Law for the Conservation of Endangered Species of Wild Fauna and Flora, which is described below, in 2004. It is also on Kagoshima Prefecture's Red List as Endangered. The Okinawa woodpecker was designated as a Special Natural Monument in 1972, and as a National Endangered Species of

Wild Fauna and Flora in 1993. The Iriomote cat was designated as a Natural Monument by the Government of the Ryukyu Islands (which governed the island at the time). When Okinawa reverted to Japanese control in 1972, the cat was designated as a Natural Monument by the Japanese government, and then as a Special Natural Monument in 1977.

The Natural Parks Law and Nature Conservation Law

The Natural Parks Law (Law No. 161 of 1957) is the legal framework for designating Japan's National Parks and Quasi-National Parks, and for promoting the preservation of their natural environments as well as comfortable visitation to them. The stated purpose of the Natural Parks Law is to protect places of excellent scenic beauty, promote their use, and thereby contribute to the health, relaxation, and education of the country's citizenry (Article 1). The Nature Conservation Law (Law No. 85 of 1972) was enacted to collectively promote the proper conservation of natural environments in conjunction with the Natural Parks Law and other laws designed to protect natural environments.

In Okinawa, for example, the Ministry of the Environment has designated about 128 hectares of Sakiyama Bay in Taketomi Town, Iriomote Island as a Nature Conservation Area pursuant to Article 22 of the Nature Conservation Law. This marine area is particularly pristine, and supports a rich variety of flora and fauna, including giant colonies of galaxy coral (Galaxea fascicularis). It is also Japan's only Marine Special Zone.

The Natural Parks Law and Nature Conservation Law were subject to partial revision in 2009 with Law No. 47 of 2009 (not yet enacted), which adds the protection of biodiversity to the stated purpose of the laws, and provides for a marine park zone system and ecosystem maintenance and restoration project system. The new amendment will play a significant role in advancing the protection of biodiversity.

The Basic Environment Law

The Basic Environment Law (Law No. 91 of 1993) establishes the groundwork for Japan's environmental policies. Before the enactment of the Basic Environment Law, there was the Basic Law for Environmental Pollution (Law No. 132 of 1967) for addressing pollution concerns, and the Nature Conservation Law for addressing conservation issues. These laws, however, were no longer sufficient to cope with environmental problems that were becoming increasingly complex and global in nature. With the enactment of the Basic Environment Law, the Basic Law for Environmental Pollution was abolished, and the Nature Conservation Law was amended so that it corresponded with the purpose of the Basic Environment Law. This law takes precedence over all other legal mechanisms in Japan concerning the environment. There are, however, portions of this law that conflict with the Basic Act on Biodiversity described below, so it is likely that the Basic Environment Law will also need amending at some point in the future.

The Species Conservation Law

The Law for the Conservation of Endangered Species of Wild Fauna and Flora (Law No. 75 of 1992) (hereinafter the "Species Conservation Law") designates endangered species of wild flora and fauna, and prohibits the capture, collection, and transfer of designated species, protects the habitats of those species as necessary, and serves as the domestic counterpart to CITES. This is one of the laws whose enactment was prompted by the ratification of the Convention on Biological Diversity.

The Iriomote cat, which is probably the best-known example in Japan of a National Endangered Species of Wild Fauna and Flora, was designated as such in 1994. For several years, this species and the Tsushima cat (Prionailurus bengalensis euptailurus), which was designated at the same time, were the only two mammals protected under the Species Conservation Law, but the Amami rabbit and the Daito flying fox were subsequently added. The Iriomote Wildlife Center was established on Iriomote Island pursuant to the Species Conservation Law as a center for projects designed to protect the Iriomote cat, maintain proper population levels, conduct studies and surveys, distribute information, and educate people.

The Law for the Promotion of Nature Restoration

The Law for the Promotion of Nature Restoration (Law No. 148 of 2002) was enacted for the purpose of promoting projects that restore natural environments that have been damaged or destroyed. The projects it provides for are conducted with the cooperation of government bodies, community residents, NPO's, specialists, etc., and entail the conservation, restoration, and/or creation of natural environments.

The underlying principles of nature restoration set forth are the need for coordination among diverse parties, the need for scientific knowledge and ongoing monitoring, the need for adaptive styles of management when directing nature restoration projects, and the utilization of such projects as opportunities to educate people on subjects related to natural environments. The law also sets forth a set of guidelines so that projects will be carried out in a comprehensive manner.

In Okinawa Prefecture, the Sekisei Lagoon Nature Restoration Project was begun in 2005, and as a result the lagoon is being restored.

The Invasive Alien Species Act

The Law concerning the Prevention of Damage to Ecosystems by Certain Nonnative Organisms (Law No. 78 of 2004) (hereinafter the "Invasive Alien Species Act") was enacted to prevent damage from nonnative organisms that pose a threat to native organisms through predation or competition, impact on the ecosystem, or that may pose a threat to human life, the threat of injury or the threat of damage to agricultural, forestry or fisheries industries. Once designated as an Invasive Alien Species, the rearing, growing, storage, transport, and import of that species becomes regulated, and if necessary, the Act gives authority to the national or local governments to remove them from the wild. In the Nansei Islands, which constitute a treasure trove of endemic species, the impact of nonnative species is serious. One typical example is the effort to remove the small Asian mongoose from Amami Ōshima and Okinawa Island. It is hoped that the mongoose can be completely eradicated from these two islands in the future.

The Basic Act on Biodiversity

When Japan ratified the Convention on Biological Diversity in 1993, domestically it implemented legal measures based on the Wildlife Protection and Hunting Law, the Natural Parks Law, the Nature Conservation Law, and the Species Conservation Law. These were followed by measures pursuant to the Invasive Alien Species Act and Cartagena Protocol. In 2008, the Basic Act on Biodiversity (Law No. 58 of 2008), a law with precedence over the others, went into force. The Basic Act on Biodiversity establishes the groundwork for Japan's biodiversity policies.

Through its stipulations this law: 1) mandates drafting of a national biodiversity strategy by the national government, 2) obliges prefectural governments and local municipalities to work at drafting a biodiversity strategy, 3) promotes the conservation of biodiversity at the community level, 4) protects species diversity in wildlife, 5) prevents damage by nonnative species, 6) promotes projects that take into account biodiversity, 7) promotes education in biodiversity-related matters in school curricula and in public awareness campaigns, 8) promotes environmental impact assessments related to biodiversity at project planning phases, 9) and secures and promotes channels for international collaboration and cooperation. Neither Kagoshima Prefecture nor Okinawa Prefecture has yet drafted a local biodiversity strategy.

The Law for the Promotion of Ecotourism

Since the rise to prominence of the problem of global warming and similar environmental issues, many people have developed a greater appreciation for the natural environments around them, and the number of tourists to nature-oriented destinations has increased. The downside has been that more and more tourism ventures do not properly consider the negative impact that they are having on the environments they visit. To help remedy this problem and ensure that the protection of environments is an overriding priority in nature-oriented tourism, the Law for the Promotion of Ecotourism (Law No. 105 of 2007) was enacted.

Ecotourism Support Councils have been organized for Yakushima and Okinawa. In Okinawa, a set of ecotourism guidelines have been drawn up.

In what will be the first example in the country of a measure to enforce the regulations of the Law for the Promotion of Ecotourism, restrictions on divers entering the waters off the Kerama Islands (Tokashiki Village and Zamami Village, Okinawa Prefecture), where rich coral reefs still grow, are scheduled to be implemented in April of 2010. The goal is to restrict the "total volume of traffic" by cutting the number of divers in both villages in half, and necessitating that diving anywhere shallower than 30 meters in depth requires special permission from the villages. Given the rampant nature of mass tourism in recent years, many hopes are riding on the success of these entry restrictions and the example that it would set.

The Environmental Impact Assessment Law

The Environmental Impact Assessment Law (Law No. 81 of 1997) is a law that outlines procedures for assessing environmental impact. Its aim is to provide directors of major public works and similar projects with criteria for evaluating in advance the potential impact that their projects may have on the environment, and based on those results allows them to either step away from projects with negative impact or reengineer projects so that they have no negative environmental impact. Despite these lofty goals, it should be noted that, at least with regard to the controversies over the Awase Tidal Flat reclamation and the Henoko military base relocation plans, the Environmental Impact Assessment Law has not fully yielded the results initially hoped for. In terms of environmental protection, some are calling for the enactment of a higher-tiered "Strategic Environmental Assessment Law" that would override the Environmental Impact Assessment Law and impose a statutory requirement for environmental impact assessments at the proposal, framing and planning stages of public works-type projects and at those same stages for public policy. The Basic Act on Biodiversity enacted last year calls for "the promotion of environmental impact assessments regarding biological diversity at the planning stages, etc. of projects" in Article 25.

The Basic Act on Ocean Policy

The Basic Act on Ocean Policy (Law No. 33 of 2007) was enacted for the purpose of establishing a fundamental legal foundation for striking a balance between marine development and utilization and the protection of marine environments, and at the same time ensuring safety in marine waters. Article 18 of the Act, which concerns the "conservation of marine environments", addresses the importance of marine environments in curbing global warming, the major positive effects that marine conservation have on the global environments, and the importance of ensuring the preservation of the biodiversity of marine life by protecting and improving the habitats of marine organisms. The Basic Plan on Ocean Policy formulated in 2008 pursuant to this law lists the following objectives for effectively protecting biodiversity: 1) to collect and compile data derived from various types of studies and surveys, 2) to specify important marine areas and, according to the characteristics of the specific ecosystems, draft action plans to protect biodiversity therein, 3) to collate and provide data collected on marine biodiversity in the form of maps to promote research by various organizations and to facilitate actions based on awareness of the protection of biodiversity, 4) to increase the various protected areas under the Natural Parks Law and Wildlife Protection and Hunting Law regarding seagrass beds, mudflats and coral reefs in shallow marine areas, which are areas important for securing marine biodiversity and environmental purification functions, and which also constitute important marine scenic views that merit conservation, 5) to aggressively restore and rehabilitate mudflats to which the Law for the Promotion of Nature Restoration also applies, ensure that the runoff sediment and nutrient salt levels are being kept at proper levels, and promote other coordinated terrestrial-marine efforts, 6) to promote the creation of a protection network of coral reefs in Asia/Oceania based on the resolutions adopted at the International Coral Reef Initiative's General Meeting (Tokyo, 2007), 7) and, as a way to secure biodiversity and for the sustainable use of marine resources, to adequately promote the establishment of marine protection areas in Japan based on the Convention on Biological Diversity and similar international agreements after the criteria for the establishment of such area in Japan has been clarified under the guidance of the relevant government ministries.

It should also be noted that a Marine Biodiversity Strategy is being developed in preparation for the 2010 Conference of the Parties to the Convention on Biological Diversity.

The Environmental Education Act

In part because of the United Nations' "Decade of Education" initiative, there was a period of renewed and intense debate in Japan over the issue of consolidating environmental educational matters under a unified legal framework. Out of that debate was borne the 2003 Law for Enhancing Motivation concerning Environmental Conservation and Promoting Environmental Education (Law No. 130 of 2003) (hereinafter the "Environmental Education Act") under the collective purview of five ministries: the Ministry of the Environment, the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Land, Infrastructure, Transport and Tourism, the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Economy, Trade and Industry. The purpose of this law is to raise awareness and motivation on the part of every Japanese citizen with the goal of creating a more sustainable society.

The Environmental Education Act is slated for revision in five years, and amendments are already being studied. One of the proposed considerations is the inclusion of education matters dealing with biodiversity in school curricula and in public awareness campaigns as part of the Basic Act on Biodiversity mentioned above.

Act on Special Measures for Amami and Okinawa

The pages above have touched upon general legal mechanisms relating to protection, but the nature of this project necessitates mention of special statutory measures specifically involving the promotion of development on Amami Ōshima and in Okinawa Prefecture, specifically the Act on Special Measures for the Promotion and Development of the Amami Islands (Law No. 189 of 1954) (hereinafter the "Amami Special Measures Act") and the Act on Special Measures for the Promotion and Development of Okinawa (Law No. 131 of 1971). The latter contained a provision which set its statutory limit at the year 2002. In renewing this law, in addition to various promotion and development measures carried over from the old law, new special measures were included, such as new steps to promote industry and to provide for easier utilization of the land left after the scheduled relocation of the military bases. This new law was also named the Act on Special Measures for the Promotion and Development of Okinawa (Law No. 14 of 2002) (hereinafter the "Okinawa Special Measures Act"). The Ministry of the Environment has included measures to promote ecotourism in Okinawa in the Okinawa Special Measures Act.

Due to special circumstances of the Amami Islands, the Amami Special Measures Act stipulates that a comprehensive development plan be drafted pursuant to the Amami Island Development Guidelines, and that special measures be implemented to facilitate projects based on this plan. Moreover, the Act aims to promote a self-sustaining economy in the islands and contribute to the economic stability and welfare of its residents by facilitating development projects that are tailored to the specific geographical and natural features of the islands.

Due to special circumstances of the Okinawa, the Okinawa Special Measures Act mandates the creation of a comprehensive development plan as well as other measures to promote various industries. It also includes special mechanisms to encourage the smooth transition and utilization of the land left after the scheduled relocation of the military bases, special provisions defining the national government's financial burden and outlining the ratios thereof, and other steps necessary for the promotion of the economy of Okinawa.
Needless to say, a tremendous sum of money is being used in public works projects associated with both of these laws.

Prefectural ordinances in Kagoshima and Okinawa

As a rule, prefectural ordinances in Japan follow and are grounded in national laws. Examples of the pertinent ordinances that Kagoshima Prefecture has passed include the Kagoshima Natural Parks Ordinance (Ordinance No. 27 of 1958), the Kagoshima Prefectural Nature Conservation Ordinance (Ordinance No. 23 of 1973), the Kagoshima Prefectural Ordinance on the Protection of Sea Turtles (Ordinance No. 6 of 1988), the Kagoshima Prefectural Basic Environment Ordinance (Ordinance No. 10 of 1999), the Kagoshima Prefectural Environmental Impact Assessment Ordinance (Ordinance No. 26 of 2000), and the Kagoshima Prefectural Ordinance on the Conservation of Endangered Species of Wild Fauna and Flora (Ordinance No. 11 of 2003).

Similarly, Okinawa Prefecture passed the Okinawa Prefectural Nature Conservation Ordinance (Ordinance No. 54 of 1973), the Okinawa Prefectural Parks Ordinance (Ordinance No. 10 of 1973), the Okinawa Prefectural Red Soil Erosion Prevention Ordinance (Ordinance No. 36 of 1994), the Okinawa Prefectural Basic Environment Ordinance (Ordinance No. 15 of 2000), and the Okinawa Prefectural Environmental Impact Assessment Ordinance (Ordinance No. 77 of 2000), among others. Furthermore, in 2006 there were deliberations in the prefecture over whether to pass an Ordinance on the Conservation of Endangered Species of Wild Fauna and Flora, a proposal that is still in the works.

When one compares the ordinances implemented by these two prefectures —the Basic Environment Ordinance for example— both are based on clearly expressed preambles and make reference to the importance of their distinct natural environments. Kagoshima's ordinance, for example, clearly states that, "The increased impact on the environment has an effect on ecosystems, leads to the destruction of environments on a global scale, and may present new and unforeseen environmental problems." Okinawa's corresponding ordinance says that, "After reversion to Japanese control, rapid economic development, including the development of social capital, has resulted in a tremendous increase in the burden on the environment, yet U.S. military installations still occupy vast areas of land, and the noise from aircraft originating from the bases presents a range of problems that affect the lifestyles of the citizens of Okinawa as well as its natural environments."

The most noteworthy feature of Okinawa's Nature Conservation Ordinance is its preamble, which states, "Now is the time for us to recognize the connection between nature and the human race, to reaffirm the existence of nature as a heritage to be shared among all of humankind, and to do our best to take on the collective responsibility as residents of this Prefecture the duty to protect that wondrous nature of our Prefecture so that present and future generations may enjoy its benefits.” Its inclusion of the phrase, “the existence of nature as a heritage to be shared among all of humankind” in 1973 is commendable.

Furthermore, there are municipalities which feature high levels of biodiversity and many endemic species live, in which residents are required to have identification microchips implanted into their pets in order to mitigate the impact of feral cats on endemic species. Commendable examples of this include Kunigami Village’s “Pet Dog Ordinance” and “Cat Rearing and Management Ordinance”, and Taketomi Town’s “Cat Rearing Ordinance”.

Conclusion

The outline above surveyed a range of legal mechanisms, from international conventions to domestic conservation laws and local administrative ordinances designed to protect the environment. The reality that different governing bodies are responsible for different laws and regulations —often in conflicting and complex loops of bureaucracy— is not something limited to Kagoshima or Okinawa, and particularly for this reason there are high expectations regarding the laws and regulations merged under the Basic Act on Biodiversity described above.

Nevertheless, given the general rule in legal circles that “a later law prevails over an earlier law” and that “special laws take precedent,” there is still much room for improvement. The principle that “a later law prevails over an earlier law” means that laws enacted later take precedence over laws enacted earlier. Hence, the Basic Act on Biodiversity enacted last year is expected to overrule other laws in various matters of policy, but in matters in which “special laws (or measures)” are in place, the “special laws” take precedence, which in effect nullifies the former rule. One cannot deny that the presence of “Special Measures” acts in the prefectures of Kagoshima and Okinawa pose problems for the advancement of future policies. Hopefully, the “Special Measures” acts will either be nullified in the near future, or be treated as a general law for which the Basic Act can take precedence.

4.4. The importance of forming local strategies that utilizes BPA maps

The BPA maps used in this project were generated by identifying priority areas in the Nansei Islands using a set of criteria that focused on biodiversity. Nonetheless, it should be noted that the priority areas presented in this project are the result of an experimental undertaking. In order to preserve the biodiversity of the Nansei Islands and utilize that diversity in a sustainable manner, in addition to hard science-based data, one must also take into account community-specific natural features, cultural and spiritual considerations, basic social infrastructure, industrial activities, and other socioeconomic circumstances. For these reasons, it is entirely possible for conservation priorities to vary from region to region depending on the perspective and the accuracy of region-specific data.

In order to effectively make use of preservation strategies and utilization plans which meet the needs of specific communities, one should use the BPA maps presented here as a starting point, and from there generate maps (local map generation) based on parameters that are in line with consensuses built among the relevant parties.

Put in more concrete terms, maps should reflect local realities and considerations. This can only be achieved by involving a diverse array of parties, such as local governments, industry groups, community residents, and NPO's, and then assessing all of the environmental resources discovered in this process. Moreover, in order to effectively advance on-site conservation measures, it is necessary to draw up conservation plans (or conservation strategies) that incorporate the community resident consensuses, and develop coherent systems to further those strategies.

The WWF Coral Reef Research and Conservation Center in Ishigaki Island's Shiraho Village coordinates with the Shiraho Community Center to further the development of the Shiraho Yurati Charter. The position of the charter is as a basic plan for village development, but it also aims to realize "an open Shiraho that nurtures the sea, greenery, and spirit". Furthermore, it incorporates the conservation of coral reefs in its declarations, "We will protect our world class coral reefs and live in harmony with nature." It also proclaims a commitment to passing on the culture and traditions associated with coral reefs and to advancing efforts to nurture industries harmonious with this overall goal.

The establishment of the Charter signifies an agreement of the parties concerned to the effect that the preservation of coral reefs is a priority issue throughout the regions. The Charter also enables the Shiraho Community Center to take the initiative in leading village efforts to preserve coral reefs. Up until the establishment of the Shiraho Yurati Charter, the "nature conservation" was something done primarily on a volunteer basis, but now that it is a matter of maintaining the community, such activities has been attracting participation from diverse circles.

The Nansei Islands consist of relatively small islands, each with its own unique ecosystems and cultures that have benefited from them in different ways. It is the authors' hope that the presentation of BPA maps in this project becomes an impetus for renewed interest in the local natural environment and ecosystems within each island or community and reconfirms the value and importance of biodiversity, and leads to the creation of maps at the community level, where people live in harmony with the natural environs, and to the creation of local strategies aimed at preserving biodiversity.

Appendix

Appendix A : List of Participants for the Regional Conferences

Name	Affiliations	First Conference (2007)	Second Conference (2008)	Third Conference (2009)
Atsushi TAKASHIMA	Subtropical Field Science Center, Faculty of Agriculture, University of the Ryukyus			◎
Fumio YAMADA	Forestry and Forest Products Research Institute	◎	◎	◎
Hidemi KAWAGUCHI	Amami Ornithologists' Club		◎	
Hidenori KUSAKARI	WWF Japan	◎	◎	◎
Hidetoshi OTA	Institute of Natural and Environmental Sciences, University of Hyogo, and Tropical Biosphere Research Center, University of the Ryukyus	◎	◎	◎
Hiroshi SUZUKI	Faculty of Fisheries, Kagoshima University	◎	◎	◎
Hiroto SHIMAZAKI	National Institute for Environmental Studies			◎
Itaru OTA	Okinawa Prefectural Fisheries and Ocean Research Center, Ishigaki Lab	◎	◎	◎
Jun NAWA	Fujukan, University of the Ryukyus	◎		
Katsuhiko MARUYAMA	Shuri Higashi High School of Okinawa Prefecture	◎	◎	◎
Katsuki OKI	Tida Planning		◎	
Katsunori TACHIHARA	Faculty of Science, University of the Ryukyus	◎	◎	◎
Kazue OKAMATSU	Coaching STEP		◎	
Kazunori KAWAGUCHI	Amami Ornithologists' Club			◎
Kazuo NAKAMURA	Part-time Lecturer, Graduate School of Okinawa University			◎
Kazuya HIRAI	Tim Tuelassa			◎
Kenji TAKEHARA	Misaki Special needs education School of Okinawa Prefecture	◎		◎
Kenichi WATANABE	Yaeyama Agricultural High School of Okinawa Prefecture	◎	◎	◎
Kimitake FUNAKOSHI	The International University of Kagoshima	◎	◎	
Kiyotaka SANO	Crested Serpent Eagle Research	◎		
Mamoru TODA	Tropical Biosphere Research Center, University of the Ryukyus	◎	◎	◎
Masahito KAMIMURA	WWF Japan		◎	◎
Masako IZAWA	Faculty of Science, University of the Ryukyus		◎	◎
Masako YAFUSO	Retired from Faculty of Agriculture, University of Ryukyus	◎	◎	◎
Masaru OSADA		◎		
Mikio TAKASHI	Amami Ornithologists' Club		◎	
Minoru YOSHIDA	Kaiyu Ltd.	◎	◎	◎
Mizuki SHICHINOHE	HAKUHODO i-studio			◎
Nana ITO	TBWA＼HAKUHODO			◎
Naoki KAMEZAKI	Sea Turtle Association of Japan	◎	◎	◎
Nozomi NAKANISHI	Graduate School of Engineering and Science, University of the Ryukyus		◎	◎
Satoshi MAEKAWA	WWF Japan	◎		
Seiki YAMANE	Faculty of Science, Kagoshima University	◎	◎	◎
Shigeki YASUMURA	WWF Japan	◎	◎	◎
Shigeru OKADA	Kagoshima Environmental Research and Service	◎	◎	◎
Shinichi HANAWA	WWF Japan	◎	◎	◎
Shintoku KAMURA	Okinawa Environmental Research & Technology Center	◎	◎	◎
Taiji KUROZUMI	Natural History Museum and Institute, Chiba	◎	◎	◎
Takeharu KOSUGE	Okinawa Regional Research Center, Tokai University	◎	◎	
Tatsuo NAKAI	Department of Geography, Kokushikan University		◎	◎
Tohru NARUSE	Transdisciplinary Research Organization for Subtropics and Island Studies, University of the Ryukyus			◎
Toshihiko YONEZAWA	Kagoshima Environmental Research and Service	◎	◎	◎
Tsuyoshi SHIBATA	Naigai Map Co., Ltd.	◎	◎	
Yasuhiro KUBOTA	Faculty of Science, University of the Ryukyus			◎
Yoshihisa FUJITA	Marine Learning Center	◎	◎	◎
Yoshiko MACHIDA	WWF Japan	◎	◎	◎
Yukari HANDA	Amami Mammalogical Society		◎	
Yukari TOYOOKA	TBWA＼HAKUHODO			◎
Yutaka YAMAGISHI	Tim Tuelassa			◎
Yuya NAGABUCHI	TBWA＼HAKUHODO			◎
Yuya WATARI	Amami Amphibian Research Group		◎	

Titles omitted;in alphabetical order; affiliation at the time of the conferences included

Appendix B: List of Indicator species

(1) Mammals as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
1	ケナガネズミ	Ryukyu long-furred rat	*Diplothrix legata*
2	ヤンバルホオヒゲコウモリ	Yanbaru Myotis	*Myotis yanbarensis*
3	リュウキュウテングコウモリ	Ryukyu tube-nosed bat	*Murina ryukyuana*
4	リュウキュウユビナガコウモリ	East-Asian little bent-winged bat	*Miniopterus fuscus*
5	アマミトゲネズミ	Amami spiny rat	*Tokudaia osimensis*
6	アマミノクロウサギ	Amami Rabbit	*Pentalagus furnessi*
7	エラブオオコウモリ	Erabu flying fox	*Pteropus dasymallus dasymallus*
8	オリイジネズミ	Orii's shrew	*Crocidura orii*
9	イリオモテコキクガシラコウモリ	Iriomote little horseshoe bat	*Rhinolophus perditus imaizumii*
10	イリオモテヤマネコ	Iriomote cat	*Prionailurus iriomotensis* *Prionailurus bengalensis iriomotensis*
11	オキナワコキクガシラコウモリ	Okinawa little horseshoe bat	*Rhinolophus pumilus pumilus*
12	オキナワトゲネズミ	Okinawa spiny rat	*Tokudaia muenninki*
13	カグラコウモリ	Lesser leaf-nosed bat	*Hipposideros turpis*
14	ジュゴン	Dugong	*Dugong dugon*
15	ダイトウオオコウモリ	Daito flying fox	*Pteropus dasymallus daitoensis*
16	ヤエヤマコキクガシラコウモリ	Yaeyama little horseshoe bat	*Rhinolophus perditus perditus*
17	セスジネズミ	Striped field mouse	*Apodemus agrarius*
18	センカクモグラ	Senkaku mole	*Mogera uchidai*

(2) Birds as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
19	リュウキュウヨシゴイ	Cinnamon bittern	*Ixobrychus cinnamomeus*
20	ヤクシマカケス	Yakushima jay	*Garrulus glandarius orii*
21	リュウキュウクロアジサシ	Common noddy	*Anous stolidus pullus*
22	ヤクシマヤマガラ	Yakushima varied tit	*Parus varius yakushimensis*
23	リュウキュウコノハズク	Ryukyu scops owl	*Otus elegans elegans*
24	ムナグロ	Pacific golden plover	
25	アカヒゲ	Ryukyu robin	*Erithacus komadori komadori*
26	アマミヤマシギ	Amami woodcock	*Scolopax mira*
27	カラスバト	Japanese wood pigeon	*Columba janthina janthina*
28	クロツラヘラサギ	Black-faced spoonbill	*Platalea minor*
29	コアジサシ	Little tern	*Sterna albifrons sinensis*
30	チュウサギ	Intermediate egret	*Egretta intermedia intermedia*
31	ベニアジサシ	Roseate tern	*Sterna dougallii bangsi*
32	ミサゴ	Osprey	*Pandion haliaetus haliaetus*
33	ミフウズラ	Barred buttonquail	*Turnix suscitator*
34	エリグロアジサシ	Black-napped tern	*Sterna sumatrana*
35	オーストンオオアカゲラ	White-backed woodpecker	*Dendrocopos leucotos owstoni*
36	オオトラツグミ	White's thrush	*Zoothera dauma major*
37	ヘラサギ	Eurasian spoonbill	*Platalea leucorodia*
38	ルリカケス	Lidth's jay	*Garrulus lidthi*
39	アホウドリ	Short-tailed albatross	*Diomedea albatrus*
40	オリイコゲラ	Japanese pygmy woodpecker	*Dendrocopos kizuki orii*
41	オリイヤマガラ	Varied tit	*Parus varius olivaceus*
42	カワセミ	Indian small blue kingfisher	*Alcedo atthis bengalensis*
43	カンムリワシ	Crested serpent eagle	*Spilorinis cheela perplexus*
44	キンバト	Emerald dove	*Chalcophaps indica yamashinai*
45	シロチドリ	Kentish plover	*Charadrius alexandrinus*

ID	Japanese Common Name	English Common Name	Scientific Name
46	ダイトウカイツブリ	Borodino islands grebe	*Tachybaptus ruficollis kunikyonis*
47	ダイトウヒヨドリ	Borodino islands bulbul	*Hypsipetes amaurotis borodinonis*
48	ノグチゲラ	Okinawa woodpecker	*Sapheopipo noguchii*
49	ヤエヤマシロガシラ	Light-vented Bulbul	*Pycnonotus sinensis orii*
50	ヤンバルクイナ	Okinawa rail	*Gallirallus okinawae*
51	ヨナクニカラスバト	Japanese wood pigeon	*Columba janthina stejnegeri*
52	リュウキュウアカショウビン	Ruddy kingfisher	*Halcyon coromanda bangsi*
53	リュウキュウキビタキ	Narcissus flycatcher	*Ficedula narcissina owstoni*
54	ダイトウコノハズク	Daito scops owl	*Otus elegans interpositus*
55	ダイトウメジロ	Daito Japanese white-eye	*Zosterops japonicus daitoensis*
56	セグロアジサシ	Sooty tern	*Sterna fuscata nubilosa*
57	カツオドリ	Brown booby	*Sula leucogaster plotus*

(3) Amphibian & Reptile as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
58	ヤエヤマハラブチガエル	Yaeyama harpist frog	*Rana okinavana*
59	ミヤコヒキガエル	Miyako toad	*Bufo gargarizans miyakonis*
60	イシカワガエル	Ishikawa's frog	*Rana ishikawae*
61	イボイモリ	Anderson's crocodile newt	*Echinotriton andersoni*
62	アマミハナサキガエル	Amami tip-nosed frog	*Odorrana amamiensis*
63	オットンガエル	Otton frog	*Babina subaspera*
64	コガタハナサキガエル	Utsunomiya's frog	*Odorrana utsunomiyaorum*
65	ナミエガエル	Namie's frog	*Limnonectes namiyei*
66	ハナサキガエル	Ryukyu tip-nosed frog	*Odorrana narina*
67	ホルストガエル	Holst's frog	*Babina holsti*
68	アオスジトカゲ	Shanghai elegant skink	*Plestiodon elegans*
69	シュウダ	Chinese keeled ratsnake	*Elaphe carinata carinata*
70	ミヤラヒメヘビ	Miyara's dwarf snake	*Calamaria pavimentata miyarai*
71	アオウミガメ	Common green turtle	*Chelonia mydas*
72	アカウミガメ	Loggerhead turtle	*Caretta caretta*
73	タイマイ	Hawksbill turtle	*Eretmochelys imbricata*
74	バーバートカゲ	Barbour's blue-tailed skink	*Plestiodon barbouri*
75	オビトカゲモドキ	Banded eyelid gecko	*Goniurosaurus kuroiwae splendens*
76	タカラヤモリ	Takara gecko	*Gekko shibatai*
77	オキナワトカゲ複合種群北トカラ個体群	Northern Tokara populations of the Ryukyuc five-lined skink complex	*Plestiodon marginatus complex; northern Tokara populations*
78	イヘヤトカゲモドキ	Toyama's eyelid gecko	*Goniurosaurus kuroiwae toyamai*
79	キクザトサワヘビ	Kikuzato's stream snake	*Opisthotropis kikuzatoi*
80	クメトカゲモドキ	Yamashina's eyelid gecko	*Goniurosaurus kuroiwae yamashinae*
81	マダラトカゲモドキ	Mottled eyelid gecko	*Goniurosaurus kuroiwae orientalis*
82	ミヤコカナヘビ	Miyako grass lizard	*Takydromus toyamai*
83	ミヤコトカゲ	Coastal skink	*Emoia atrocostata atrocostata*
84	ミヤコヒバァ	Miyako keelback snake	*Amphiesma concelarum*
85	ミヤコヒメヘビ	Pfeffer's dwarf snake	*Calamaria pfefferi*
86	ヤエヤマセマルハコガメ	Yaeyama yellow margined box turtle	*Cuora flavomarginata evelynae*
87	ヨナグニキノボリトカゲ	Yonaguni tree lizard	*Japalura polygonata donan*
88	ヨナグニシュウダ	Yonaguni keeled ratsnake	*Elaphe carinata yonaguniensis*
89	リュウキュウ ヤマガメ	Ryukyu black-breasted leaf turtle	*Geoemyda japonica*

(4) Insects as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
90	アマミヘビトンボ	Dobson fly	*Protohermes immaculatus*
91	アマミクマバチ	Large carpenter bee	*Xylocopa amamensis*
92	ヤエヤマツダナナフシ	Stick insect	*Megacrania tsudai adan*
93	ヤエヤマヘビトンボ	Dobson fly	*Neochauliodes azumai*
94	リュウキュウルリモントンボ伊平屋島個体群	Damsel fly	*Coeliccia ryukyuensis ryukyuensis*
95	ナンザンミナミボタル	Fire fly	*Drilaster tenebrosus*
96	アカアシセジロクマバチ	Large carpenter bee	*Xylocopa albinotum*
97	センカククロトラカミキリ	Longhorn beetle	*Chlorophorus yakitai*
98	ダイトウウミコオロギ	Cricket	*Caconemobius daitoensis*
99	ツマグロゼミ　宮古島個体群	Cicada	*Nipponosemia terminalis*
100	イリオモテツノトンボ（仮称）	Owl fly	*Suhpalacsa iriomotensis*
101	ヤンバルヘビトンボ	Dobson fly	*Parachauliodes yanbaru*
102	オキナワクマバチ	Large carpenter bee	*Xylocopa flavifrons*
103	イシガキニイニイ	Cicada	*Platypleura albivannata*
104	イヘヤアカミナミボタル	Fire fly	*Drilaster akakanajai*
105	タテオビヒゲボタル伊平屋島亜種	Fire fly	*Stenocladius azumai iheyanus*
106	クメジマミナミボタル	Fire fly	*Drilaster kumejimensis*
107	タイワンツバメシジミ	Indian cupid	*Everes lacturnus rileyi*
108	タガメ	Giant water bug	*Lethocerus deyrolli*
109	ハマコオロギ(リュウキュウハマコオロギ)	Taiwan beach cricket	*Taiwanemobius ryukyuensis*
110	フチトリゲンゴロウ	Predacious diving beetle	*Cybister limbatus*
111	ハラビロハンミョウ	Tiger beetle	*Lophyridia angulata niponensis*
112	エサキタイコウチ	Water scorpion	*Laccotrephes maculatus*
113	オキナワミナミヤンマ	Dragon fly	*Chlorogomphus okinawensis*
114	クメジマボタル	Kumejima firefly	*Luciola owadai*
115	ダイトウヒメハルゼミ	Cicada	*Euterpnosia chibensis daitoensis*
116	タイワンタガメ	Giant water bug	*Lethocerus indicus*
117	タラマハヤシウマ（タラマオオハヤシウマ）	Camel cricket	*Diestrammena taramensis*
118	トゲアシアメンボ	Water strider	*Limnometra femorata*
119	ミヤコホラアナゴキブリ	Carvernicolous cockroach	*Nocticola uenoi miyakoensis*
120	アマミシリアゲ	Scorpion fly	*Panorpa amamiensis*
121	アサトカラスヤンマ	Dragon fly	*Chlorogomphus brunneus keramensis*
122	アマミトゲオトンボ	Damsel fly	*Rhipidolestes amamiensis*
123	ヒラタツユムシ（別名クサキリモドキ）	Green grasahopper	*Togona unicolor*
124	ヤンバルクロギリス（科の初記録）	Cave cricket	*Paterdecolyus yanbarensis*
125	コフキオオメトンボ	Dragon fly	*Zyxomma obtusum*

*Indicator species had been selected in more detail than the islands, therefore further 151 species were added.

(5) Fish as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
126	アカボウズハゼ	Belted rockclimbing goby	*Sicyopus zosterophorum*
127	アゴヒゲハゼ	Bearded goby	*Glossogobius bicirrhosus*
128	エソハゼ		*Schismatogobius roxasi*
129	カエルハゼ	Specklefin rockclimbing goby	*Sicyopus leprurus*
130	キバラヨシノボリ	Stream goby	*Rhinogobius* sp.
131	コンジキハゼ	Golden goby	*Glossogobius aureus*
132	コンテリボウズハゼ		*Stiphodon atropurpureus*
133	シマエソハゼ		*Schismatogobius ampluvinculus*
134	ジャノメハゼ	Four-eyed sleeper	*Bostrychus sinensis*
135	タイワンキンギョ	Paradise fish or Chinese fighting fish	*Macropodus opercularis*

ID	Japanese Common Name	English Common Name	Scientific Name
136	タウナギ	Swamp eel	*Monopterus albus*
137	タナゴモドキ	Tropical carp-gudgeon or Green prigi	*Hypseleotris cyprinoides*
138	タメトモハゼ	Mud gudgeon	*Ophieleotris* sp.
139	ツバサハゼ	Loach goby	*Rhyacichthys aspro*
140	トサカハゼ		*Cristatogobius lophius*
141	ドジョウ	Oriental weatherfish	*Misgurnus anguillicaudatus*
142	トビハゼ	Mudskipper	*Periophthalmus modestus*
143	ミナミアシシロハゼ		*Acanthogobius insularis*
144	メダカ	Medaka or Japanese rice fish	*Oryzias latipes*
145	ヤエヤマノコギリハゼ	Olive flathead-gudgeon	*Butis amboinensis*
146	ヨロイボウズハゼ		*Lentipes armatus*
147	ルリボウズハゼ	Red-tailed goby	*Sicyopterus lagocephalus*
148	リュウキュウアユ	Ryukyu ayu	*Plecoglossus altivelis ryukyuensis*
149	アオバラヨシノボリ	Common freshwater goby	*Rhinogobius* sp.
150	ウラウチフエダイ	Papuan black snapper	*Lutjanus goldiei*
151	オキナワキチヌ	Butter bream	*Acanthopagrus* sp.
152	ブナカ（カワアナゴ科の１種）	Green-backed gauvina	*Bunaka gyrinoides*
153	カワボラ（仮称）		*Cestraeus* sp.
154	キララハゼ	Spotted green goby	*Acentrogobius viridipunctatus*
155	クロトサカハゼ		*Cristatogobius nonatoae*
156	シミズシマイサキ	Terapontid fish	*Mesopristes iravi*
157	ゼブラアナゴ	Zebra garden eel	*Heteroconger polyzona*
158	ゴシキタメトモハゼ（従来のタメトモハゼ属の１種）	Mud gudgeon	*Ophieleotris* sp.
159	チンヨウジウオ	Pugheaded pipefish	*Bulbonaricus brauni*
160	テッポウウオ	Banded archerfish	*Toxotes jaculatrix*
161	トカゲハゼ	Walking goby, Bearded goby or Blue mud-hopper	*Scartelaos histophorus*
162	ドロクイ	Japanese gizzard shad	*Nematalosa japonica*
163	ナガレフウライボラ	Half fringelip mullet	*Crenimugil heterocheilos*
164	ナンヨウチヌ	Picnic seabream	*Acanthopagrus berda*
165	ニセシマイサキ	Silver grunter	*Mesopristes argenteus*
166	ハヤセボウズハゼ		*Stiphodon imperiorientis*
167	ヒメトサカハゼ		*Cristatogobius aurimaculatus*
168	フナ	Japanese silver crucian carp	*Carassius auratus langsdorfii*
169	ホクロハゼ	Tropical sand goby	*Acentrogobius caninus*
170	マイコハゼ	Blackstripe dartfish	*Parioglossus lineatus*
171	マサゴハゼ		*Pseudogobius masago*
172	ミスジハゼ	Bauchot’s goby	*Callogobius* sp.
173	ミナミヒメミミズハゼ（従来の琉球列島のミミズハゼ）		*Luciogobius* sp.
174	ヨコシマイサキ	Tairoid grunter	*Mesopristes cancellatus*
175	沖縄島のクサフグ	Grass puffer	*Takifugu niphobles*
176	ホシマダラハゼ	Northern mud gudgeon	

(6) Crustacean as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
178	ウリガーテナガエビ	Miyako troglobitic prawn	*Macrobrachium miyakoense*
179	オキナワオオサワガニ	Okinawa big freshwater crab	*Geothelphusa grandiovata*
180	ドウクツベンケイガニ	Bohol carvernicolous crab	*Karstarma boholano*
181	イヘヤオオサワガニ	Iheya big freshwater crab	*Geothelphusa iheya*
182	黒島のサワガニ	Kuroshima freshwater crab	*Geothelphusa* sp.
183	ドウクツモクズガニ	Yaeyama anchialine crab	*Orcovita miruku*
184	アマミマメコブシガニ	Amami brackish leucosiid crab	*Philyra taekoae*

ID	Japanese Common Name	English Common Name	Scientific Name
185	トカシキオオサワガニ	Tokashiki big freshwater crab	*Geothelphusa levicervix*
186	サカモトサワガニ	Sakamoto's freshwater crab	*Geothelphusa sakamotoana*
187	シオマネキ	East Asian fiddler crab	*Uca arcuata*
188	ツブテナガエビ	Rainbow freshwater prawn	*Macrobrachium gracilirostre*
189	ヤシガニ	Coconut crab / Robber crab	*Birgus latro*
190	イッテンコテナガエビ	Single-dotted brackishwater prawn	*Palaemon concinnus*
191	ヤクシマサワガニ	Yakushima freshwater crab	*Geothelphusa marmorata*
192	アシナガヌマエビ	Long-legged troglobitic shrimp	*Caridina rubella*
193	イシガキヌマエビ	Ishigaki freshwater shrimp	*Neocaridina ishigakiensis*
194	イボテカニダマシ	Rugged-chela porcellanid crab	*Novorostrum decorocrus*
195	オキナワアカシマホンヤドカリ	Red-striped hermit crab	*Pagurus pilosipes*
196	カッショクサワガニ	Iriomote freshwater crab	*Geothelphusa marginata fulva*
197	キノボリエビ	Semi-terrestrial hippolytid shrimp	*Merguia oligodon*
198	クメジマミナミサワガニ	Kumejima freshwater crab	*Candidiopotamon kumejimense*
199	シオカワヨコエビ	Brackishwater amphipod	*Paracalliope dichotomus*
200	ショキタテナガエビ	Shokita's freshwater prawn	*Macrobrachium shokitai*
201	センカクサワガニ	Senkaku freshwater crab	*Geothelphusa shokitai*
202	ヒメユリサワガニ	Long-legged freshwater crab	*Geothelphusa tenuimanus*
203	ミヤコサワガニ	Miyako freshwater crab	*Geothelphusa miyakoensis*
204	ムラサキサワガニ	Ishigaki freshwater crab	*Geothelphusa marginata marginata*
205	ヤエヤマヒメオカガニ	Polished dwarf land crab	*Epigrapsus politus*
206	ルリマダラシオマネキ	Lazuline fiddler crab	*Uca tetragonon*
207	アマミミナミサワガニ	Amami freshwater crab	*Candidiopotamon amamense*

(7) Shellfish as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
208	ハベマメシジミ	Freshwater pea mussel	*Pisidium (Pisidium)* sp.
209	ヤクスギイトカケノミギセル		*Hemizaptyx subtilis*
210	和名なし		*Psammotaea inflata*
211	マルタニシ	Mud snail or Chinese mystery snail	*Cipangopaludina chinensis laeta*
212	サメハダヘソアキアツマイマイ		*Nesiohelix omphalina omphalina*
213	ウラキヤマタカマイマイ		*Satsuma (Luchuhadra) hemihelvus*
214	ツキカガミ		*Phacosoma aspera*
215	クロズミアカグチカノコ		*Neritina* sp.
216	リュウキュウギセル		*Luchuphaedusa inclyta*
217	ヘソアキアツマイマイ		*Nesiohelix omphalina proximate*
218	シワツキガイ		*Eamesiella corrugata*
219	ウスイロバイ	Babylon shell	*Babylonia kirana*
220	オキナワドブシジミ		*Sphaerium okinawaense*
221	ヤコウガイ	Great green turban	*Turbo marmoratus*
222	アマミヤマタカマイマイ		*Satsuma (Luchuhadra) shigetai*
223	オキノエラブヤマタカマイマイ		*Satsuma (Luchuhadra) erabuana*
224	トクノシマヤマタカマイマイ		*Satsuma (Luchuhadra) tokunoshimana*
225	ヤエヤマヒルギシジミ		*Gelonina reosa*
226	オオズングリアゲマキ		*Azorinus scheepmakeri*
227	オキシジミ	Chinese cyclina or Chinese dosinia	*Cyclina sinensis*
228	オキナワムシオイ類似種		*Chamaricaeus* sp. *cf. okinawaensis*
229	クメジママイマイ		*Satsuma (Satsuma) mercatoria kumejimaensis*
230	サキシマヒシマイマイ		*Camaena (Miyakoia) sakishimana*
231	ジャングサマテガイ		*Solen soleneae*
232	スグカワニナ		*Stenomelania uniformis*

ID	Japanese Common Name	English Common Name	Scientific Name
233	ダンダラマテガイ		*Solen kurodai*
234	トゥドゥマリハマグリ		*Meretrix* sp.
235	ナズミガイ		*Cyllindrotis quadrasi*
236	ニシキコギセル		*Proreinia elegans*
237	ニッコウガイ	Striped tellin	*Tellinella virgata*
238	ヌバタママクラ	Furrowed horse mussel	*Modiolus aratus*
239	マテガイ	Gould's jackknife clam	*Solen strictus*
240	モモイロサギガイ		*Macoma nobilis*
241	アツマイマイ		*Nesiohelix solida*
242	アマノヤマタカマイマイ		*Satsuma (Luchuhadra) amanoi*
243	イヘヤヤマタカマイマイ		*Satsuma (Luchuhadra iheyaensis*
244	イトヒキツムガタノミギセル		*Pulchratyx longiplicata*
245	ウラジロヤマタカマイマイ		*Satsuma (Luchuhadra) sororcula*
246	オキナワギセル		*Stereophaedusa valida*
247	カザリクロヅケ		
248	クロマイマイ		*Euhadra tokarainsula*
249	コメツブダワラ		*Sinoennea densecostata*
250	サンゴウラウズ		*Astralium nakamineae*
251	センカクコギセル		*Euphaedusa senkakuensis*
252	トクネニヤダマシギセル		*Phaedusa neniopsis caudatus*
253	ナカノシマノミギセル		*Zaptyx nakanoshimana*
254	ナガヤマヤマツボ		*Allepithema nagayamai*
255	ハラブトギセル		*Stereophaedusa stereoma*
256	ヘリトリケマイマイ		*Aegista (Plectotropis) marginata*
257	ホシヤマビロウドマイマイ		*Yakuchloritis hoshiyamai*
258	マキミゾアマオブネ	Snake-skin nerite	*Nerita exuvia*
259	ミドリマイマイ		
260	ヤエヤマヤマタニシ		*Cyclophorus turgidus radians*
261	ユキタノミギセル		*Hemizaptyx yukitai*
262	ヨナクニゴマガイ		*Diplommatina yonakunijimana*

(8) Marine plants & algae as indicator species

ID	Japanese Common Name	English Common Name	Scientific Name
263	ウミヒルモ	Spoon seagrass	*Halophila ovalis*
264	リュウキュウアマモ	Serrated ribbon seagrass	*Cymodocea serrulaa*
265	リュウキュウスガモ	Sickle seagrass	*Thalassia hemprichii*
266	カワツルモ	Widgeon grass	*Ruppia maritime*
267	コアマモ	Dwarf eelgrass	*Zostera japonica*
268	イソモッカ		*Catenella caespitosa syn. C.*
269	イトゲノマユハキモ		*Chlorodesmis caespitosa*
270	ウスガサネ		*Cymopolia vanbosseae*
271	ウミトラノオ		*Sargassum thunbergii*
272	オオネダシグサ		*Rhizoclonium grande*
273	カサノリ		*Acetabularia ryukyuensis*
274	コテングノハウチワ		*Avrainvillea obscura (C. Agardh) (syn. Avrainvillea erecta)*
275	コバモク	Rough-stemmed sargassum	*Sargassum polycystum*
276	タニコケモドキ		*Bostrychia simpliciuscula Harvey (syn. B. andoi)*
277	タンポヤリ		*Chamaedoris orientalis*
278	チョウチンミドロ		*Dichotomosiphon tuberosus*
279	ツクシホウズキ		*Acrocystis nana*
280	ハイコナハダ		*Yamadaella caenomyce (Decaisne) (syn. Liagora caenomyce)*

ID	Japanese Common Name	English Common Name	Scientific Name
281	ハナヤナギ		*Chondria armata*
282	ヒジキ		*Sargassum fusiformis (syn. Hizikia fusiformis)*
283	ウミトラノオ		*Sargassum thunbergii*
284	ヒロハサボテングサ		*Halimeda macroloba*
285	フクロフノリ		*Gloiopeltis furcata*
286	ベニモズク		*Helminthocladia australis* *(syn. H. macrocephala* シマベニモズク *)*
287	ホソアヤギヌ		*Caloglossa ogasawaraensis*
288	ホソバロニア		*Valoniopsis pachynema*
289	マガタマモ	Bubble green seaweed	*Boergesenia forbesii (syn. Valonia forbesii Harvey)*
290	ヤバネモク	Wedgeshaped chainweed	*Hormophysa cuneiformis (Gmelin)* *Silva (syn. Cystoseira prolifera)*
291	リュウキュウオゴノリ	Prostrate gracilaria	*Gracilaria eucheumoides*
292	タカノハヅタ		*Caulerpa sertularioides f. longipes*
293	ハゴロモ		*Udotea orientalis*

Appendix C: List of Members and Cooperators of Nansei Islands Wide Area Overall Research Team

Name	Affiliations
Akiyuki IRIKAWA	Association for Kerama Coral Reef Conservation
Eiji YAMAKAWA	Okinawa Environmental Research & Technology Center
Hiroya YAMANO (sub-leader)	Satellite Remote Sensing Research Section, Center for Global Environmental Research, National Institute for Environmental Studies
Katsuki OKI (main person in charge of Amami Islands)	Tida Planning
Kazuhiko SAKAI (leader)	Tropical Biosphere Research Center, University of the Ryukyus, Sesoko Lab.
Kazuo NADAOKA (advisor)	Graduate School, Tokyo Institute of Technology
Ken OKAJI	Coral Quest Inc.
Kenji KAJIWARA (main person in charge of Miyako Islands)	Miyako station, National Center for Stock Enhancement
Mariko ABE	Okinawa Reef Check and Research Group
Masahiko FUJII	Hokkaido University
Masahiro NAKAOKA (advisor)	Akkesi Marine Station, Field Science Center for Northern Biosphere, Hokkaido University
Minoru YOSHIDA (main person in charge of Yaeyama Islands)	Kaiyu Ltd.
Moritaka NISHIHIRA (advisor)	Meio University
Naoki KAMEZAKI	Sea Turtle Association of Japan
Rintaro SUZUKI	Institute for Applied Geography, Komazawa University
Ryo IGUCHI	Graduate School of Engineering and Science, University of the Ryukyus
Shigeki YASUMURA	Conservation Division, WWF Japan
Tadashi KIMURA	Japan Wildlife Research Center
Takanori SATO	Ishigaki Ranger Office, Naha Nature Conservation Office, Ministry of the Environment
Takeshi MATSUMOTO (main person in charge of Osumi Islands)	YNAC Yakushima Nature Activity Center
Tomofumi NAGATA (main person in charge of Okinawa Islands)	Okinawa Environmental Research & Technology Center
Tomoyo KOBAYASHI	International Coral Reef Research and Monitoring Center, Ministry of the Environment
Tsuyoshi SHIBATA	Naigai Map Co., Ltd.
Yoko NOZAWA	Biological Institute on Kuroshio

Titles omitted; in alphabetical order; affiliation at the time of the research included

Appendix D-1. The generation of basic GIS data

Tsuyoshi SHIBATA (Aero Photo Center Co.)

1. Implementation

GIS data was generated for A) and B) below. The generation of GIS data made editing, aggregation, and analyses possible for raw data.

A) TPA data generation

TPA data was generated for eight taxa: mammals, birds, amphibians/reptiles, insects, fish, crustaceans, mollusks, and seagrasses/algae.

B) Catchment data generation

Catchment data was generated via topographical analysis.

2. Processes (TPA's)

2-0. Applications and equipment used

The applications used in data generation were ArcView 9.2, which is a general GIS software application, and PC-Mapping ver. 7. The file format used was ShapeFile. A CS500-11/EN/PRO (GRAPHTECH) was used to read the graphic data.

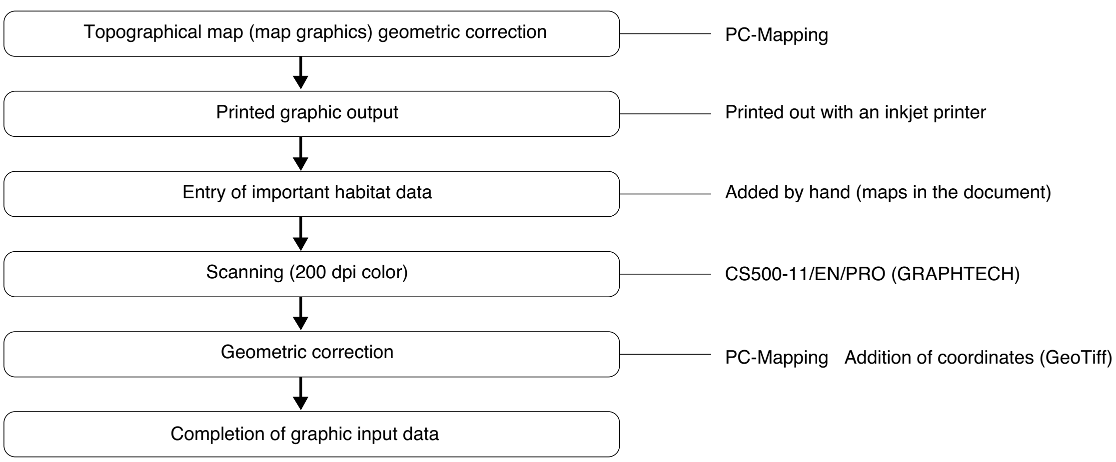
2-1. The generation of input image data (maps in the document)

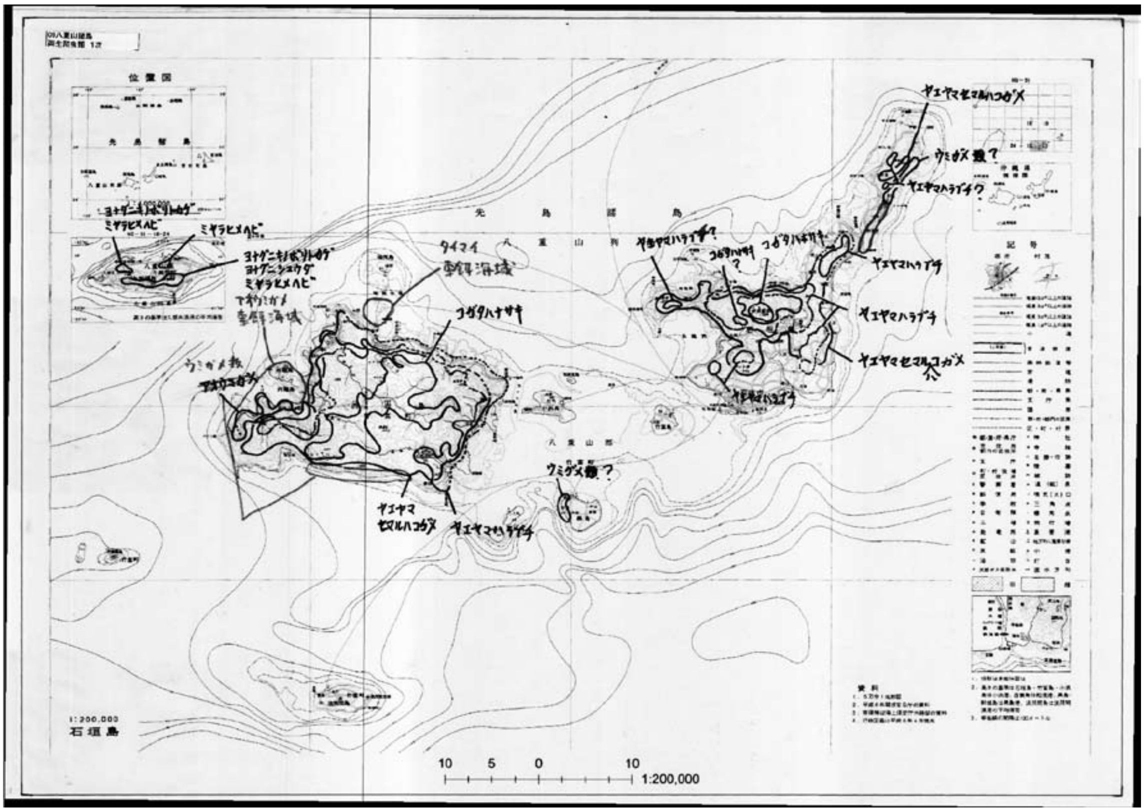
The selection of background maps for input should ideally be based on the scope of areas surveyed and data obtained, but because this project involved the generation of maps covering an extremely broad area, namely the entirety of the Nansei Islands, the decision was made to employ the 200,000:1 scale topographical maps (map graphics) provided by the Geographical Survey Institute as scanned background map data.

Important habitat data was entered into this map data, resulting in the input image data (maps in the document).

The processes followed are as follows.

Likewise, the input image data (maps in the document) for the TPA of the eight taxa was generated.





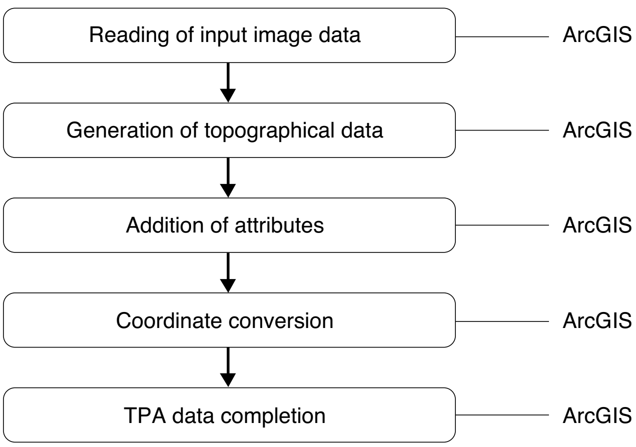
Since we are using the 200,000:1 scale topographical maps (map graphics) provided by the Geographical Survey Institute, the coordinate system employed is the Japanese Geodetic Datum. This coordinate system was converted to the global standard (JGD2000) when TPA data was generated

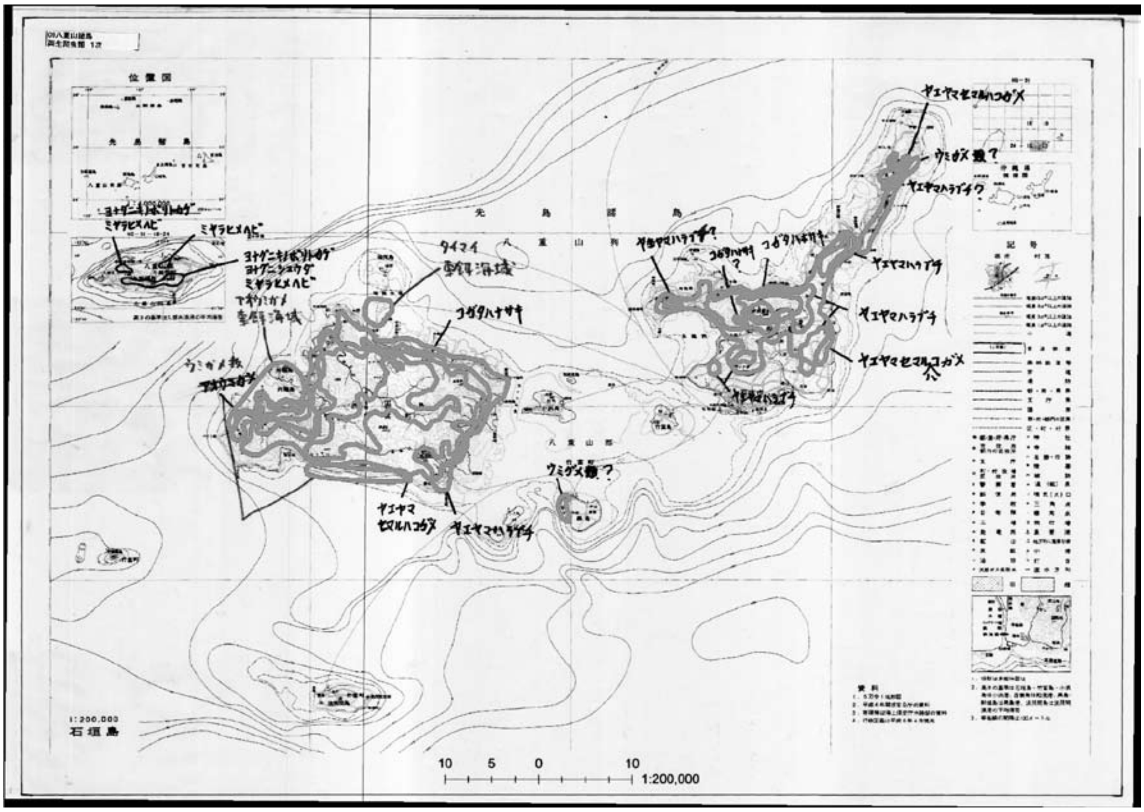
2-3. Data entry and editing

Data generation involved reading of input manuscript data, tracing TPA boundaries, and creating polygons. The data had seven attributes: ID, name, selection reason, basis for inclusion, permission to publicize, indicator species, and other considerations.

The processes performed are shown below.

Seven types of corresponding data (polygons) were also created.





Data input example (attribute table)

ID	Name	Selection reason	Basis for inclusion	Permission to publicize	Indicator species	Other considerations
132	Ishigaki Island northeast region	＊＊＊＊	＊＊＊＊	Not permitted	＊＊＊＊	Cannot be publicized due to the need to protect rare species

3. Processes (Catchment area data)

3-0. Applications and equipment used

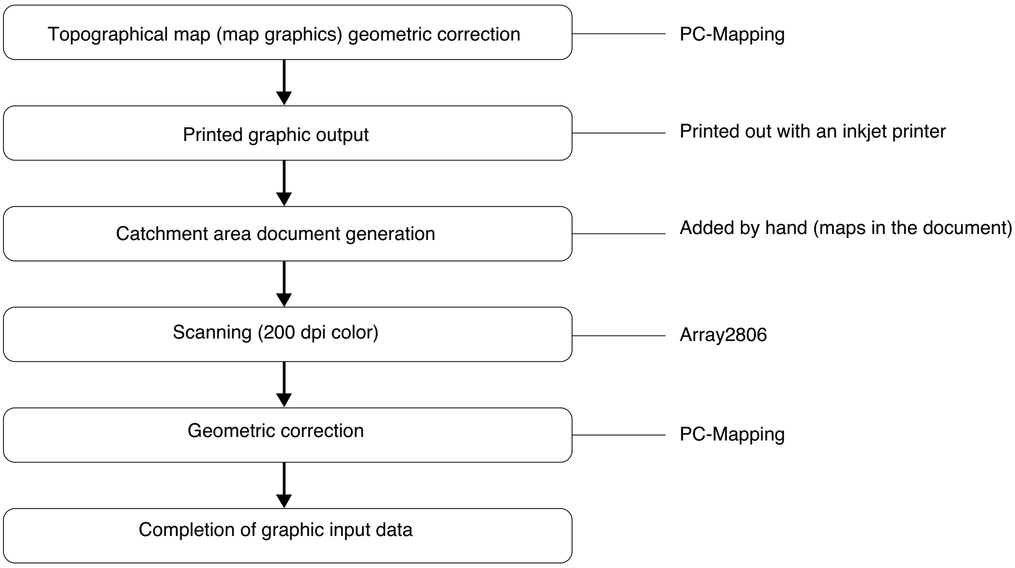
The applications used in data generation were ArcView 9.2, which is a general GIS software application, and PC-Mapping ver. 7. The file format used was ShapeFile. A CCD Scanner Array 2806 was used to read the graphic data.

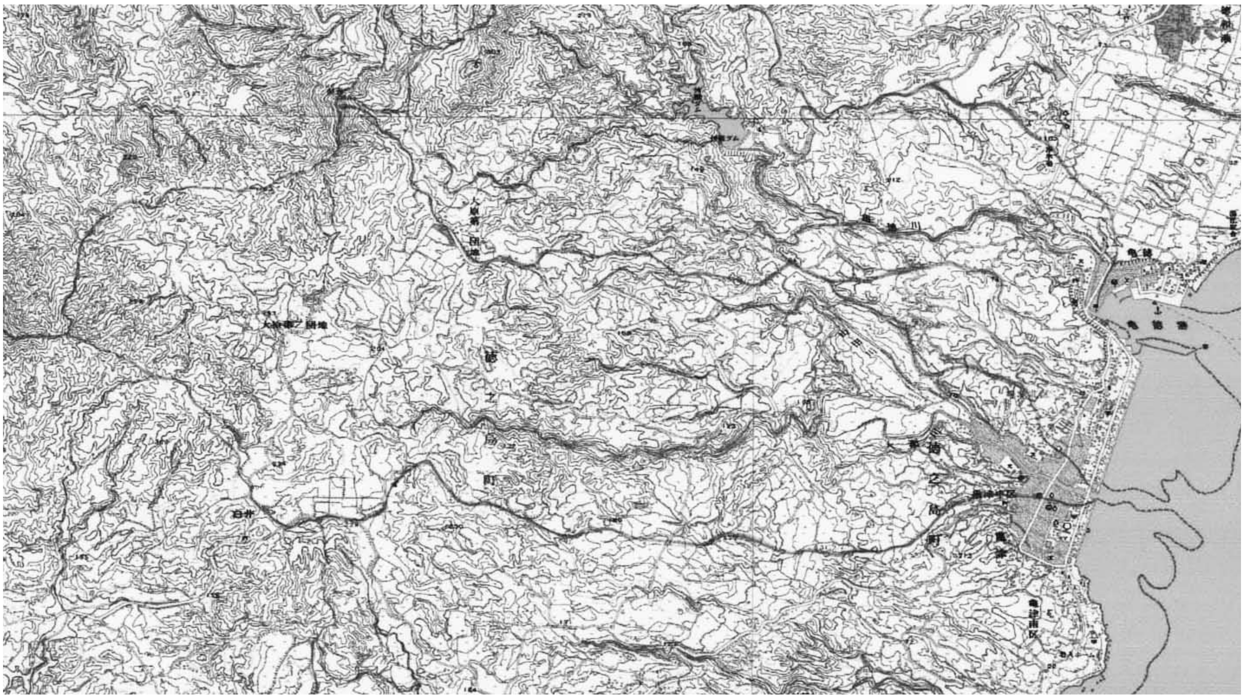
3-1. The generation of input image data

Because the catchment areas are largely dependent upon topographical features, in many cases they do not correspond to shapes automatically generated by Digital Elevation Model (DEM) data. For this reason, maps in the document were generated from the shapes of contour lines.

For maps generated for the document the mapping features of Digital Map 25000 provided by the Geographical Survey Institute were used.

The processes performed are shown below.



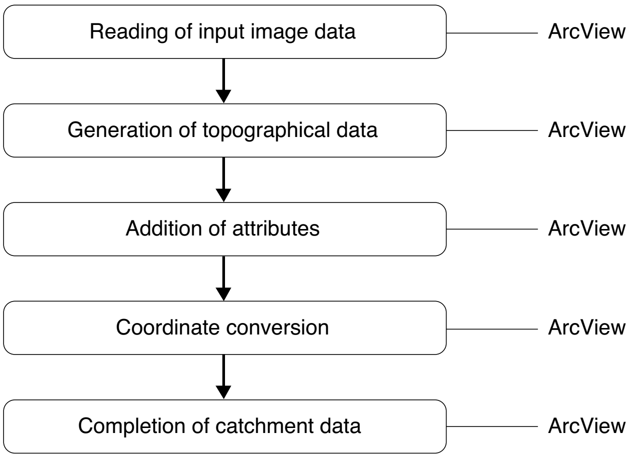


Green lines depict the boundaries of the catchment area based on topographical analysis. For better efficiency, lines depicting rivers (valleys) are also indicated.

3-3. Data entry and editing

Data generation involved reading of input manuscript data, tracing catchment boundaries, and creating polygons.

The processes performed are shown below.



4. List of data generated

Datasets generated are as follows:

TPA:

mammals.shp, birds.shp, amphibians_reptiles.shp, insects.shp, fish.shp, crustaceans.shp, mollusks.shp, seagrass_algae.shp

Water catchments:

catchments.shp

The file format is ShapeFile. The coordinate system is the global standard (JGD2000).

Appendix D-2. Report on the GIS analysis to identify Biodiversity Priority Area

Shimazaki, Hiroto (National Institute for Environmental Studies)

1. About this report

This is a final report on the GIS analysis task “Identification of Biodiversity Priority Area,” which was carried out under the contract between the WWF Japan and Hiroto Shimazaki, in the framework of “Biodiversity Evaluation Project in the Nansei Islands Ecoregion.”

2. An overview of the task

The task was divided into the following six sub-tasks:

Error correction of spatial data: Map projection was properly re-defined for each of the spatial data; and the geometrical and topological errors were checked and corrected if needed.

Summary of TPAs and ECHs by areal unit: Using basin and PGU as areal units for land and marine areas respectively, the number and combination of spatially coexistent categories of TPAs and ECHs were summarized at each areal unit.

Summary of overlapping TPAs: Overlaying the TPAs for different taxa, the number and combination of spatially coexistent categories of TPAs were summarized at each of the overlapping areas.

Identification of BPAs: BPAs were identified based on the results from sub-tasks II and III.

Areal summary of nature reserves and national forests by BPAs: Areas of the nature reserves and national forests which were contained within BPAs were calculated.

Map preparation for the review meeting in Okinawa, and others: Several maps were prepared to help correct errors in TPAs and support finalizing the BPA definition. A small scale (1:200,000) map layout was also designed as a tentative output of BPA map product.

3. Methodology

This section describes methodologies for sub-tasks from II to V. Methodologies for the others were described elsewhere (see, Kani-houkoku-syo).

3-1. Software and spatial data

ESRI ArcGIS Ver.9.3 and R Ver.2.7.2 were used for processing and visualizing spatial data. The ESRI Shapefile or simply a Shapefile, which is the most commonly used spatial data format, was employed to store geometry and attribute data. A Shapefile consists of a main file (.shp), an index file (.shx), and a dBASE file (.dbf). For example, the Shapefile "Japan" would have the following three files:

Japan.shp

Japan.shx

Japan.dbf

The main file, index file, and dBASE file must all have the same prefix. The prefix must start with an alphanumeric character and can contain any alphanumeric, underscore (_), or hyphen (-). This report puts parentheses "[ ]" around a prefix to indicate a specific spatial data in the form of Shapefile (e.g. [Japan]). A file extension and a dot are also put in the parentheses together with a prefix when willing to indicate a specific file (e.g. [Japan.dbf]).

3-2. Sub-task II: Summary of TPAs and ECHs by areal unit

Using basin and PGU as areal units for land and marine areas respectively, the number and combination of spatially co-existent categories of TPAs and ECHs were summarized at each of the areal units. Specific steps are described as follows, separately for land and marine areas.

3-2-1. Summary of TPAs and ECHs by basin polygons

(1) Overlay operation of polygons for basins, TPAs and ECHs

A set of thirteen spatial data listed in Table 1 were overlaid using "Union" function of ArcGIS and, this yielded a new spatial data named [WS_Union]. Among the various attributes stored in the thirteen input data (Table 1), only the FIDs were inherited by the new data through this operation. Here, FID is a set of sequential identification numbers assigned automatically to the features in each Shapefile. A FID value is always non negative integer. A relationship between overlapping features and their FIDs is exemplified in Fig.1.

Table 1. Thirteen input data sets used in summary operation with basin polygons.

Level I	Level II	Level III	Spatial data name
Areal unit		Basin	[Watershed]
Data to be summarized	TPA	Mammalia	[01_Mammalia_ver04_t]
		Aves	[02_Aves_ver03]
		Amphibia and Reptile	[03_Amphibia_Reptile_ver04_t]
		Insecta	[04_Insecta_ver05]
		Pisces	[05_Pisces_ver02]
		Crustacea	[06_Crustacea_ver02]
		Mollusks	[07_Mollusks_ver02]
		Seagrass and Seaweed	[08_Seagrass_Seaweed_ver02]
	ECH	Natural vegetation in *Fagetea Crenatae* regions	[veg04]
		Natural vegetation in *Camellietea japonicae* regions	[veg06]
		Secondary vegetation in *Camellietea japonicae* regions	[veg07]
		Riverbank, moor, salty marshland and dune vegetation	[veg08]

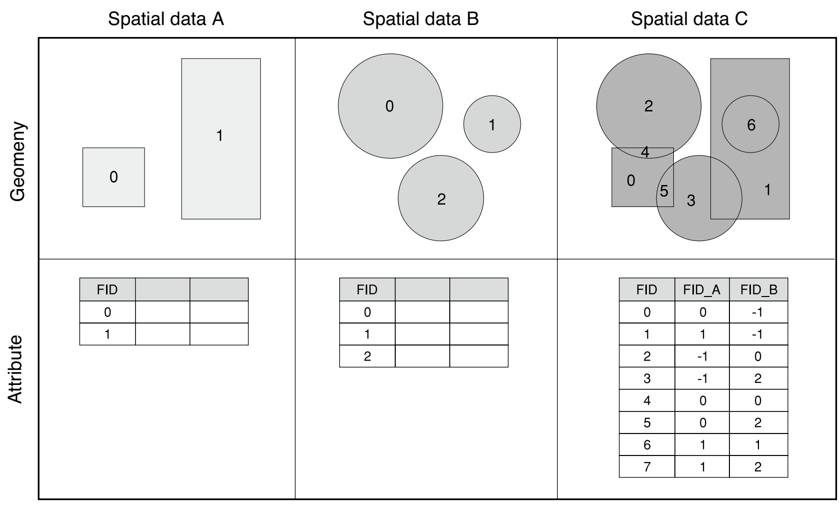


Fig.1. A relationship between overlapping features and their FIDs. This illustrates how FIDs of spatial data A and B will be inherited by spatila data C through "Union" operation. The attribute table for spatial data C contains three colums: FID, FID_A and FID_B. The coulmn FID stores FID values for spatial data C. The columns FID_A and FID_B store the FID values inherited from spatial data A and B respectively. In spatial data C, the features (or records) having negative value in the column FID_B correspond to the areas where spatial data B didn' t exist.

(2) Summary of the overlaid data

The number and combination of spatially co-existent categories of TPAs and ECHs were summarized at each areal unit, based on WSID and FIDs recorded in attribute data [WS_Union.dbf]. Here, WSID is an identification number assigned to each of the basin polygons and, its value was defined by adding 1 to FID value of [Watershed]. A column of WSID was added to [WS_Union.dbf] before executing summary operation.

Adding the WSID column to [WS_Union.dbf] and performing the subsequent summary operation were done using a R script [R_final_Terrestrial_summary_by_zone.R]. Results of the summary operation were written in a Tab-separated text file [Terrestrial_summary_by_zone.txt].

[Terrestrial_summary_by_zone.txt] contains fourteen columns. In the order from left to right, the first column stores WSID values without duplication. From the second column to the thirteenth column, binary outputs (1 or 0) are stored to indicate whether each of the eight TPA categories and four ECH categories coexists within each of the basin polygons. The last fourteenth column stores the number of TPA and ECH categories coexisting within each of the basin polygons. The number of categories corresponds to the summation of binary outputs over from the second column to the thirteenth column at each record.

(3) Table Join, Export, and Removing temporary data

The summary results recorded in [Terrestrial_summary_by_zone.txt] were added to [Watershed], using "Table Join" function of ArcGIS, where WSID was used as the primary key. After having attribute fields of [Watershed] invisible except those for summary results, [Watershed] was replicated and saved as a new spatial data named [Terrestrial_summary_by_zone], using "Export" function of ArcGIS. Finally, a series of temporary data were removed.

3-2-2. Summary of TPAs and ECHs by PGU polygons

(1) Modification of PGU data

The PGU data prepared before the review meeting in Okinawa was replicated and saved as new spatial data named [PGU_v03] and [PGU_v03a]. According to the request from the person who was in charge of PGU definition, several PGU polygons in [PGU_v03a] were spatially aggregated using "Dissolve" function of ArcGIS. PGUIDs for aggregated polygon features were shown in Table 2. As a result of this operation, several PGUIDs (={2417,2449,2450,2473,2471}) dropped out from [PGU_v03a] and, two spatial data [PGU_v03] and [PGU_v03a] became inconsistent in terms of PGUID. Here, PGUID is an identification number assigned to each of the PGU polygons and, its value was defined by adding 1 to FID value of [PGU_v03]. Note that the PGUID is not a set of sequential numbers.

Table 2. PGUIDs for aggregated features

	Before aggregation	After aggregation
PGUIDs	2416, 2417	2146
	2449, 2450, 2328, 2473, 2471	2328

In the same way, the PGU data prepared after the review meeting in Okinawa was replicated and saved as new spatial data named [PGU_v04] and [PGU_v04a]. [PGU_v04a] was a spatially aggregated version of [PGU_v04], where the aggregation rule was same as that for [PGU_v03]. The main difference between [PGU_v03a] and [PGU_v04a] was in their geometry, i.e., while the ocean-side boundaries of [PGU_v04a] were drawn based on geomorphological boundaries such as reef edge, those of [PGU_v03a] were arbitrarily shifted to the ocean side so that PGU polygons could cover the reef slope features which were incorrectly georeferenced for a visualization purpose. In fact, several reef slope features were out of the range of [PGU_v04a]. Hence [PGU_v03a] was used as a set of areal unit polygons only when summarizing the reef slope features. [PGU_v04a] was used as a set of areal unit polygons to summarize other TPA and ECH features.

(2) Consistency assessment of PGU data

In order to use [PGU_v03a] in combination with [PGU_v04a] when performing a summary operation, both of them had to be consistent in terms of PGUID. Hence before performing the summary operation, the consistency of [PGU_v03a] and [PGU_v04a] was assessed using a R script [R_final_PGU_check.R] and, the errors detected through the assessment was modified manually using ArcGIS.

(3) Overlay operation of polygons for PGU, TPAs and ECHs

A set of fourteen spatial data listed in Table 3 were overlaid using "Union" function of ArcGIS. More properly, by overlaying [PGU_v03a], [Reef_slope_steep] and [Reef_slope_gentle], a new spatial data named [PGU_v03a_Union] was generated. In the same way, by overlaying [PGU_v04a], TPA features and ECH features except the reef slope features, a new spatial data named [PGU_v04a_Union] was obtained. Among the various attributes stored in the input data (Table 3), only the FIDs were inherited by the new data through the Union operation.

(4) Summary of the overlaid data

The number and combination of spatially co-existent categories of TPAs and ECHs were summarized at each areal unit, based on PGUID and FIDs recorded in spatial data [PGU_v03a] and [PGU_v04a] and attribute data [PGU_v03a_Union.dbf] and [PGU_v04a_Union.dbf]. Since [PGU_v03a_Union.dbf] and [PGU_v04a_Union.dbf] didn't contain PGUID columns, a column of PGUID was added to each of them before executing summary operation.

Adding the PGUID columns and performing the subsequent summary operation were done using a R script [R_final_Marine_summary_by_zone.R]. Results of the summary operation were written in a Tab-separated text file [Marine_summary_by_zone.txt].

[Marine_summary_by_zone.txt] contains thirteen columns. In the order from left to right, the first column stores PGUID values without duplication. From the second column to the twelfth column, binary outputs (1 or 0) are stored to indicate whether each of the seven TPA categories and four ECH categories coexists within each of the PGU polygons. The last thirteenth column stores the number of TPA and ECH categories coexisting within each of the PGU polygons. The number of categories corresponds to the summation of binary outputs over from the second column to the twelfth column at each record.

(5) Table Join, Export, and Removing temporary data

The summary results recorded in [Marine_summary_by_zone.txt] were added to [PGU_v04a], using "Table Join" function of ArcGIS, where PGUID was used as the primary key. After having attribute fields of [PGU_v04a] invisible except those for summary results, [PGU_v04a] was replicated and saved as a new spatial data named [Marine_summary_by_zone], using "Export" function of ArcGIS. Finally, a series of temporary data were removed.

Table 3. Fourteen input data sets used in summary operation with PGU polygons

Level I	Level II	Level III	Spatial data name
Areal unit		PGU	[PGU_v03a] [PGU_v04a]
Data to be summarized	TPA	Mammalia	[01_Mammalia_ver04_o]
		Aves	[02_Aves_ver03]
		Amphibia and Reptile	[03_Amphibia_Reptile_ver04_o]
		Pisces	[05_Pisces_ver02]
		Crustacea	[06_Crustacea_ver02]
		Mollusks	[07_Mollusks_ver02]
		Seagrass and Seaweed	[08_Seagrass_Seaweed_ver02]
		Mangrove	[Mangrove]
	EDH	Lagoon	[Lagoon]
		Reef sploe	[Reef_slope_gentle] [Reef_slope_steep]
		Natural coast	[Natural_coast]

3-3. Sub-task III: Summary of overlapping TPAs

Overlaying the TPAs for eight different taxa, the number and combination of spatially coexistent categories of TPAs were summarized at each of the overlapping areas on land. Specific steps are described as follows.

(1) Dissolve operation of polygons for TPAs

Spatial data listed in Table 4 were corresponding to TPAs of eight different taxa. Each of them stored the priority area polygons of various species, allowing the polygon features to be overlapped. However, when summarizing overlapping TPAs, the difference in species and overlapping features were of redundancy. Hence, "Dissolve" function of ArcGIS was used to merge multiple polygon features into a single polygon feature for each TPA.

Table 4. Spatial data of TPAs for eight different taxa.

Taxon category	Spatial data name	
	Before dissolve operation	After dissolve operation
Mammalia	[01_Mammalia_ver04]	[01_Mammalia_ver04_Dissolve]
Aves	[02_Aves_ver03]	[02_Aves_ver03_Dissolve]
Amphibia and Reptile	[03_Amphibia_Reptile_ver04]	[03_Amphibia_Reptile_ver04_Dissolve]
Insecta	[04_Insecta_ver05]	[04_Insecta_ver05_Dissolve]
Pisces	[05_Pisces_ver02]	[05_Pisces_ver02_Dissolve]
Crustacea	[06_Crustacea_ver02]	[06_Crustacea_ver02_Dissolve]
Mollusks	[07_Mollusks_ver02]	[07_Mollusks_ver02_Dissolve]
Seagrass and Seaweed	[08_Seagrass_Seaweed_ver02]	[08_Seagrass_Seaweed_ver02_Dissolve]

(2) Overlay operation of dissolved TPAs

[Watershed] and eight dissolved TPAs listed in Table 4 were overlaid using "Union" function of ArcGIS and, this yielded a new spatial data named [TPA_Union]. Among the various attributes stored in the nine input data, only the FIDs were inherited by the new data through this operation.

(3) Removing unnecessary features

Among various features stored in [TPA_Union], the features having non-negative integer values in the column of FID values inherited from [Watershed] were selectively replicated and saved as a new spatial data named [TPA_Union2], using "Export" function of ArcGIS.

(4) Summary of the overlaid data

The number and combination of spatially coexistent categories of TPAs were summarized at each of the overlapping areas, based on FIDs stored in attribute data [TPA_Union2.dbf]. The summary operation was performed using a R script [R_final_Terrestrial_summary_by_overlay.R]. Results of the summary operation were written directly in [TPA_Union2.dbf].

After having attribute fields of [TPA_Union2] invisible except those for summary results, [TPA_Union2] was replicated and saved as a new spatial data named [Terrestrial_summary_by_overlay], using "Export" function of ArcGIS.

Attribute data of [Terrestrial_summary_by_overlay] contains nine columns. In the order from left to right, the first eight columns store binary outputs (1 or 0), which are indicating whether each of the eight TPA categories coexists within each of the overlapping areas. The last ninth column stores the number of TPA categories coexisting within each of the overlapping areas. The number of categories corresponds to the summation of binary outputs over from the first column to the eighth column at each record.

3-4. Sub-task IV: Identification of BPAs

BPAs for land and marine areas were identified based on the results from sub-tasks II and III. Among the IAs distributed over the land areas of Nansei Islands, especially important IAs were selected as land BPAs, so that the 30% of the total area of IAs should be covered with BPAs. Relative importance of each IA was evaluated based on the "Count" value recorded in [Terrestrial_summary_by_zone] and [Terrestrial_summary_by_overlay]. Here, the "Count" value was the number of TPA and ECH categories coexisting at a specific area. In the same way, among the IAs distributed over the PGU areas of Nansei Islands, especially important IAs were selected as marine BPAs, so that the 30% of the total area of IAs should be covered with BPAs. Relative importance of each IA was evaluated based on the "Count" value recorded in [Marine_summary_by_zone]. Requirements for land and marine BPAs were described in Table 5. The following part of this sub-section explains more specific steps of BPA identification.

Table 5. Requirements for BPAs.

Type	Requirements
Land	Let BPA(i), (i= 1, … , k), represent a land BPAs for the i-th sub-region sampled from a set of k sub-regions of Nansei Islands. Considering that the land BPAs for whole of the Nansei Islands is equivalent to the summation of BPA(i) over all the sub-regions, the area of land BPAs is identified as follows: 1. Let IA(i), (i= 1, … , k), represent a land IA for the i-th sub-region sampled from a set of k sub-regions of Nansei Islands. Define IA(i) as the area covered by the polygon features of which "Count" value obtained from [Terrestrial_summary_by_overlay], denoted by m, is greater than or equal to 1. 2. Define BPA1(i) as the area covered by the polygon features of which "Count" value m is greater than or equal to M(i), where the M(i) is the minimum among a set of positive integers which satisfy the condition of BPA1(i)/IA(i) < 0.3. 3. Define BPA2(i) as the area covered by the polygon features of which "Count" value m is greater than or equal to 1 and also "Count" value obtained from [Terrestrial_summary_by_zone], denoted by n, is greater than or equal to N(i), where the N(i) is the maximum among a set of positive integers which satisfy the condition of BPA(i)/IA(i) ≥ 0.3; and the BPA(i) is defined as the union of BPA1(i) and BPA2(i). 4. Repeat the steps from 1 to 3 for the two cases: (1) it is considered that whole of the Nansei Islands is one sub-region (k = 1); and (2) it is considered that whole of the Nansei Islands consists of 13 sub-region (k = 13). 5. Finally, define the land BPAs as the union of the land BPAs derived from cases 1 and 2.
Marine	Considering that whole of the Nansei Islands is one sub-region, the area of marine BPAs is identified as follows: 1. Let IA represent the area of marine IA. Define IA as the area covered by the polygon features of which "Count" value obtained from [Marine_summary_by_zone], denoted by u, is greater than or equal to 1. 2. Let BPA represent the area of marine BPA. Define BPA as the area covered by the polygon features of which "Count" value u is greater than or equal to U, where the U is the maximum among a set of positive integers which satisfy the condition of BPA/IA ≥ 0.3.

3-4-1. Identification of land BPAs

(1) Overlay operation, Arranging attribute data, and Calculation of area

[Terrestrial_summary_by_overlay] and [Terrestrial_summary_by_zone] were overlaid using "Union" function of ArcGIS and, this yielded a new spatial data named [Terrestrial_summary_Union]. Among the attribute data of the new spatial data, only the "Count" values inherited from [Terrestrial_summary_by_overlay] and [Terrestrial_summary_by_zone] were kept in the attribute table [Terrestrial_summary_Union.dbf] and the others were all removed. Then area of each polygon feature was calculated in the unit of square meters and was stored in the Area column of [Terrestrial_summary_Union.dbf].

(2) Spatial Join

Attribute tables of [region13] and [Terrestrial_summary_Union] were spatially joined using "Spatial Join" function of ArcGIS and, this yielded a new spatial data named [BPA_T_v04]. [region13] was a spatial data representing the extents of sub-regions of the Nansei Islands. The sub-regions were distinguished by arbitrary assigned identification number, region ID (RID), which were stored in the attribute table of [region13]. All the attribute data of [region13] and [Terrestrial_summary_Union] were inherited by [BPA_T_v04] through the

"Spatial Join" operation.

(3) Identification of land BPAs

Land BPAs were identified using a R script [R_final_Terrestrial_BPA_selection.R], based on the attribute data stored in [BPA_T_v04.dbf], i.e., the "Count" values inherited from [Terrestrial_summary_by_overlay] and [Terrestrial_summary_by_zone], RID values, and area of each polygon feature. The identification results were written directly to the newly created five columns in the attribute data [BPA_T_v04.dbf]. In the order from left to right, the first column of the five columns stores a binary output (1 or 0), which indicates whether each polygon feature satisfies the requirement for land IA. Subsequent three columns store binary outputs (1 or 0), which indicate whether each polygon feature satisfies the requirement for land BPA when dividing the Nansei Islands into one, four and thirteen sub-regions, respectively. The last fifth column stores a binary output (1 or 0), which indicates whether each polygon feature satisfies the requirement for land BPA described in Table 5.

3-4-2. Identification of marine BPAs

(1) Calculation of area

Area of each PGU polygon was calculated in the unit of square meters and was stored in the Area column of [Marine_summary_by_zone.dbf].

(2) Spatial Join and Arranging attribute data

Although the Nansei Islands was not necessarily divided into sub-regions in identifying marine BPAs, for a comparison purpose, attribute tables of [region13] and [Marine_summary_by_zone] were spatially joined using "Spatial Join" function of ArcGIS and, this yielded a new spatial data named [BPA_M_v04]. All the attribute data of [region13] and [Marine_summary_by_zone] were inherited by [BPA_M_v04] through the "Spatial Join" operation. Then, the columns unnecessary for marine BPA identification were removed from the attribute data of [BPA_M_v04].

(3) Identification of marine BPAs

Marine BPAs were identified using a R script [R_final_Marine_BPA_selection.R], based on the attribute data stored in [BPA_M_v04.dbf], i.e., the "Count" values inherited from [Marine_summary_by_zone], RID values, and area of each PGU polygon feature. The identification results were written directly to the newly created five columns in the attribute data [BPA_M_v04.dbf]. In the order from left to right, the first column of the five columns stores a binary output (1 or 0), which indicates whether each PGU polygon feature satisfies the requirement for marine IA. Subsequent three columns store binary outputs (1 or 0), which indicate whether each PGU polygon feature satisfies the requirement for marine BPA when dividing the Nansei Islands into one, four and thirteen sub-regions, respectively. The last fifth column stores a binary output (1 or 0), which indicates whether each PGU polygon feature satisfies the requirement for marine BPA described in Table 5.

3-5. Sub-task V: Areal summary of nature reserves and national forests by BPAs

Areas of the nature reserves and national forests which were contained within BPAs were calculated. Specific steps are described as follows.

(1) Preparing spatial data on nature reserves

A set of spatial data on nature reserves, which were listed in Table 6, were carefully checked in terms of consistency among the data and, the errors were modified properly. After the error correction, a part of data necessarily for subsequent analysis (e.g. features whose values in the MAJOR1 column were positive integer) was selected and saved as a temporary data. This operation was repeated for each data on different types of nature reserves. Then temporary data were merged to form a single spatial data for each of the nature reserve types and saved as a new spatial data with a simple name convenient for processing with a computer program.

Table 6. Spatial data of nature reserves

Date source	ID	Old name	New name	Memo
MPA_Data	1	mpa_poly_reef.shp	MPA_v01.shp	Geodesic coordinates were transferred from WGS84 to JGD2000. To correct geometric errors, features with FIDs={7}, {8}, {9}, {10}, {22, 24, 25, 26} were moved parallel.
081113送付 国立公園 区域等 GISデータ	2	乗入規制区域.shp		This data was ignored. Similar features were in spatial data of ID={12} and they should be replaced by this data. But doing this was difficult because of the difference in data structure of attribute table.
	3	国立公園地区_石垣地域.shp		This data was merged into spatial data of ID={13}.
	4	国立公園地区_石垣地域(海域).shp		This data was merged into spatial data of ID={13}.
	5	国立公園地区_西表地域.shp		This data was ignored. Similar features were in spatial data of ID={13} and they should be replaced by this data. But doing this was difficult because of the difference in data structure of attribute table.
	6	崎山湾自然環境保全地域.shp		This data was ignored. Identical features were in spatial data of ID={16}
	7	普通地域_西表地域.shp		This data was ignored. Similar features were in spatial data of ID={13} and they should be replaced by this data. But doing this was difficult because of the difference in data structure of attribute table.
	8	海中公園地区_石垣地域.shp		This data was ignored. Identical features were in spatial data of ID={14}
	9	海中公園地区_西表地域.shp		This data was ignored. Identical features were in spatial data of ID={15}
自然保護地域_ 沖縄県	10	ラムサール条約登録湿地区域_47.shp	NRS.shp	
	11	国定公園地域区分_47.shp	QNP.shp	Spatial data of ID={11,21} were merged to form a single QNP data.
	12	国立公園乗り入れ規制_47.shp	NP2.shp	Spatial data of ID={12,22} were merged to form a single NP2 data.
	13	国立公園地域地区区分_47.shp	NP.shp	Spatial data of ID={13,23} were merged to form a single NP data.
	14	海中公園地区_石垣地域.shp	MPZ.shp	Spatial data of ID={14,15} were merged to form a single MPZ data. MPZ stands for Marine Park Zone.
	15	海中公園地区_西表地域.shp	MPZ.shp	Spatial data of ID={14,15} were merged to form a single MPZ data. MPZ stands for Marine Park Zone.
	16	生息地等保護区_47.shp	NHC.shp	Spatial data of ID={16,24} were merged to form a single NHC data.
	17	自然環境保全地域_47.shp	NCA.shp	Spatial data of ID={17,25} were merged to form a single NCA data.
	18	鳥獣保護区_47.shp	NWP.shp	Spatial data of ID={18,26} were merged to form a single NWP data.
自然保護地域_ 鹿児島県	19	世界自然遺産地域_46.shp	WHA.shp	
	20	原生自然環境保全地域_46.shp	WA.shp	Wilderness Area.
	21	国定公園地域地区区分_46.shp	QNP.shp	Spatial data of ID={11,21} were merged to form a single QNP data.
	22	国立公園乗り入れ規制_46.shp	NP2.shp	Spatial data of ID={12,22} were merged to form a single NP2 data.
	23	国立公園地域地区区分_46.shp	NP.shp	Spatial data of ID={13,23} were merged to form a single NP data.
	24	生息地等保護区_46.shp	NHC.shp	Spatial data of ID={16,24} were merged to form a single NHC data.
	25	自然環境保全地域_46.shp	NCA.shp	Spatial data of ID={17,25} were merged to form a single NCA data.
	26	鳥獣保護区_46.shp	NWP.shp	Spatial data of ID={18,26} were merged to form a single NWP data.

(2) Preparing spatial data on national forests

A set of spatial data on national forests, which were listed in Table 7, were merged to form a single spatial data named [NF].

Table 7. Spatial data on national forests

Data source	ID	Old name	New name	Memo
国有林	1	国有林_鹿児島県.shp	NF,shp	Spatial data of ID={1,2} were merged to form a single NF data.
	2	国有林_沖縄県.shp		Spatial data of ID={1,2} were merged to form a single NF data.

(3) Overlay operation of BPAs, national forests and nature reserves

[BPA_T_v04], [NF] and twelve spatial data on nature reserves listed in the "New name" column of Table 6 were overlaid using "Union" function of ArcGIS and, this yielded a new spatial data named [BPA_T_v04_Union_NF_NR]. Through this operation, all the attributes stored in the fourteen spatial data except FIDs were inherited by the new data.

In the same way, [BPA_M_v04], [NF] and twelve spatial data on nature reserves listed in the "New name" column of Table 6 were overlaid using "Union" function of ArcGIS and, this yielded a new spatial data named [BPA_M_v04_Union_NF_NR]. Through this operation, all the attributes stored in the fourteen spatial data except FIDs were inherited by the new data.

(4) Areal summary

Area of each polygon feature in [BPA_T_v04_Union_NF_NR] and [BPA_M_v04_Union_NF_NR] was calculated in the unit of square meters and was stored in the Area column of [BPA_T_v04_Union_NF_NR.dbf] and [BPA_M_v04_Union_NF_NR.dbf], respectively.

Areas of the national forests and nature reserves overlapping with land BPAs were summarized using a R script [R_final_Terrestrial_BPA_Areal_summary.R], based on the FIDs, area of each polygon feature, RIDs, binary indicator of IA and binary indicators of BPA, BPA01, BPA04 and BPA13 stored in [BPA_T_v04] and [BPA_T_v04_Union_NF_NR]. Summary results were written in Tab-separated text files [BPA_T_v04_areal_summary_NF_NR.txt], [BPA_T_v04_areal_summary_NF_NR_01.txt], [BPA_T_v04_areal_summary_NF_NR_04.txt] and [BPA_T_v04_areal_summary_NF_NR_13.txt]. Of these four files, the first one stored the results based on the land BPAs selected by the definition described in Table 5. Remaining three files stored the results based on the land BPAs selected by dividing the Nansei Islands into one, four and thirteen sub-regions.

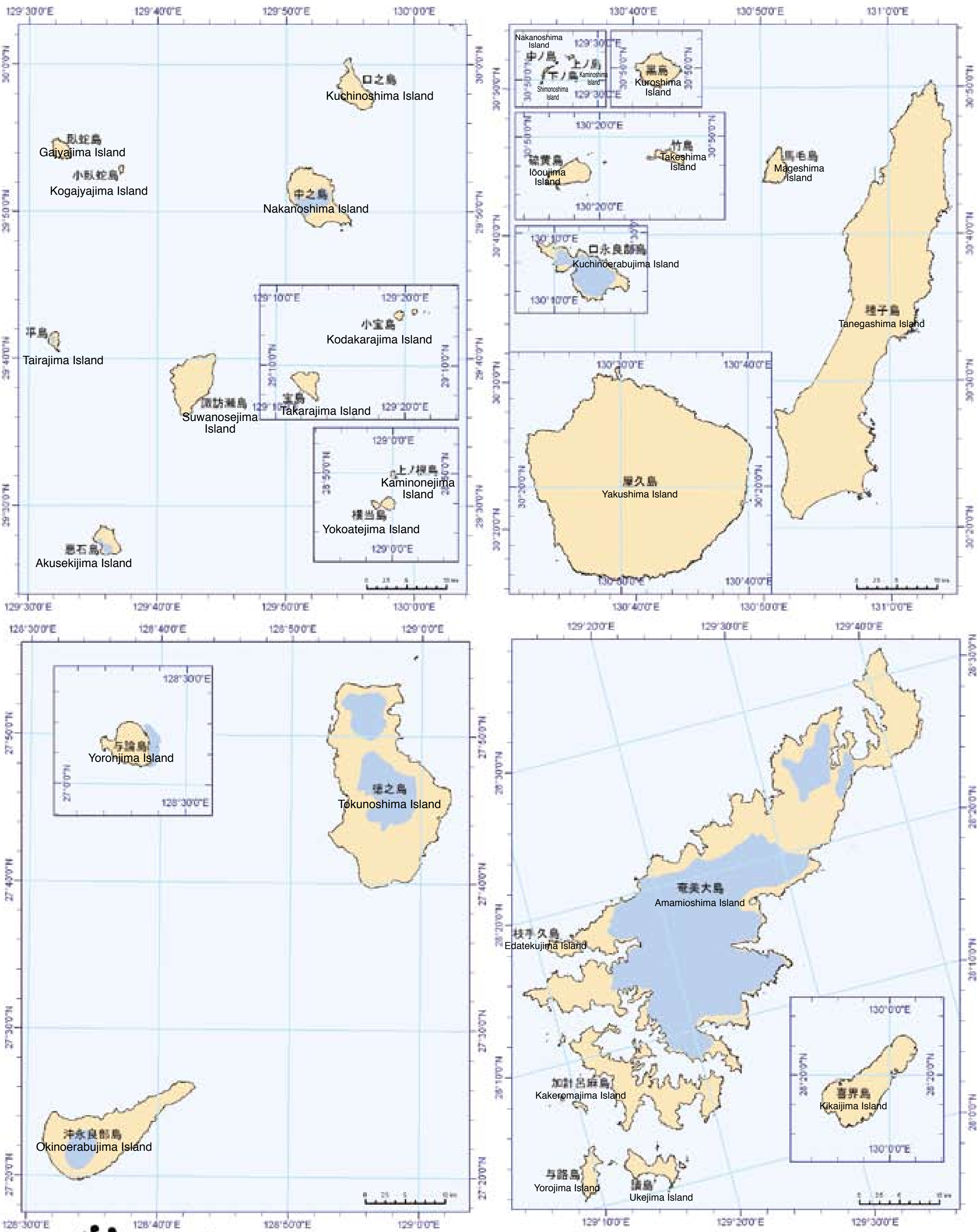
In the same way, areas of the national forests and nature reserves overlapping with marine BPAs were summarized using a R script [R_final_Marine_BPA_Areal_summary.R], based on the FIDs, area of each polygon feature, RIDs, binary indicator of IA and binary indicators of BPA, BPA01, BPA04 and BPA13 stored in [BPA_M_v04] and [BPA_M_v04_Union_NF_NR]. Summary results were written in Tab-separated text files [BPA_M_v04_areal_summary_NF_NR.txt], [BPA_M_v04_areal_summary_NF_NR_01.txt], [BPA_M_v04_areal_summary_NF_NR_04.txt] and [BPA_M_v04_areal_summary_NF_NR_13.txt]. Of these four files, the first one stored the results based on the marine BPAs selected by the definition described in Table 5. Remaining three files stored the results based on the marine BPAs selected by dividing the Nansei Islands into one, four and thirteen sub-regions.I

Each of the eight output files for land BPAs and marine BPAs stored data in the form of a 19 by 19 matrix. The first row of the matrix stored column names. The names and meanings of columns were shown in Table 8. The second row stored the areas which were totaled by whole of the Nansei Islands region. In the third to sixth rows, the areas which were totaled by each of the four sub-regions of the Nansei Islands were stored. In the seventh to nineteenth rows, the areas which were totaled by each of the thirteen sub-regions of the Nansei Islands were stored.

Table 8. Contents of the output file from areal summary operation.

Row No.	Column name	Meaning
1	numRegion	The number of sub-regions
2	RID	Identification number of sub-region
3	Land or PGU	Area of land or PGU
4	IA	Area of the land or marine IA
5	BPA	Area of the land or marine BPA
6	NF	Area of national forest in the land or marine BPA
7	NR	Area of nature reserves (union of the 9 to 19 columns) in the land or marine BPA
8	NFNR	Area of the union of NF and NR in the land or marine BPA
9	MPA_v0	Area of MPA in the land or marine BPA
10	NWP	Area of NWP in the land or marine BPA
11	NCA	Area of NCA in the land or marine BPA
12	NHC	Area of NHC in the land or marine BPA
13	MPZ	Area of MPZ in the land or marine BPA
14	NP	Area of NP in the land or marine BPA
15	NP2	Area of NP2 in the land or marine BPA
16	WA	Area of WA in the land or marine BPA
17	QNP	Area of QNP in the land or marine BPA
18	WHA	Area of WHA in the land or marine BPA
19	NRS	Area of NRS in the land or marine BPA

Appendix E. TPA Maps (8 taxa)



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The Nansei Islands Biological Diversity Evaluation

Project Mammals TPA Maps

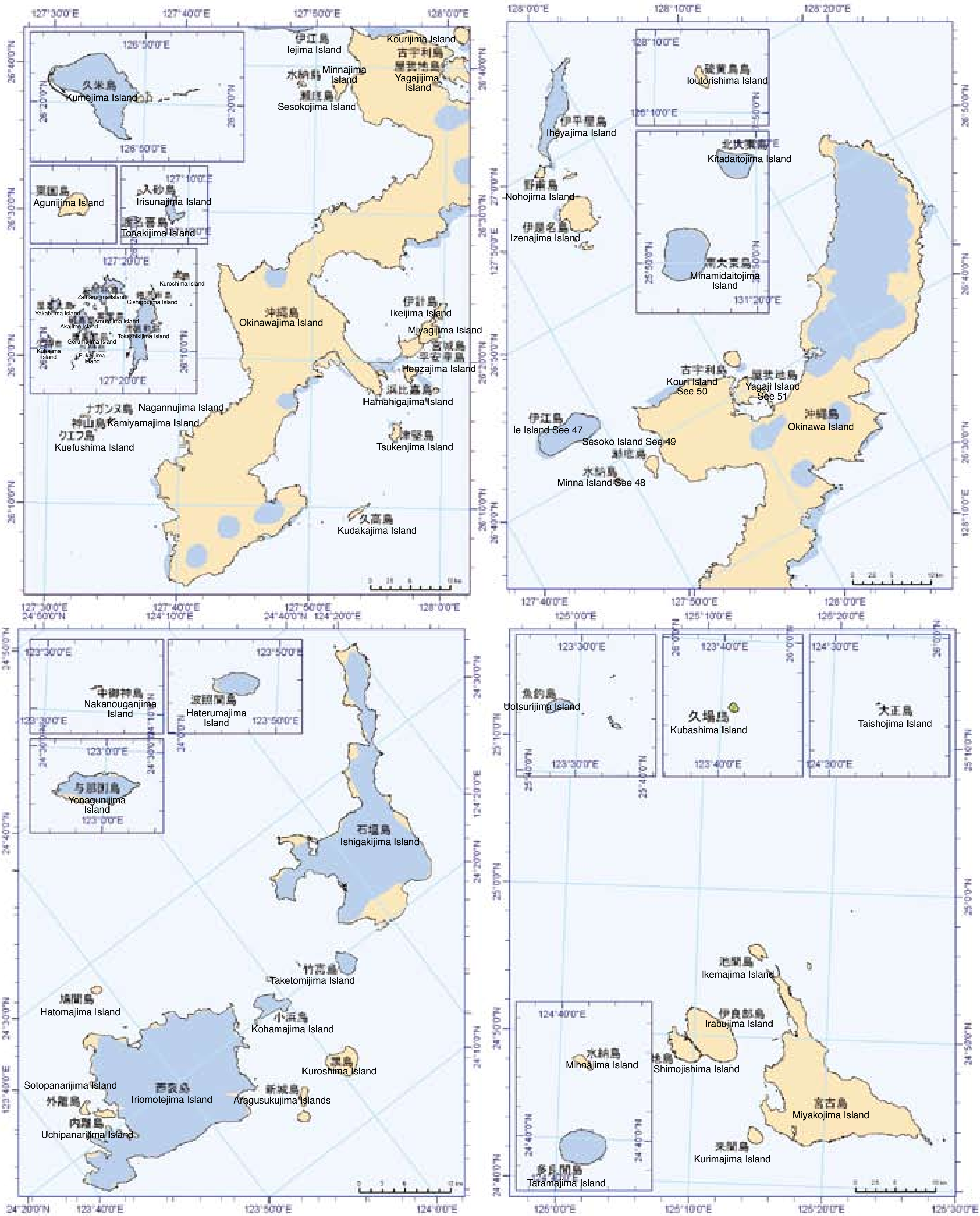
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Mammals
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Project Mammals TPA Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

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Mammals
Taxon Priority Areas (TPA's)

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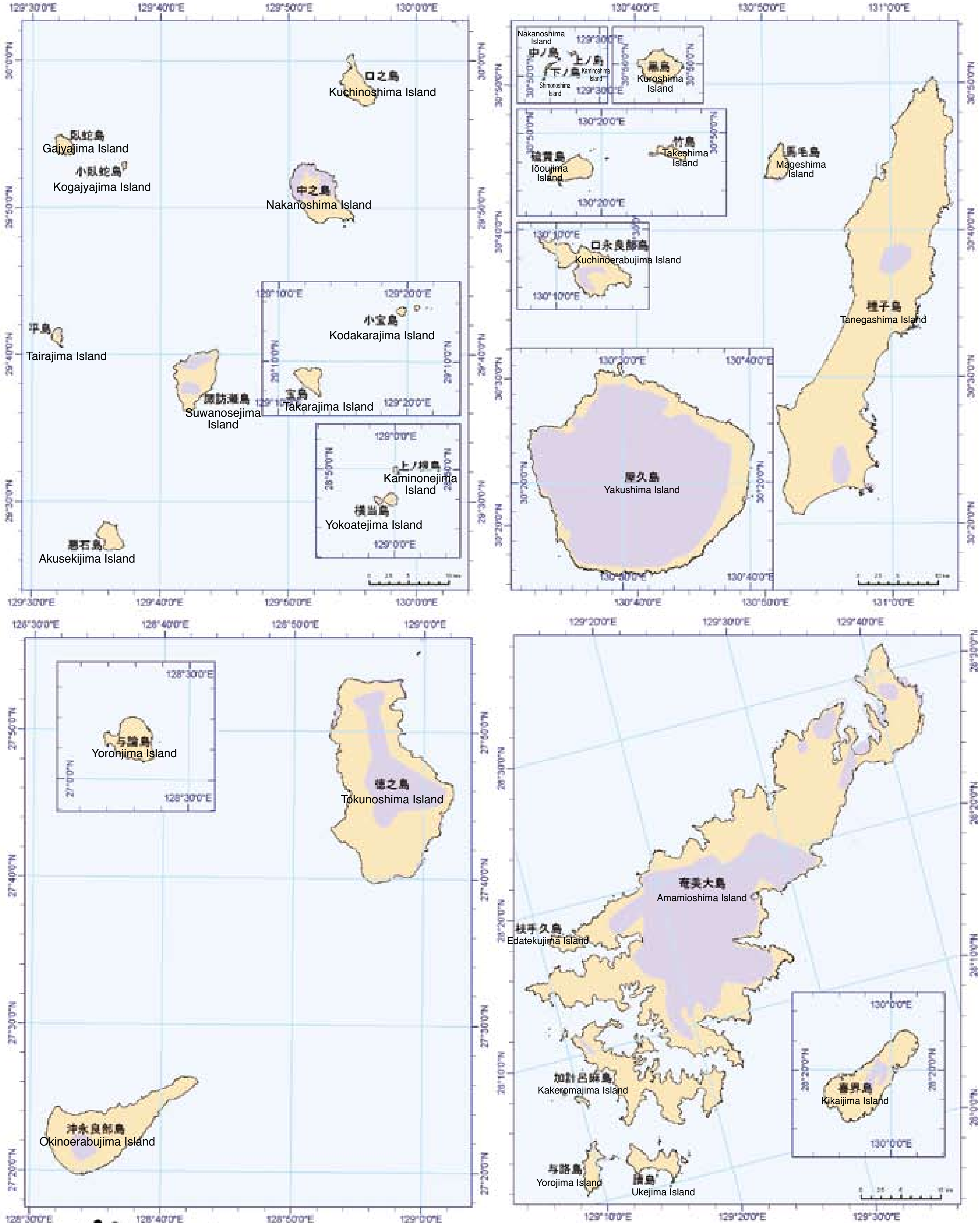

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Birds TPA Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

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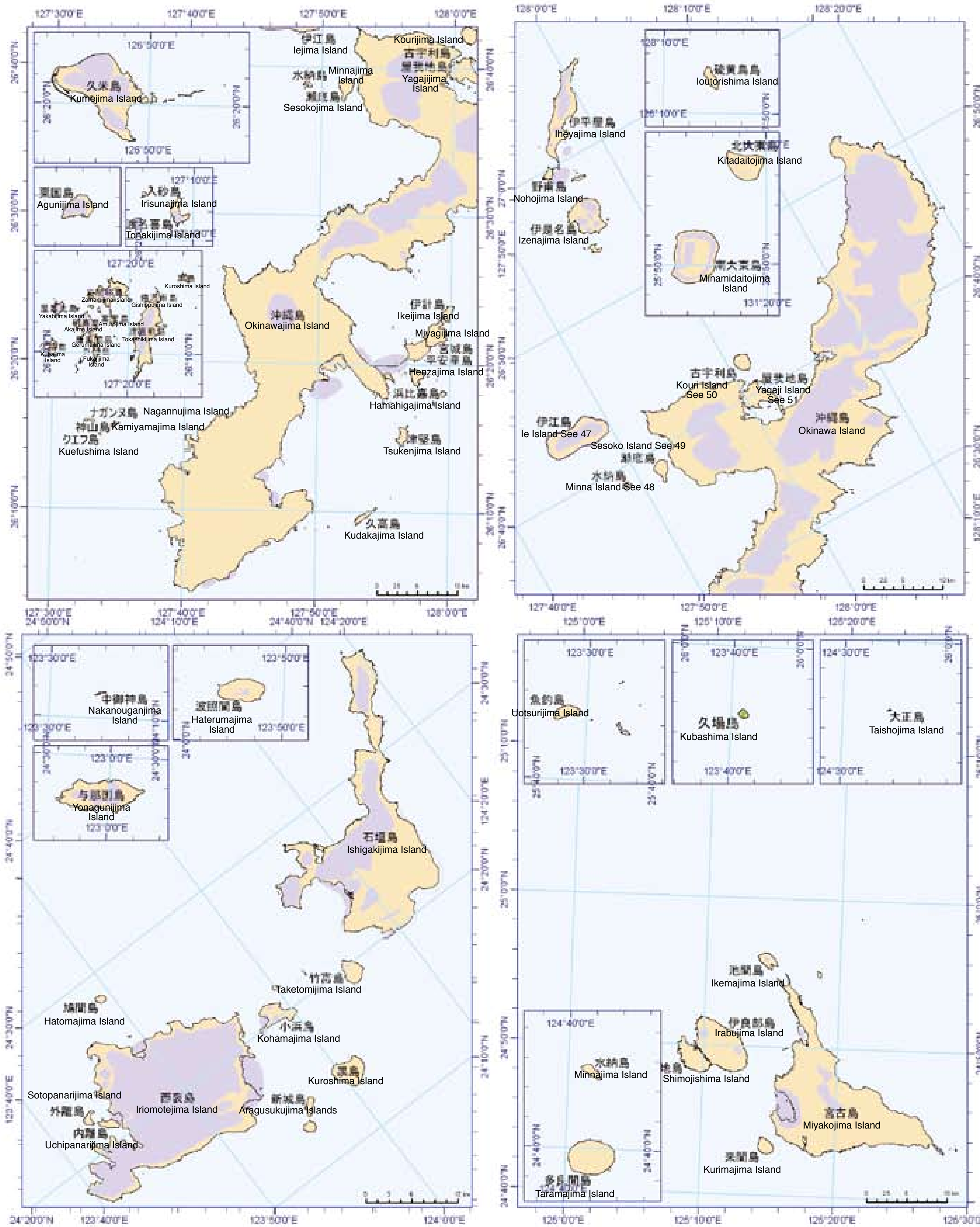
Legend

Birds
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



The Nansei Islands Biological Diversity Evaluation

Birds TPA Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

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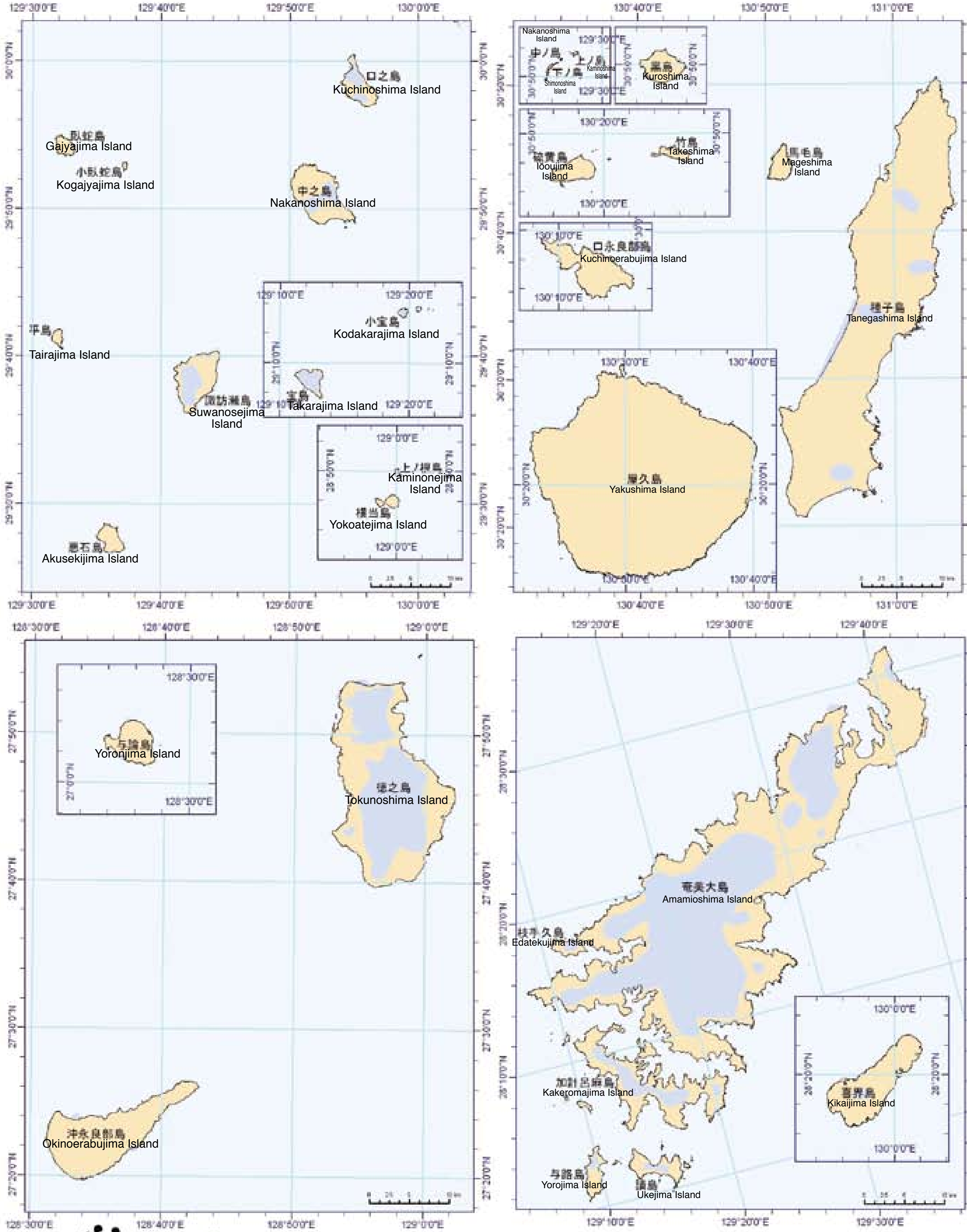
Legend

Birds
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Amphibians/Reptiles TPA Maps

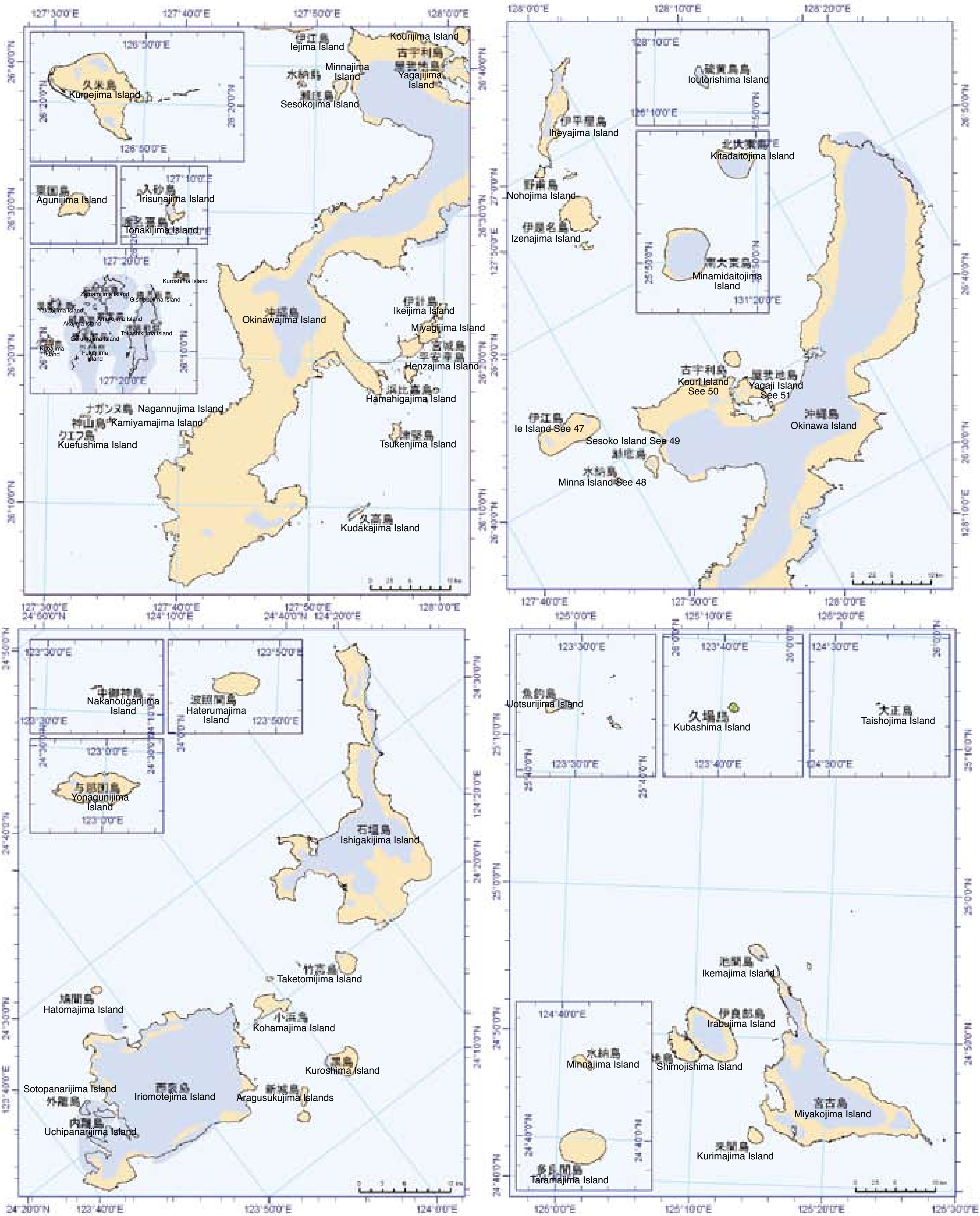
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Amphibians/Reptiles Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Amphibians/Reptiles TPA Maps

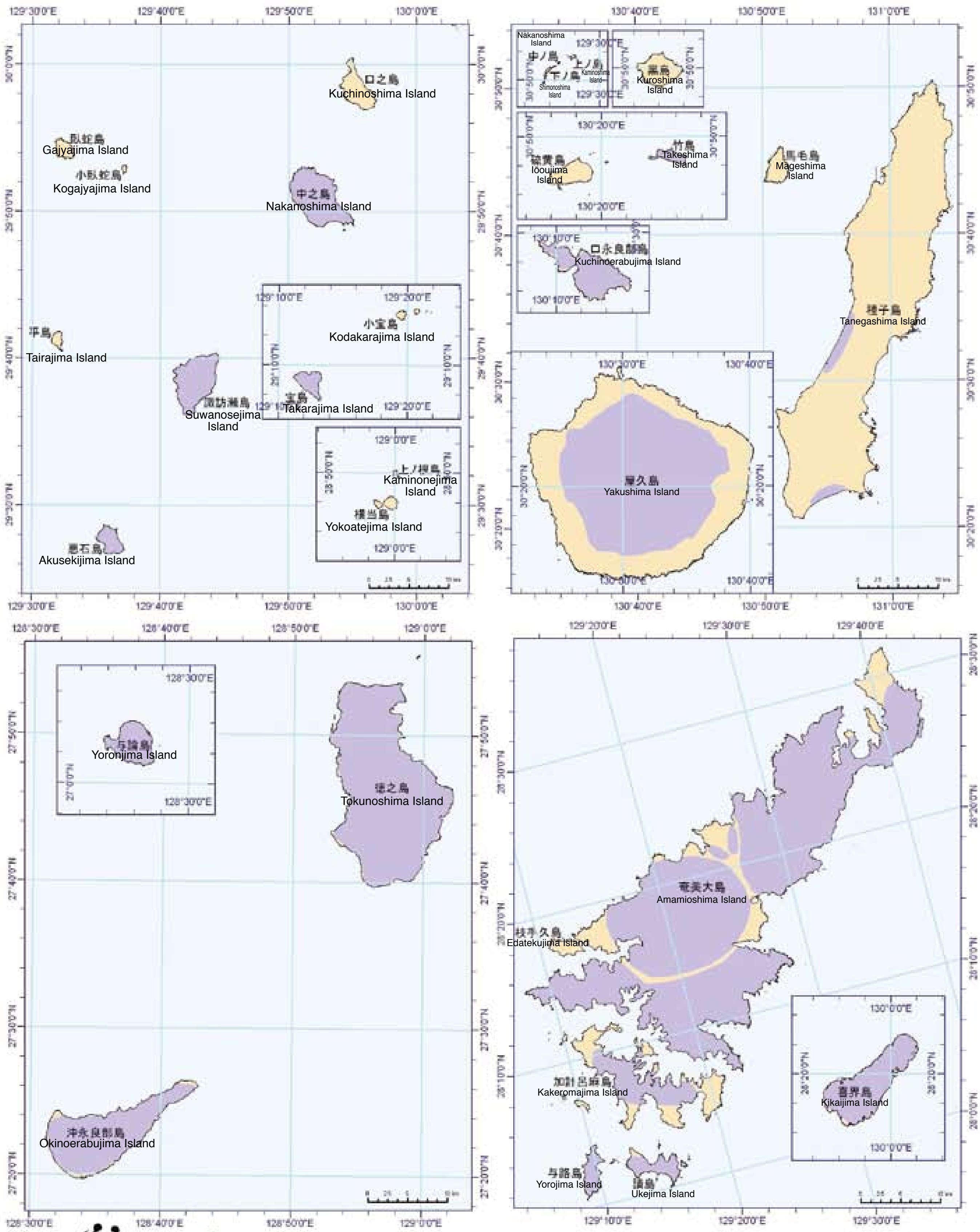
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Amphibians/Reptiles Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Insects TPA Maps

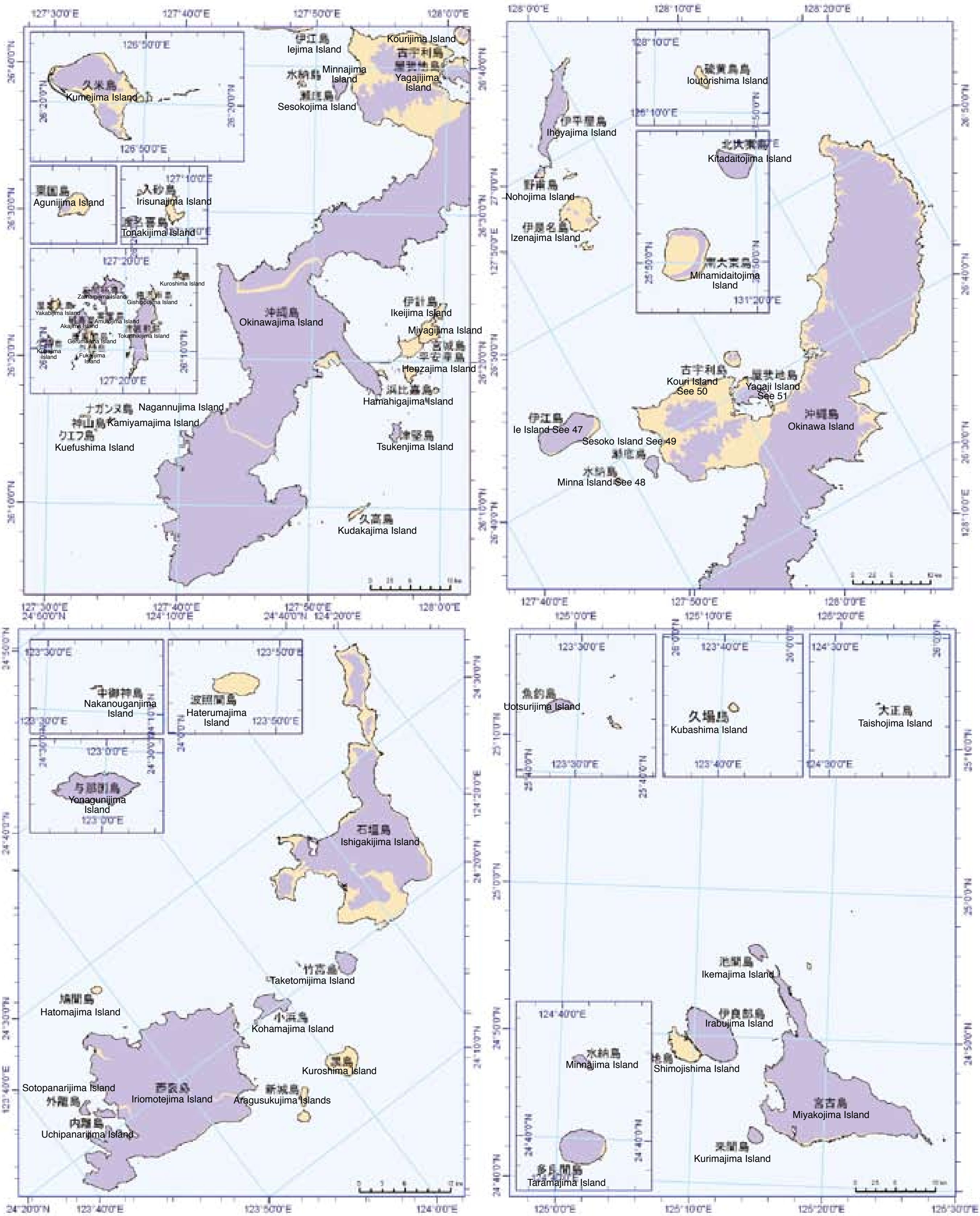
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Insects
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



The Nansei Islands Biological Diversity Evaluation

Insects TPA Maps

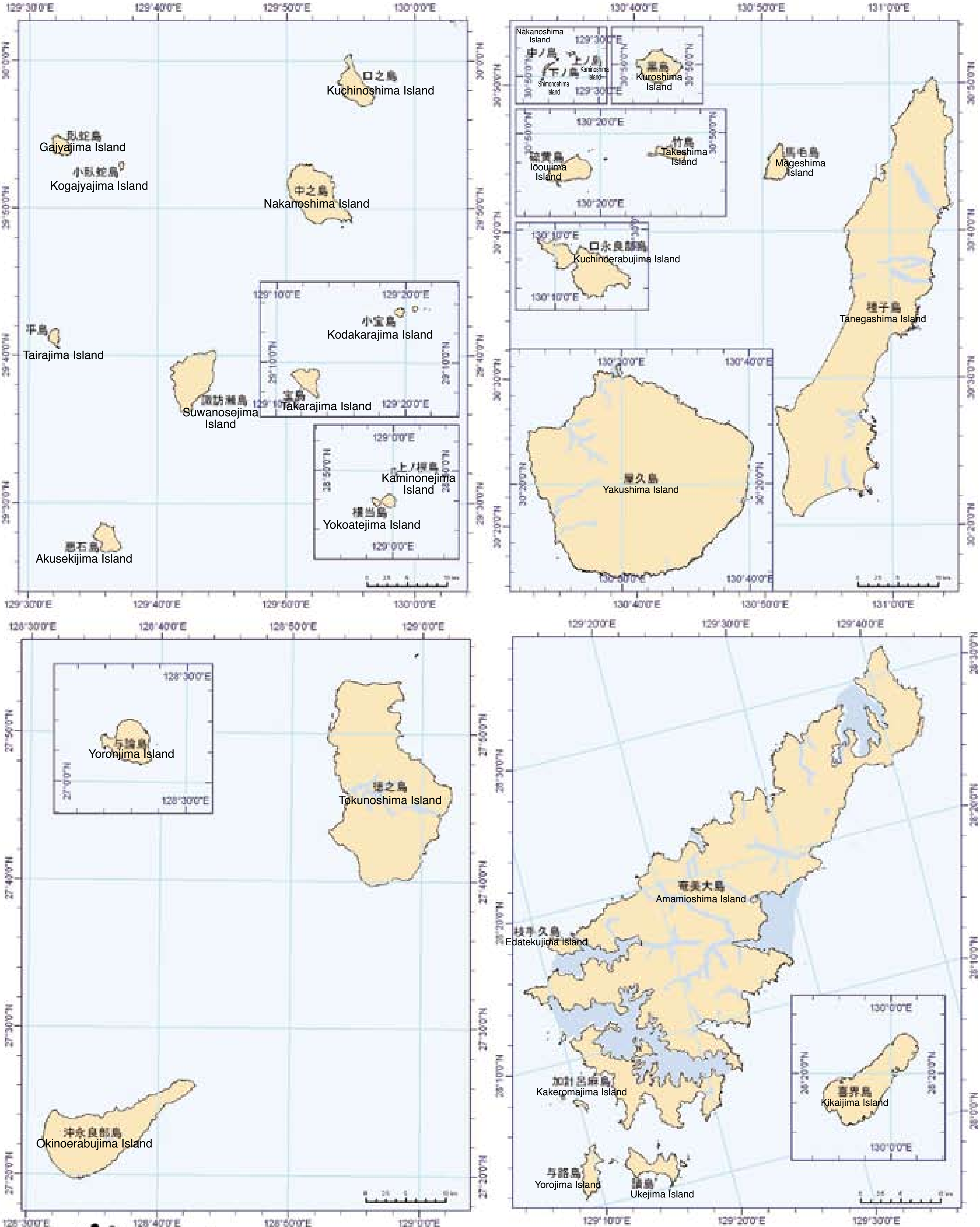
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Insects
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Fish TPA Maps

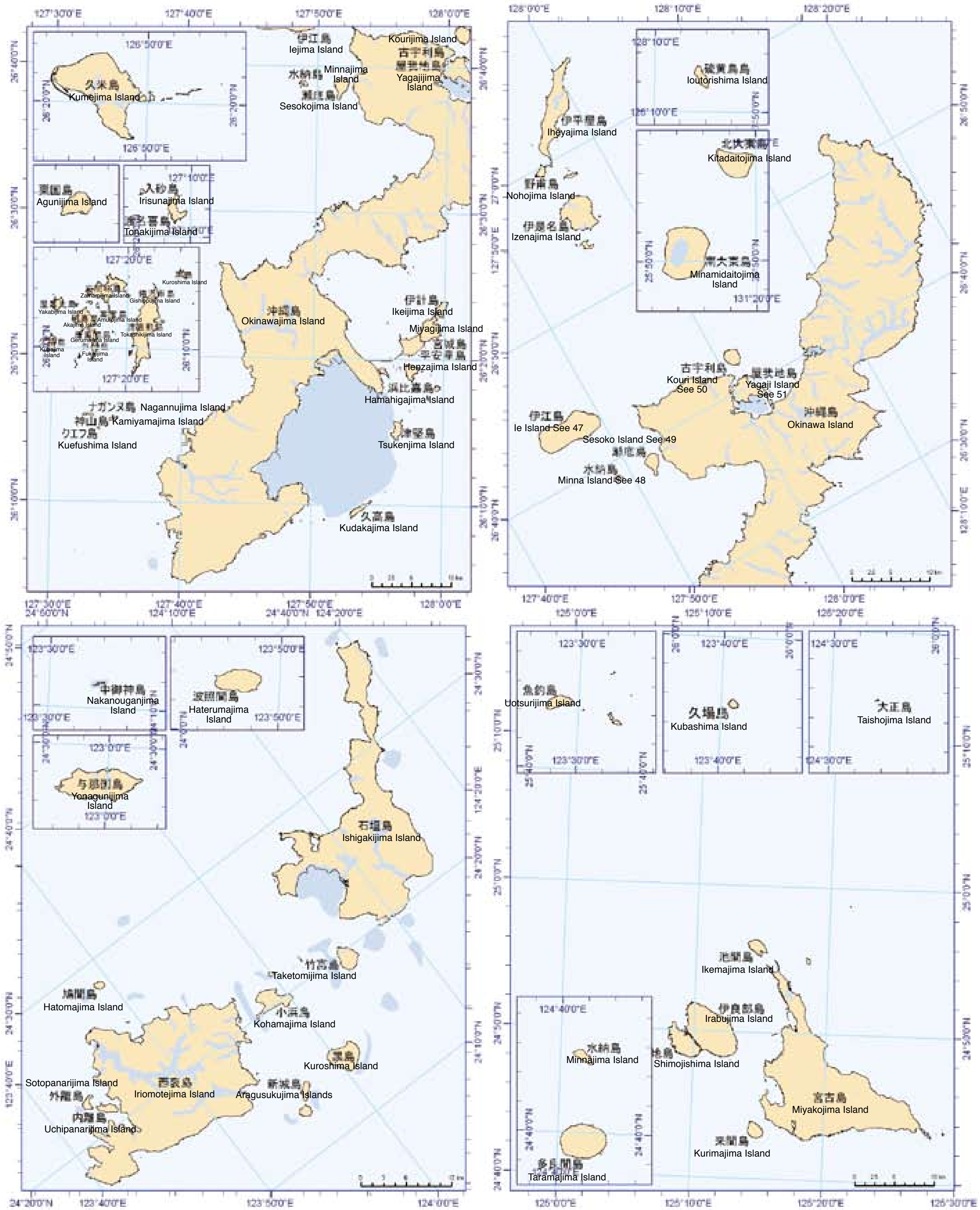
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Fish
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Fish TPA Maps

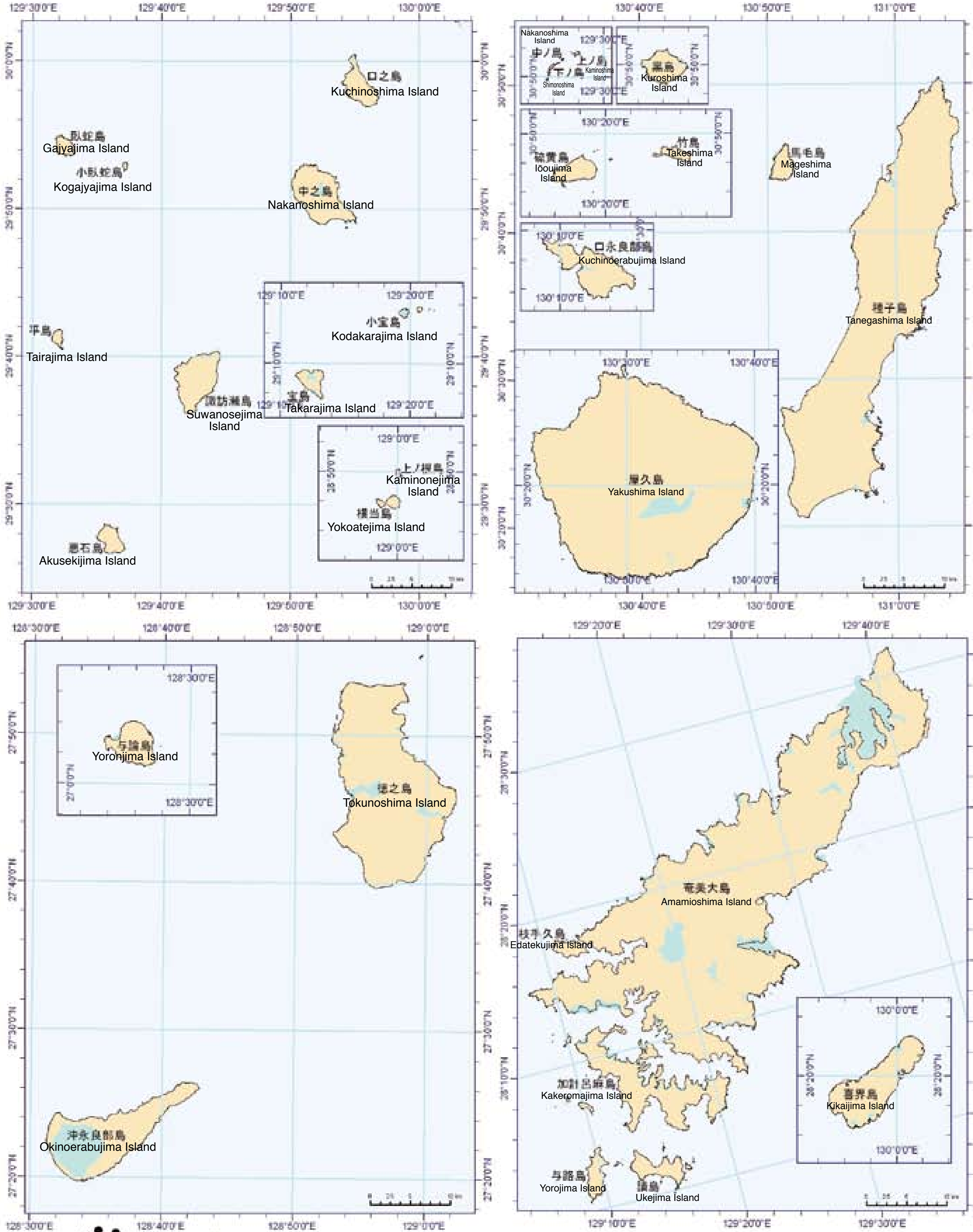
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Fish
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Crustaceans TPA Maps

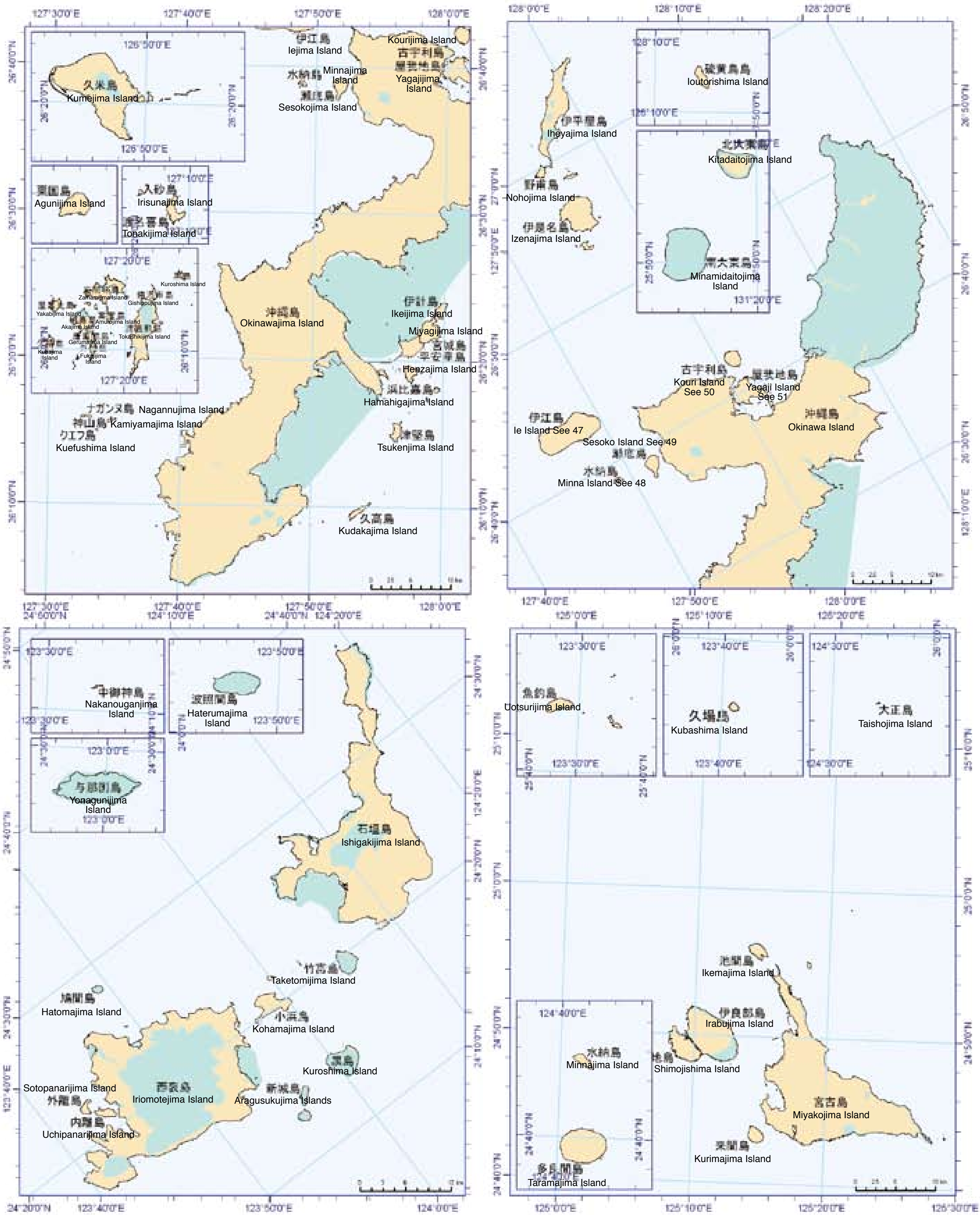
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Crustaceans Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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Crustaceans TPA Maps

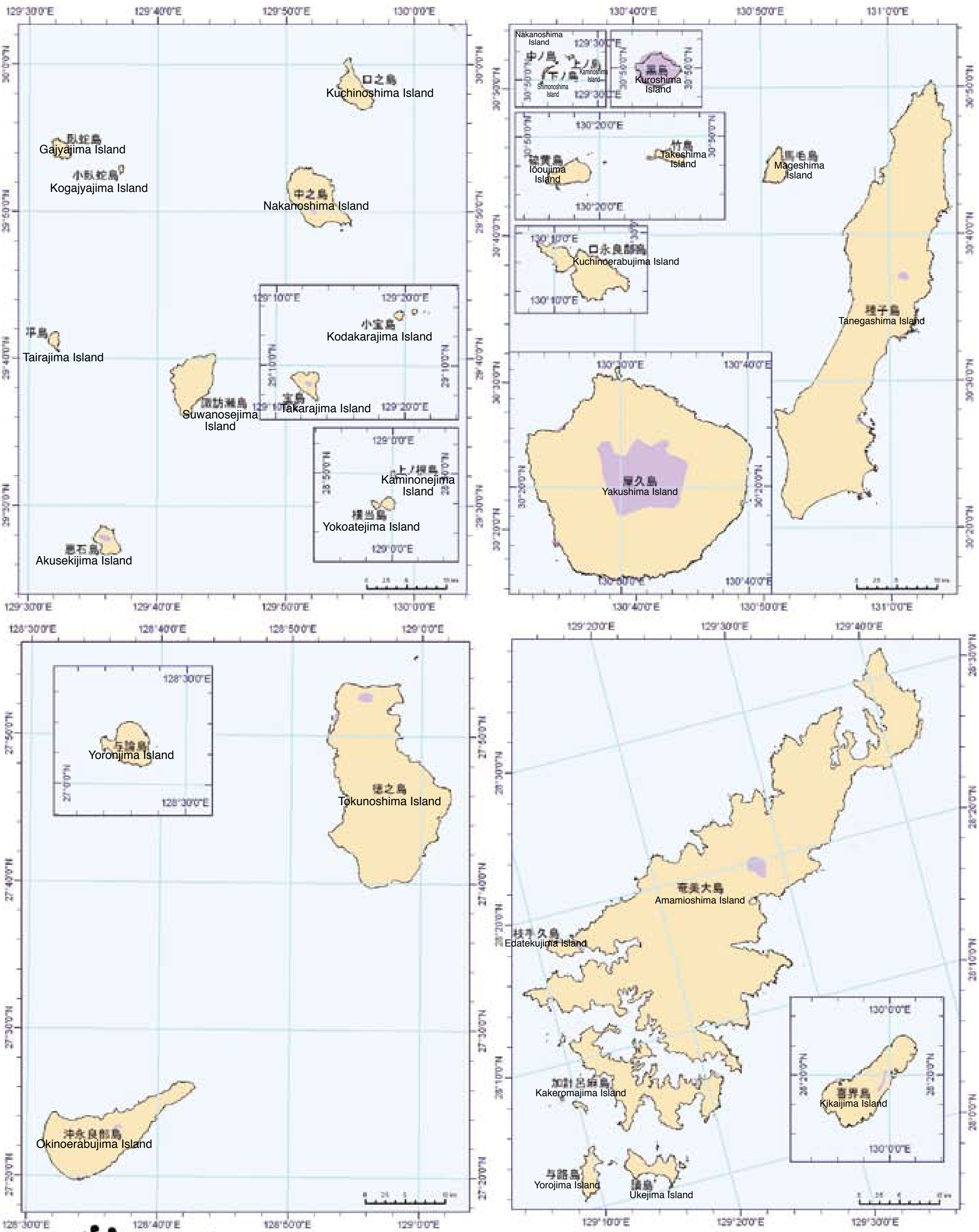
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Crustaceans Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



The Nansei Islands Biological Diversity Evaluation

Mollusks TPA Maps

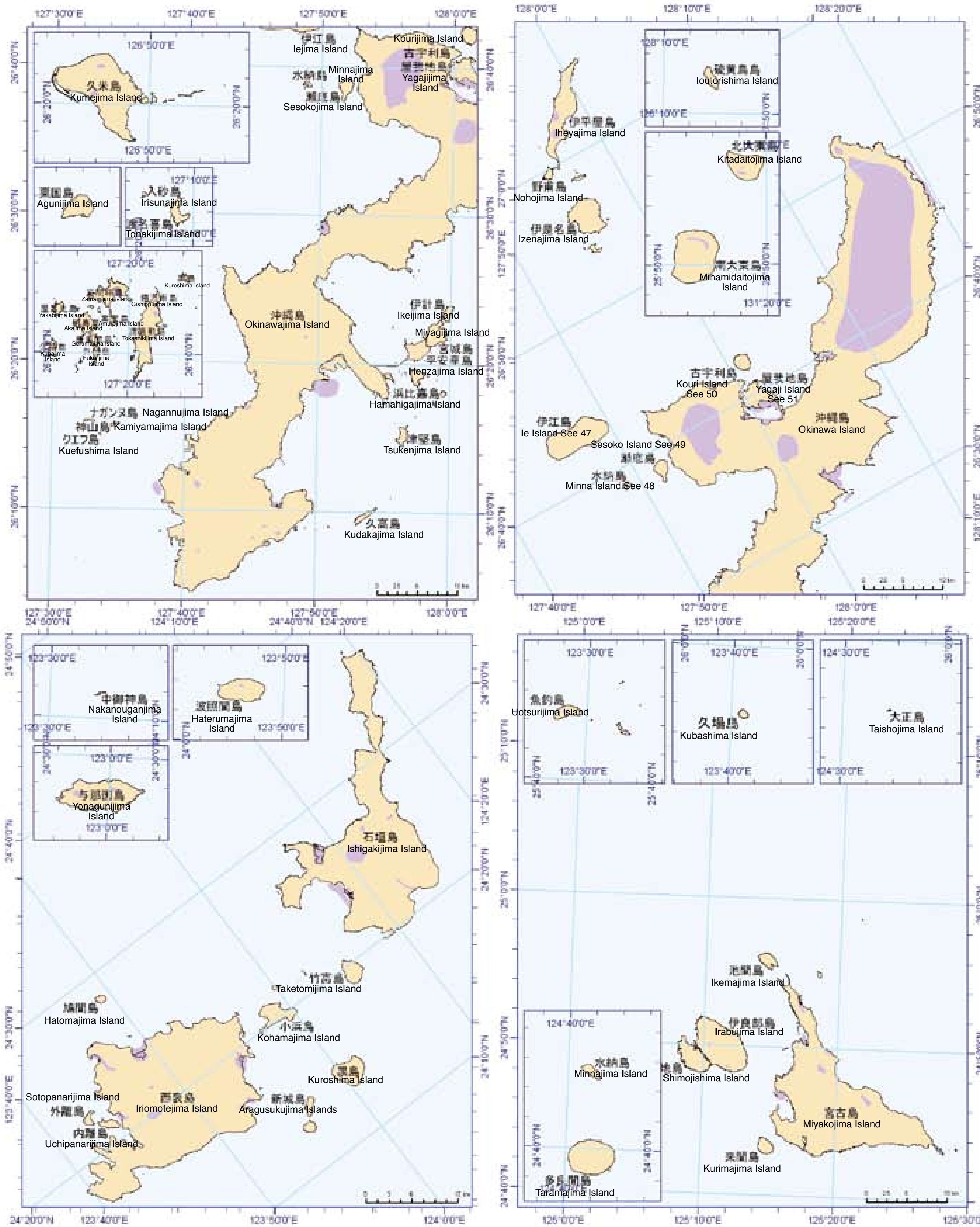
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Mollusks
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



The Nansei Islands Biological Diversity Evaluation

Mollusks TPA Maps

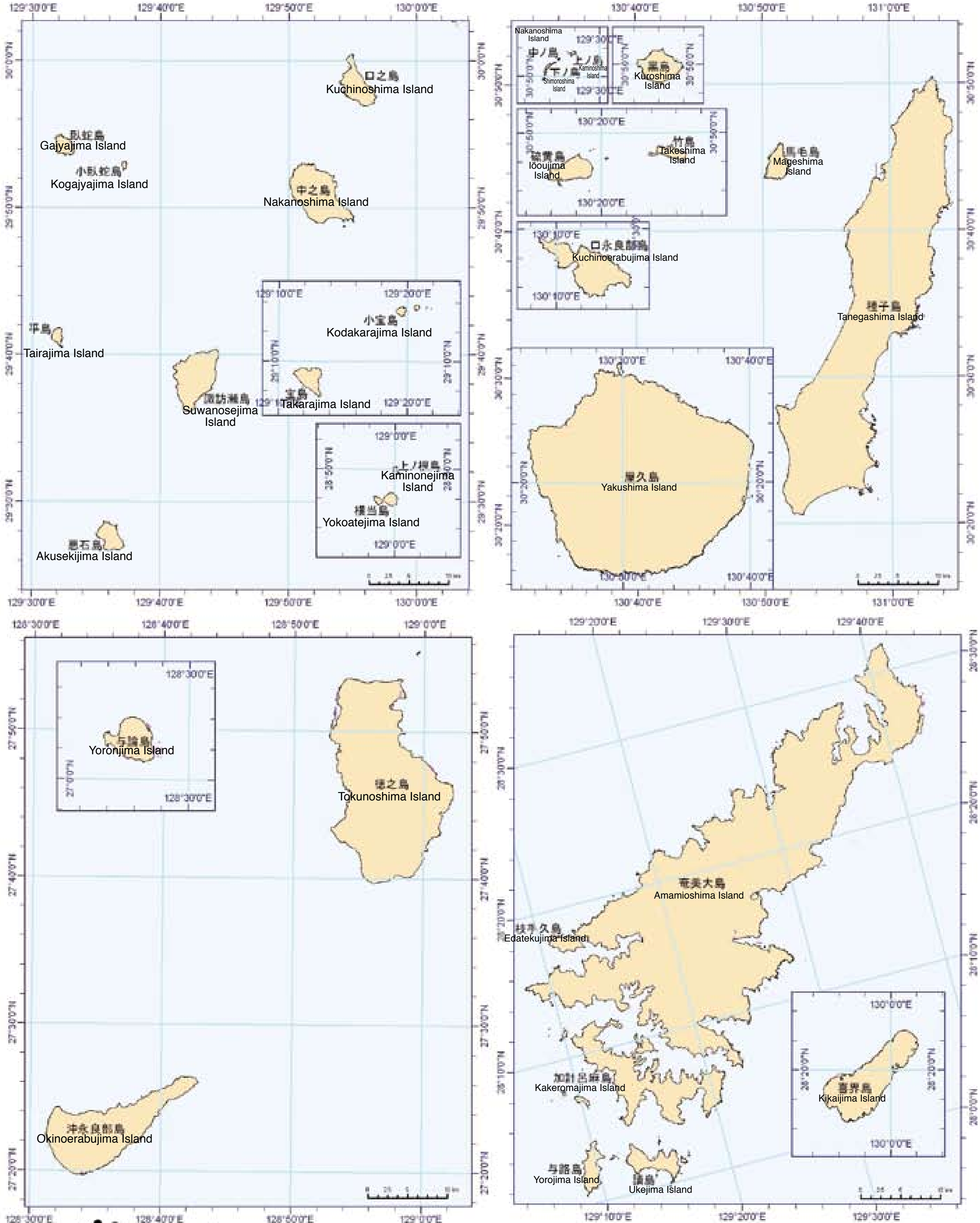
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Mollusks
Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



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The Nansei Islands Biological Diversity Evaluation

Seagrasses/Algae TPA Maps

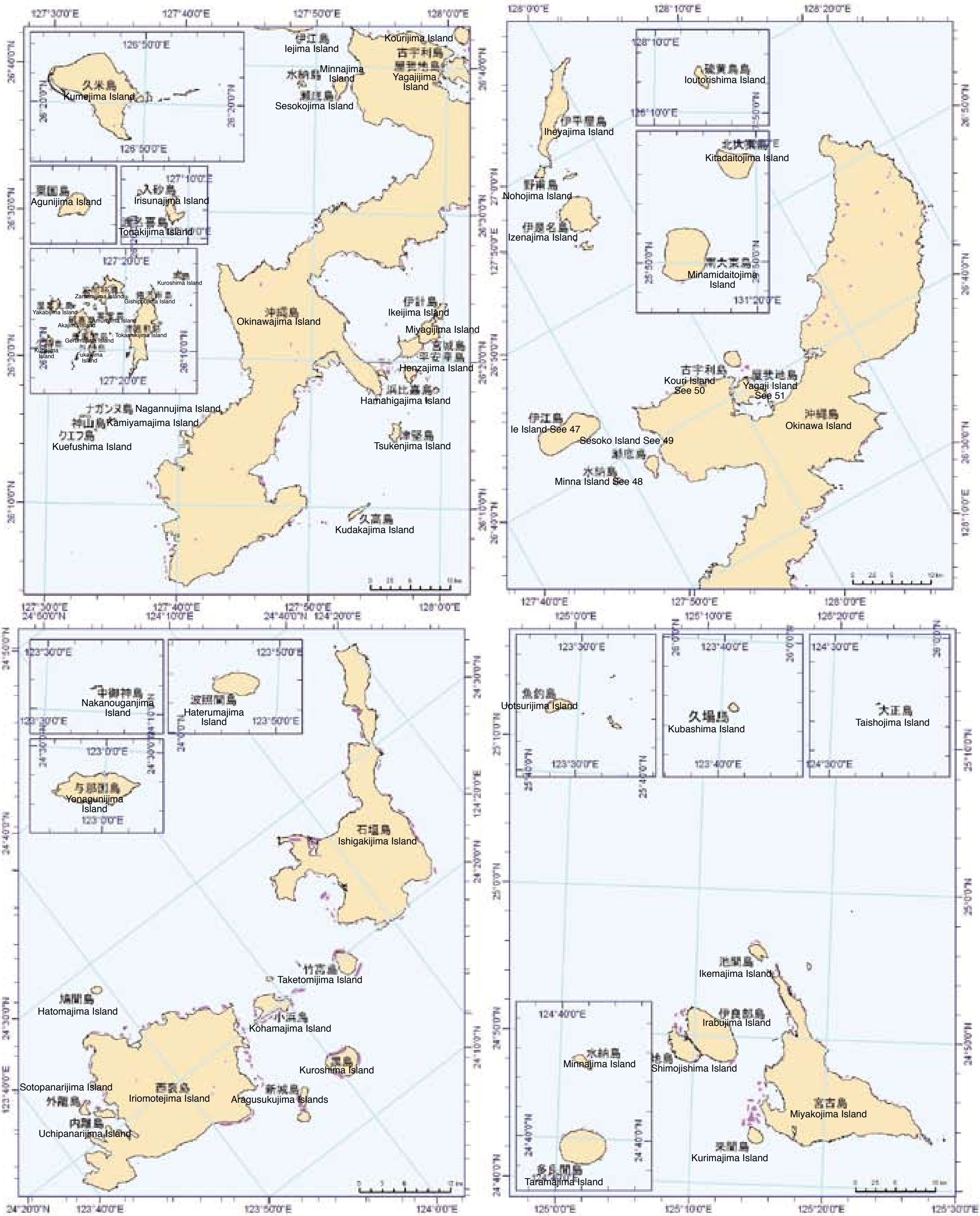
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Seagrasses/Algae Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.



The Nansei Islands Biological Diversity Evaluation

Seagrasses/Algae TPA Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

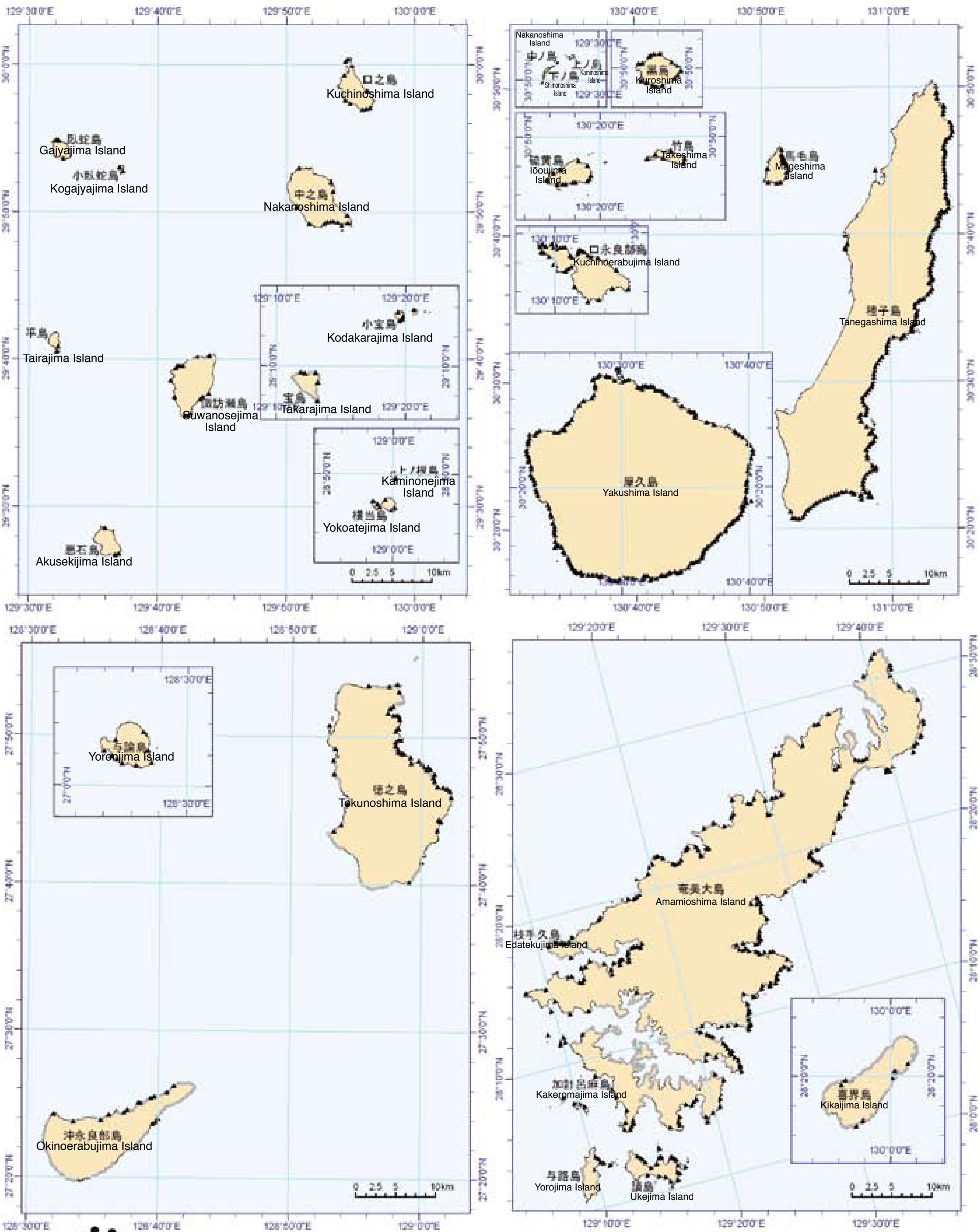
Please note that, in the interests of protecting certain rare species, some priority areas are intentionally not shown.

Legend

Seagrasses/Algae Taxon Priority Areas (TPA's)

These priority area maps indicate areas thought to be important to selected indicator species based on information available at the time of this project. They do not exhaustively indicate important areas for entire species within the relevant taxon.

Appendix F. Coral Potential Maps/Priority Coral Community Maps



The Nansei Islands Biological Diversity Evaluation

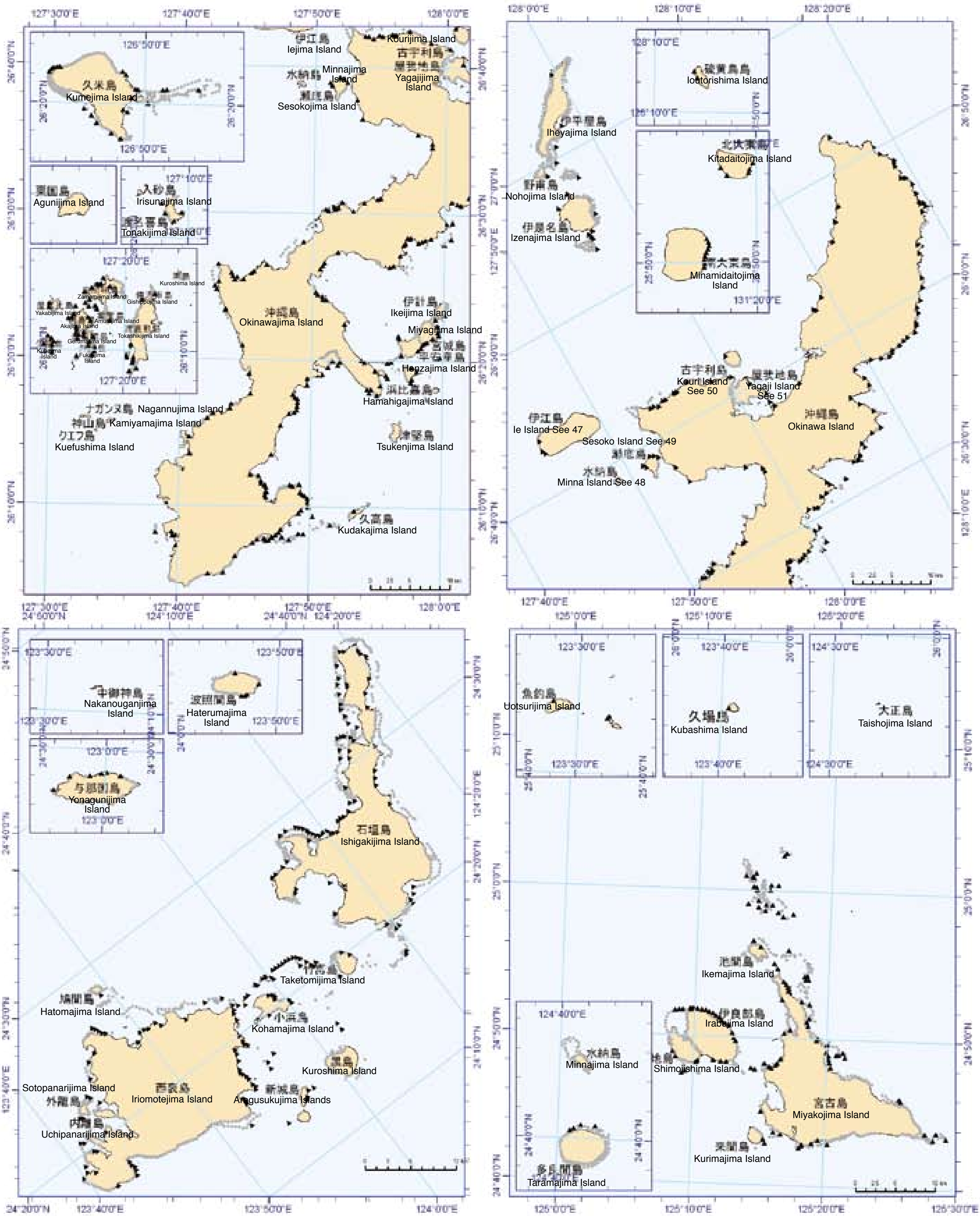
Coral Potential Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend Sites deemed to be of high potential

▲ Open ocean ● Intra-bay/moat

Types of sites identified as high potential: For sites classified as "Intra-bay/moat", sites or points with low levels of land-based pressures (located at a distance exceeding 1 km from river mouths and heavily populated areas). For sites classified as "Open ocean", sites with mid-level energy indicators (either surge energy or wind speed indicate high-level energy) that are fairly resistant to the effects of typhoons.



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The Nansei Islands Biological Diversity Evaluation

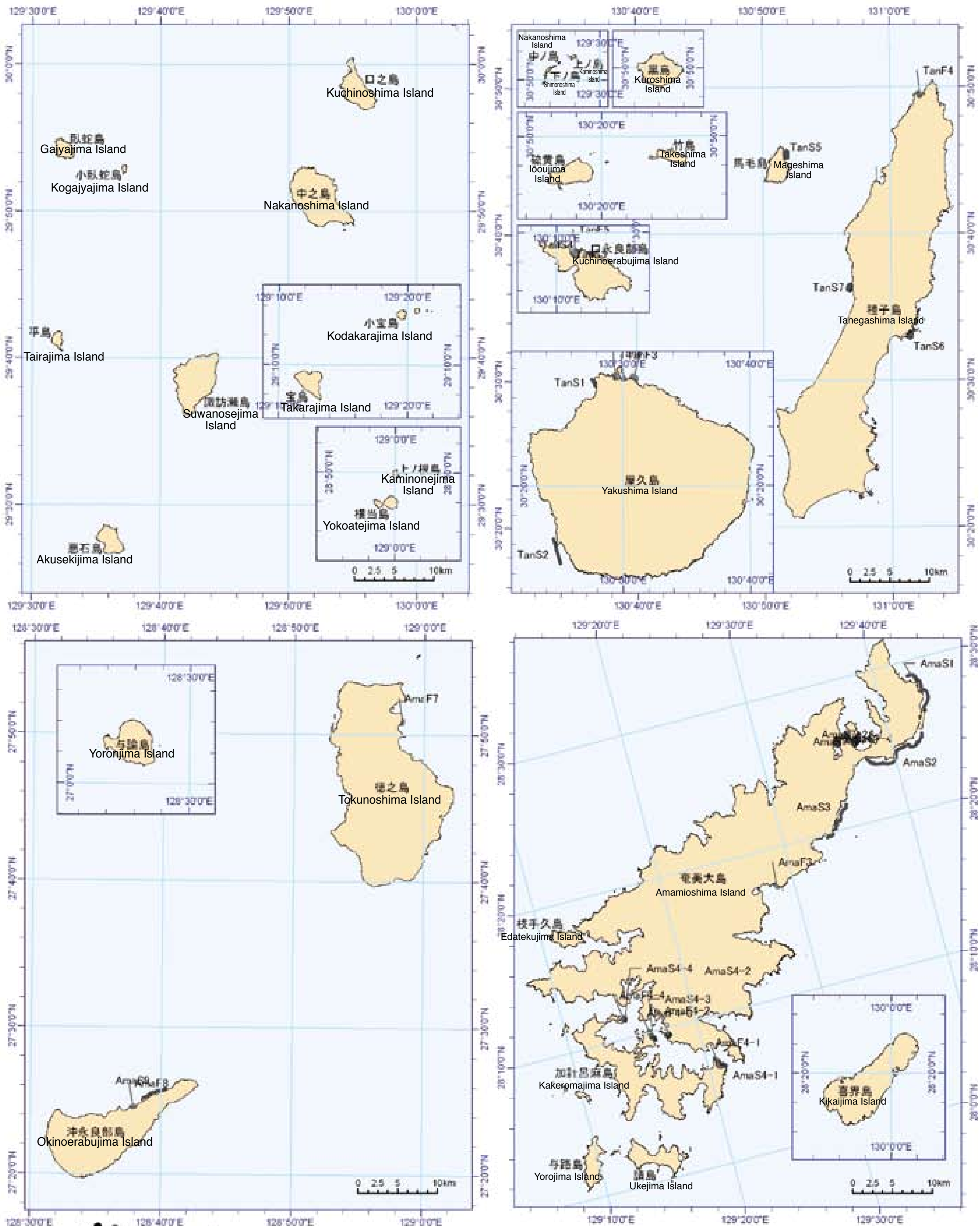
Coral Potential Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend Sites deemed to be of high potential

▲ Open ocean ● Intra-bay/moat

Types of sites identified as high potential: For sites classified as “Intra-bay/moat”, sites or points with low levels of land-based pressures (located at a distance exceeding 1 km from river mouths and heavily populated areas). For sites classified as “Open ocean”, sites with mid-level energy indicators (either surge energy or wind speed indicate high-level energy) that are fairly resistant to the effects of typhoons.



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The Nansei Islands Biological Diversity Evaluation

Priority Coral Community Maps

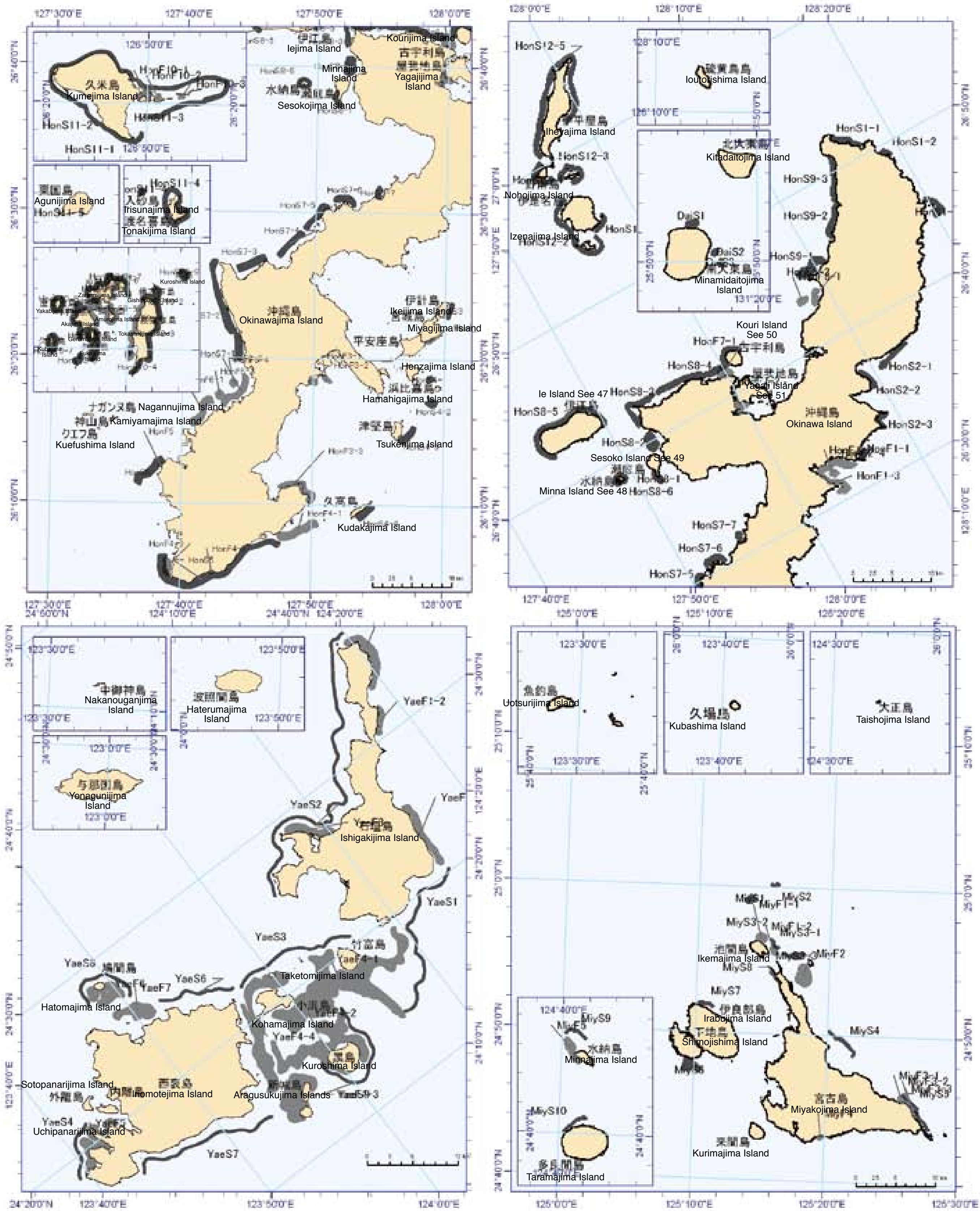
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend

- Priority moat/flat (F) communities
- Priority slope (S) communities

Alphanumeric codes: Ōsumi Islands (Tan), Amami Islands (Ama), Okinawa Islands (Hon), Miyako Islands (Miy), Yaeyama Islands (Yae)

Example: “AmaS1-2” (Priority reef slopes No. 2-1 in the Amami Islands)



The Nansei Islands Biological Diversity Evaluation

Priority Coral Community Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

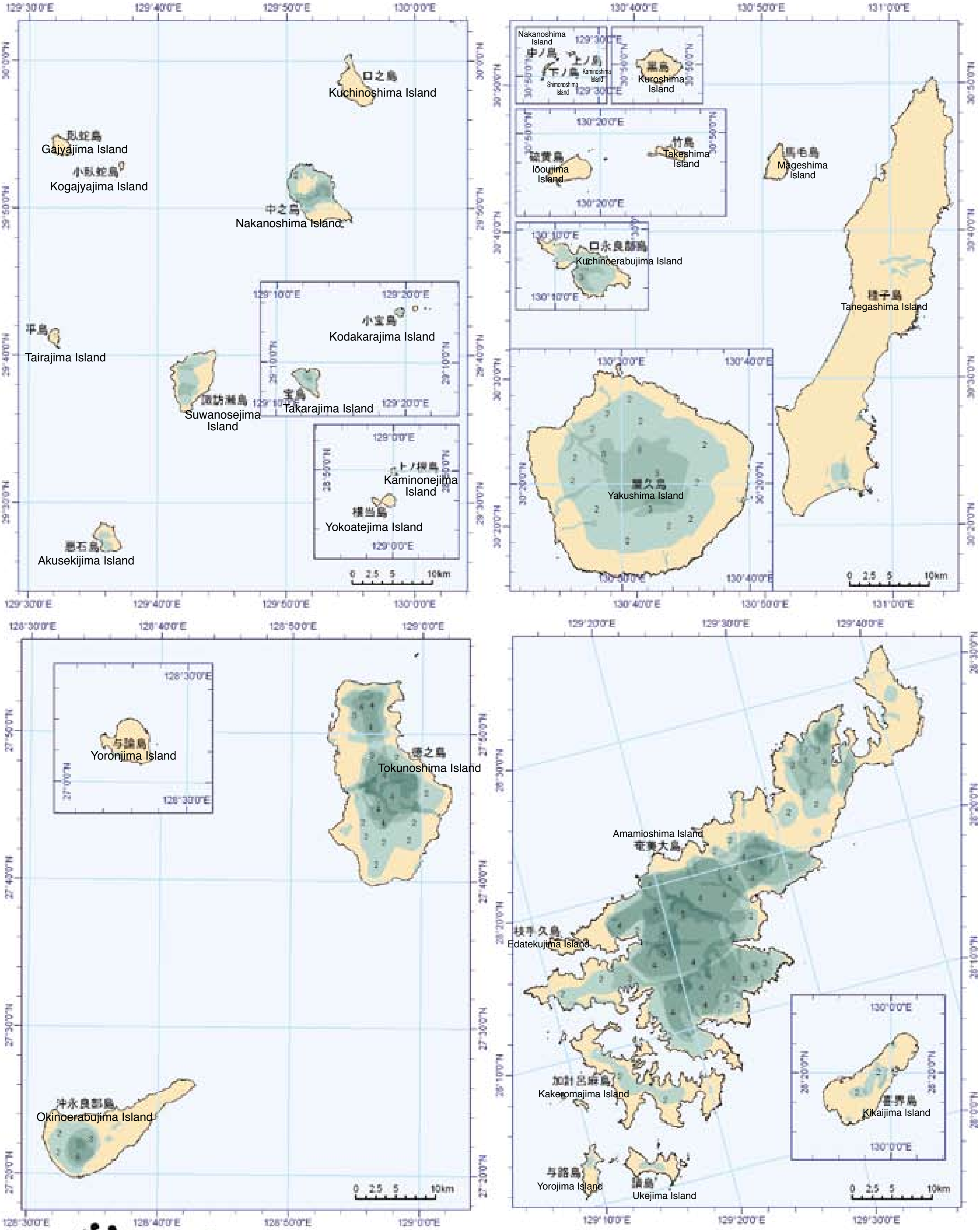
Legend

- Priority moat/flat (F) communities
- Priority slope (S) communities

Alphanumeric codes: Ōsumi Islands (Tan), Amami Islands (Ama), Okinawa Islands (Hon), Miyako Islands (Miy), Yaeyama Islands (Yae)

Example: "AmaS1-2" (Priority reef slopes No. 2-1 in the Amami Islands)

Appendix G. Overlay Maps



The Nansei Islands Biological Diversity Evaluation

Taxon Priority Areas Overlay method

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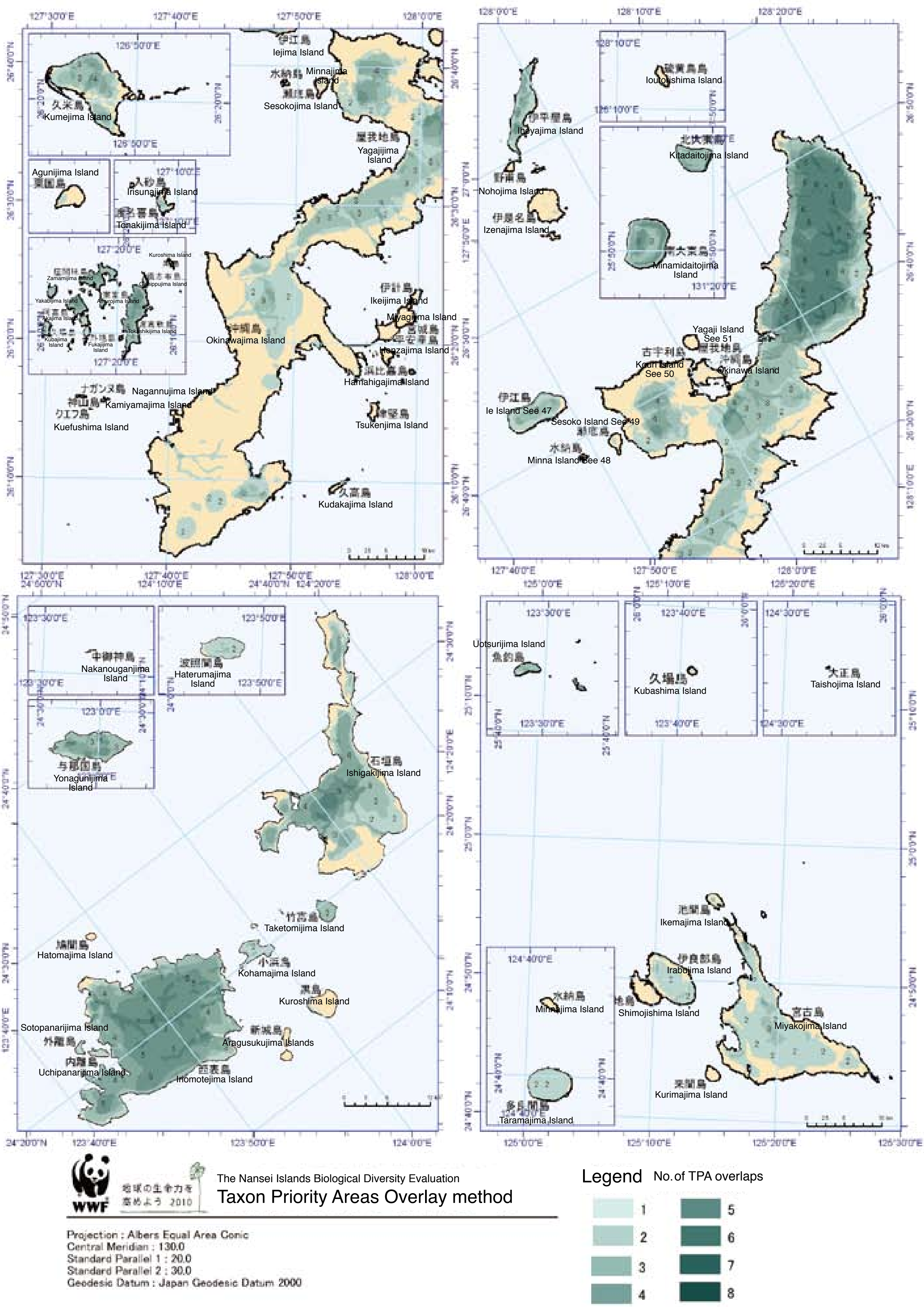
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

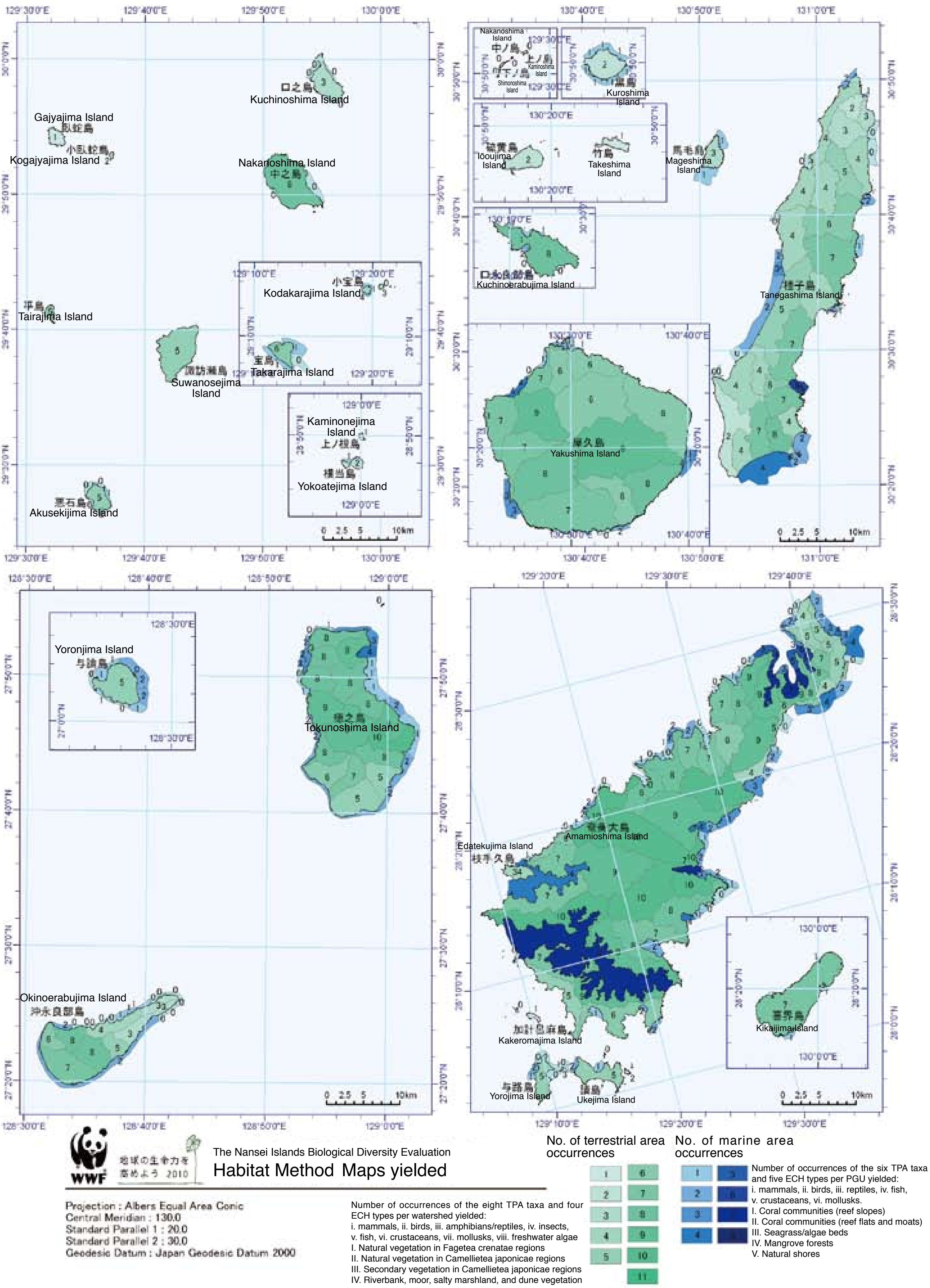
Legend No.of TPA overlaps

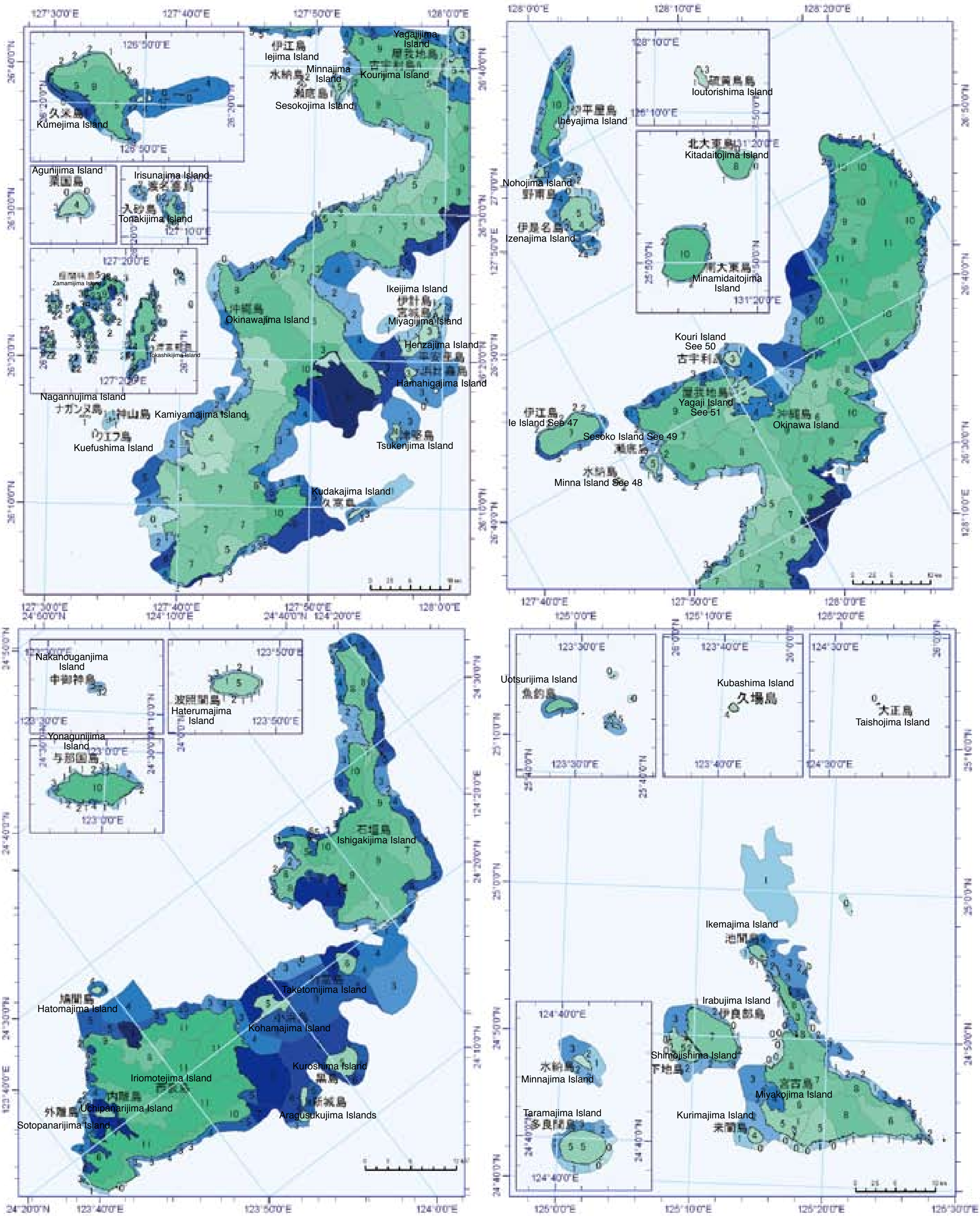
1, 2, 3, 4, 5, 6, 7, 8



伊江島
Iejima Island
水納島
Minnajima Island
瀬底島
Sesokojima Island
久米島
Kumejima Island
屋我地島
Yagajijima Island
Agunijima Island
粟国島
入砂島
Irisunajima Island
渡名喜島
Tonakijima Island
Kuroshima Island
Zamamijima Island
Gerumajima Island
Yakabijima Island
Amurojima Island
Akajima Island
Kubajima Island
Fukajijima Island
Tokashikijima Island
伊計島
Ikeijima Island
沖縄島
Okinawajima Island
Miyagijima Island
宮城島
平安座島
Henzajima Island
浜比嘉島
Hamahigajima Island
ナガンヌ島
Nagannujima Island
神山島
Kamiyamajima Island
クエフ島
Kuefushima Island
津堅島
Tsukenjima Island
久高島
Kudakajima Island
硫黄鳥島
Ioutorishima Island
伊平屋島
Iheyajima Island
北大東島
Kitadaitojima Island
野甫島
Nohojima Island
伊是名島
Izenajima Island
南大東島
Minamidaitojima Island
Yagaji Island
See 51
古宇利島
Kouri Island
See 50
屋我地島
沖縄島
Okinawa Island
伊江島
Ie Island See 47
Sesoko Island See 49
瀬底島
水納島
Minna Island See 48
中御神島
Nakanouganjima Island
波照間島
Haterumajima Island
与那国島
Yonagunijima Island
石垣島
Ishigakijima Island
竹富島
Taketomijima Island
鳩間島
Hatomajima Island
小浜島
Kohamajima Island
黒島
Kuroshima Island
Sotopanarijima Island
外離島
内離島
Uchipanarijima Island
新城島
Aragusukujima Islands
西表島
Iriomotejima Island
Uotsurijima Island
魚釣島
久場島
Kubashima Island
大正島
Taishojima Island
池間島
Ikemajima Island
伊良部島
Irabujima Island
水納島
Minnajima Island
下地島
Shimojishima Island
宮古島
Miyakojima Island
来間島
Kurimajima Island
多良間島
Taramajima Island
The Nansei Islands Biological Diversity Evaluation
Taxon Priority Areas Overlay method
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Legend No. of TPA overlaps
1
2
3
4
5
6
7
8

Appendix H. Ecologically Critical Habitat (ECH) Maps





The Nansei Islands Biological Diversity Evaluation

Habitat Method Maps yielded

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

No. of terrestrial area occurrences

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

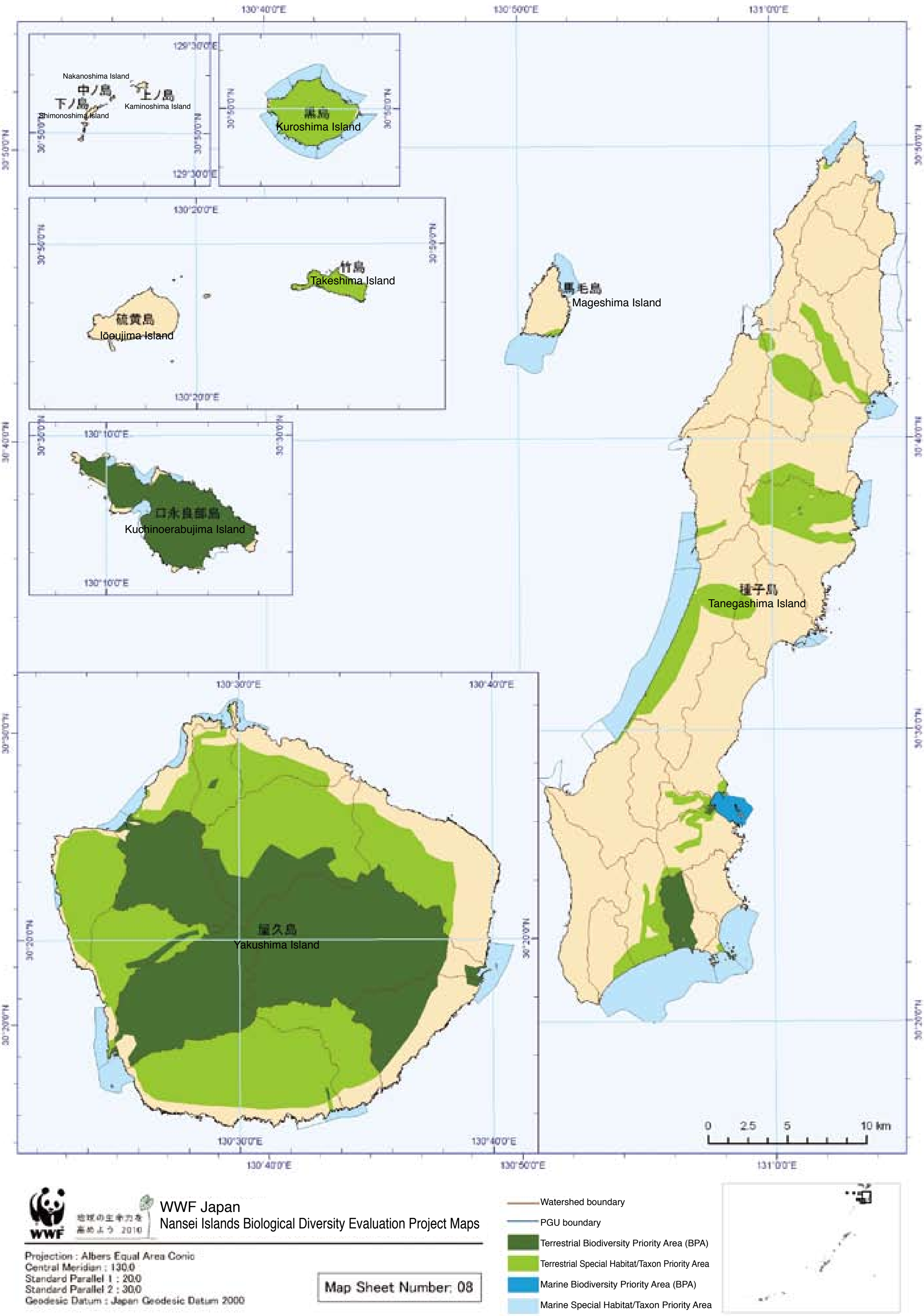
Number of occurrences of the eight TPA taxa and four ECH types per watershed yielded:
i. mammals, ii. birds, iii. amphibians/reptiles, iv. insects,
v. fish, vi. crustaceans, vii. mollusks, viii. freshwater algae
I. Natural vegetation in Fagetea crenatae regions
II. Natural vegetation in Camellietea japonicae regions
III. Secondary vegetation in Camellietea japonicae regions
IV. Riverbank, moor, salty marshland, and dune vegetation

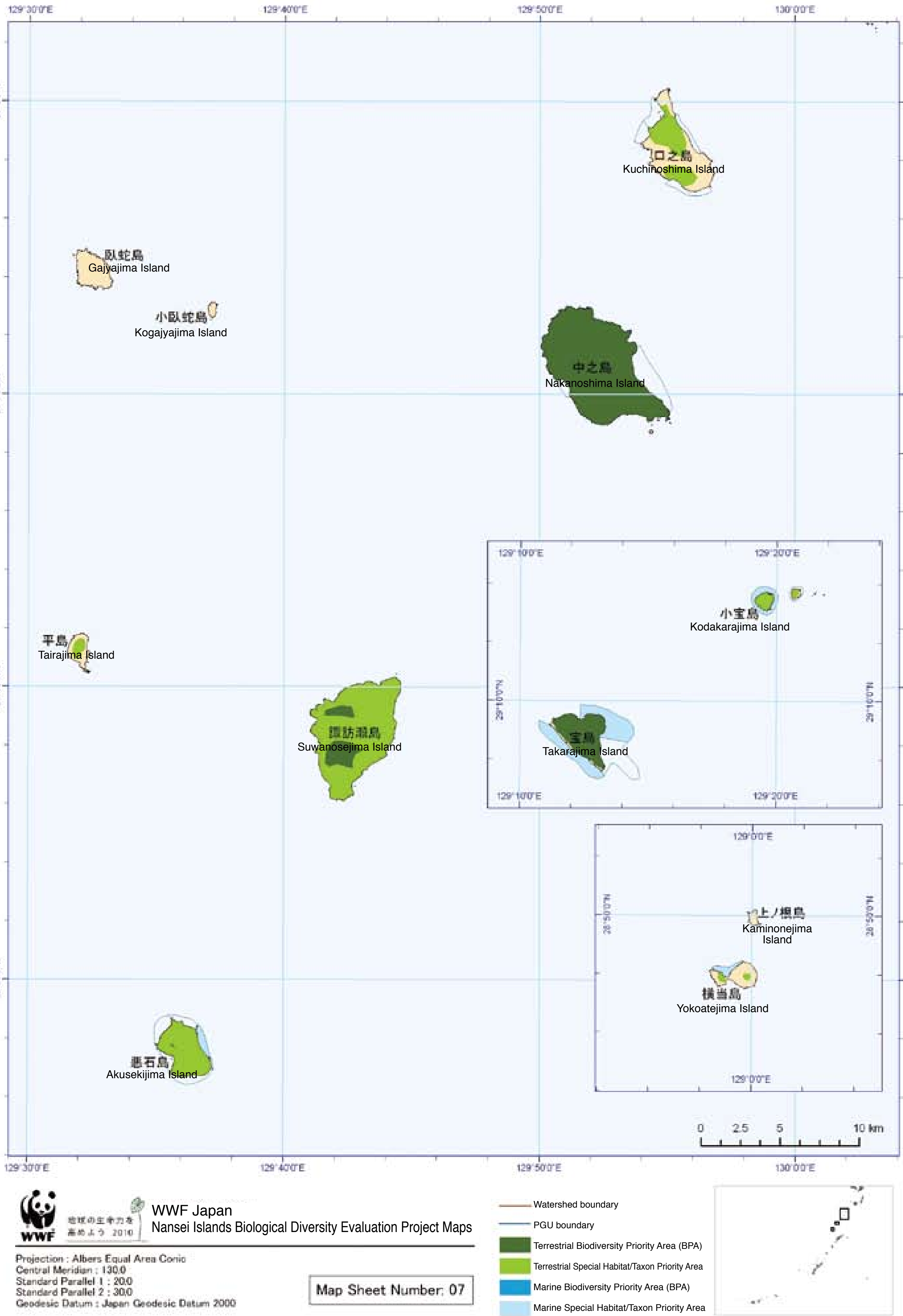
No. of marine area occurrences

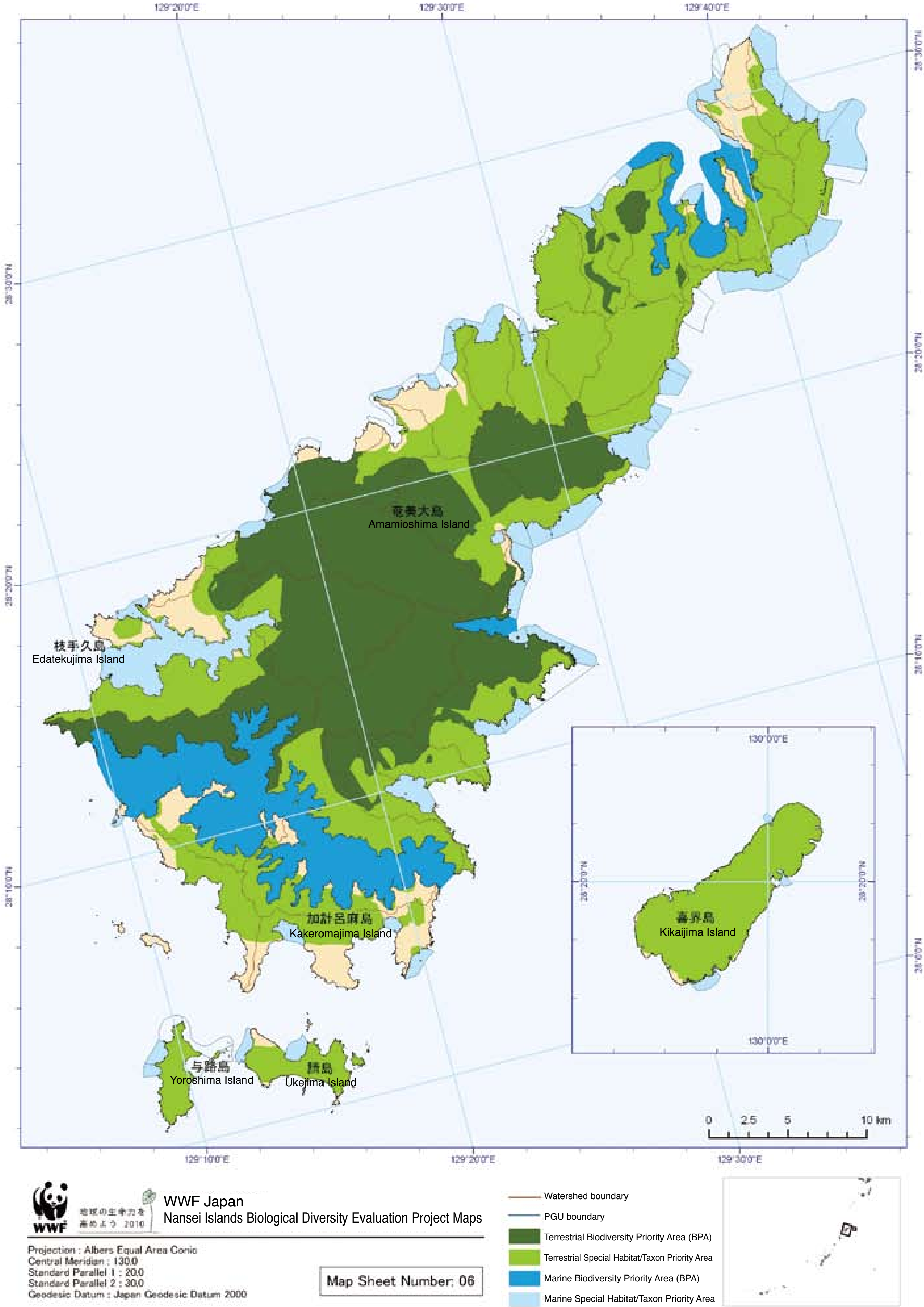
1, 2, 3, 4, 5, 6, 7, 8

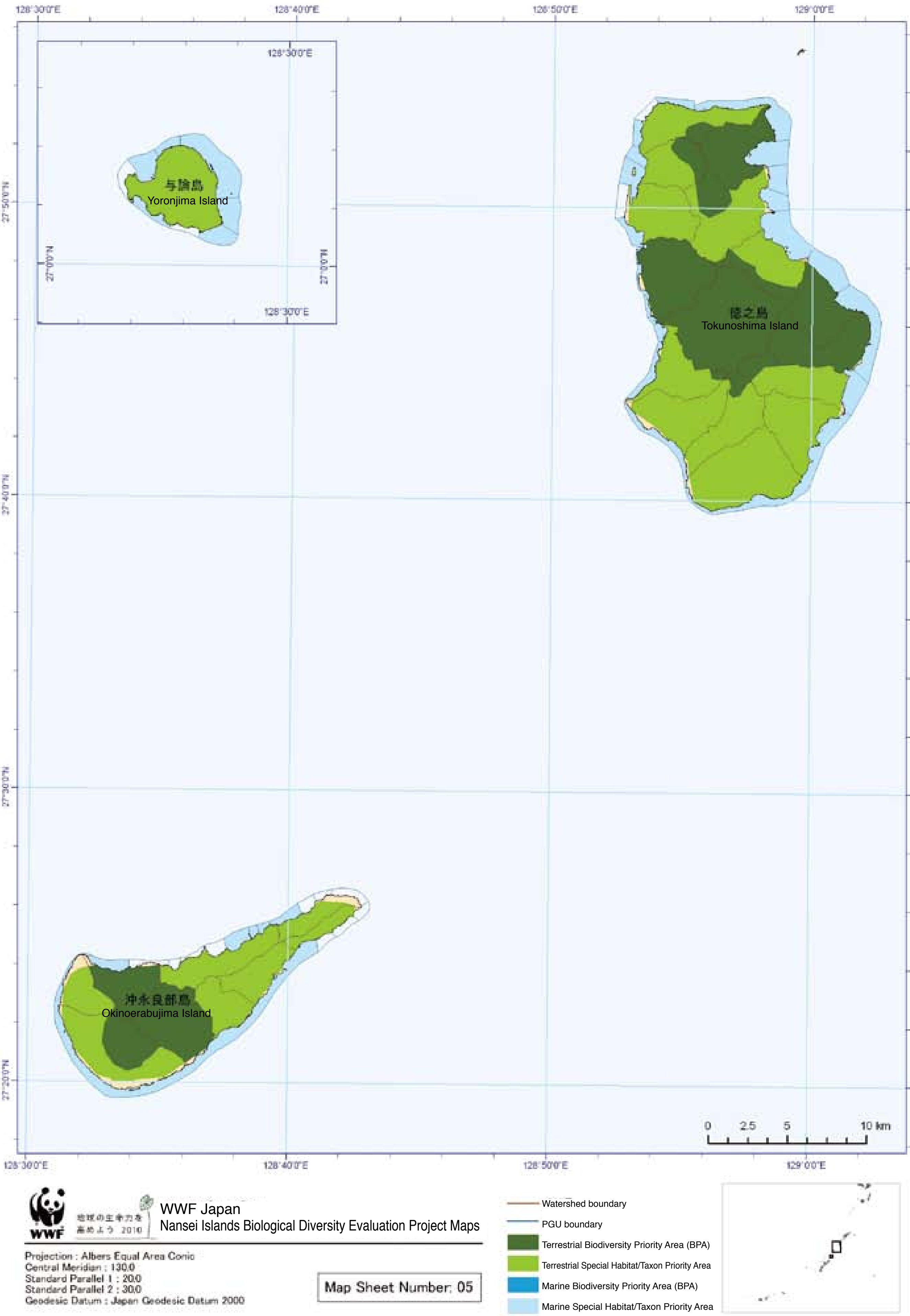
Number of occurrences of the six TPA taxa and five ECH types per PGU yielded:
i. mammals, ii. birds, iii. reptiles, iv. fish,
v. crustaceans, vi. mollusks.
I. Coral communities (reef slopes)
II. Coral communities (reef flats and moats)
III. Seagrass/algae beds
IV. Mangrove forests
V. Natural shores

Appendix I. BPA Maps




129°30'0"E
129°40'0"E
129°50'0"E
130°0'0"E
30°0'0"N
29°50'0"N
29°40'0"N
29°30'0"N
口之島
Kuchinoshima Island
臥蛇島
Gajyajima Island
小臥蛇島
Kogajyajima Island
中之島
Nakanoshima Island
平島
Tairajima Island
諏訪瀬島
Suwanosejima Island
悪石島
Akusekijima Island
129°10'0"E
129°20'0"E
29°10'0"N
小宝島
Kodakarajima Island
宝島
Takarajima Island
129°0'0"E
28°50'0"N
上ノ根島
Kaminonejima Island
横当島
Yokoatejima Island
0 2.5 5 10 km
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Map Sheet Number: 07
Watershed boundary
PGU boundary
Terrestrial Biodiversity Priority Area (BPA)
Terrestrial Special Habitat/Taxon Priority Area
Marine Biodiversity Priority Area (BPA)
Marine Special Habitat/Taxon Priority Area


129°20'0"E
129°30'0"E
129°40'0"E
28°30'0"N
28°20'0"N
28°10'0"N
28°40'0"N
28°30'0"N
28°20'0"N
28°10'0"N
奄美大島
Amamioshima Island
枝手久島
Edatekujima Island
加計呂麻島
Kakeromajima Island
与路島
Yoroshima Island
請島
Ukejima Island
喜界島
Kikaijima Island
130°0'0"E
28°20'0"N
0 2.5 5 10 km
129°10'0"E
129°20'0"E
129°30'0"E
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Map Sheet Number: 06
Watershed boundary
PGU boundary
Terrestrial Biodiversity Priority Area (BPA)
Terrestrial Special Habitat/Taxon Priority Area
Marine Biodiversity Priority Area (BPA)
Marine Special Habitat/Taxon Priority Area



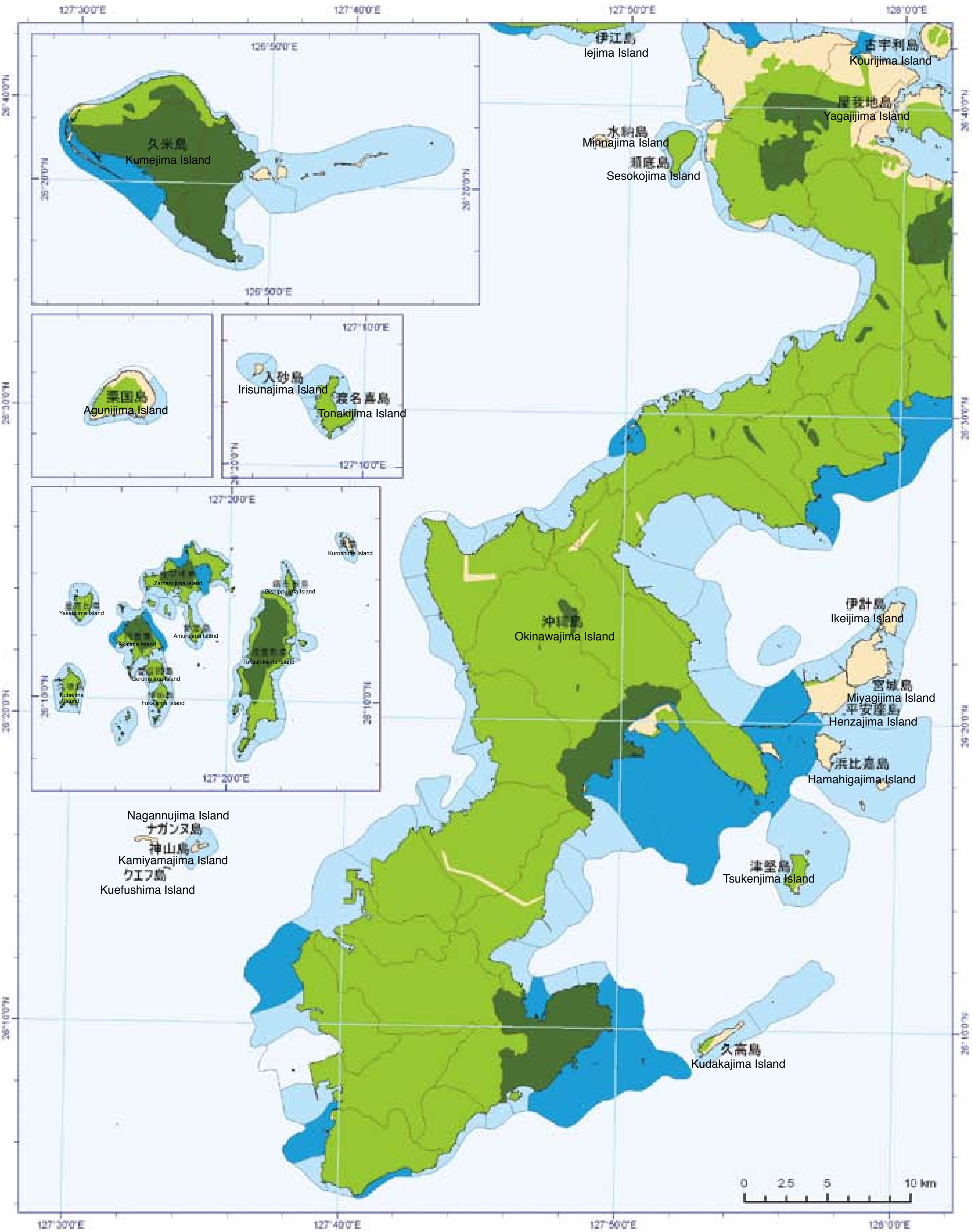
128°30'0"E
128°40'0"E
128°50'0"E
129°0'0"E
27°50'0"N
27°40'0"N
27°30'0"N
27°20'0"N
27°0'0"N
与論島
Yoronjima Island
徳之島
Tokunoshima Island
沖永良部島
Okinoerabujima Island
0 2.5 5 10 km
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Map Sheet Number: 05
Watershed boundary
PGU boundary
Terrestrial Biodiversity Priority Area (BPA)
Terrestrial Special Habitat/Taxon Priority Area
Marine Biodiversity Priority Area (BPA)
Marine Special Habitat/Taxon Priority Area

WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Map Sheet Number: 04

- Watershed boundary
- PGU boundary
- Terrestrial Biodiversity Priority Area (BPA)
- Terrestrial Special Habitat/Taxon Priority Area
- Marine Biodiversity Priority Area (BPA)
- Marine Special Habitat/Taxon Priority Area

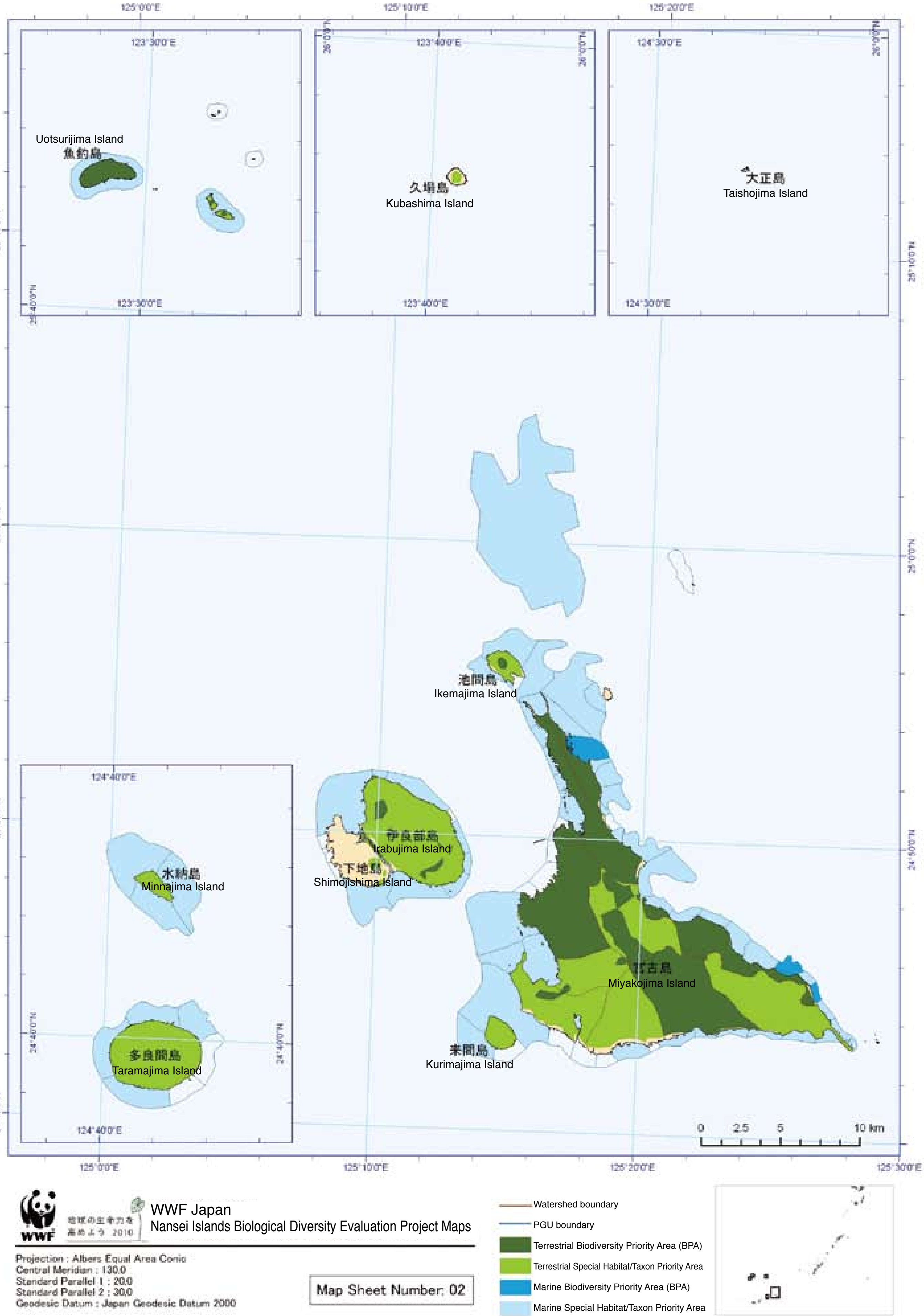


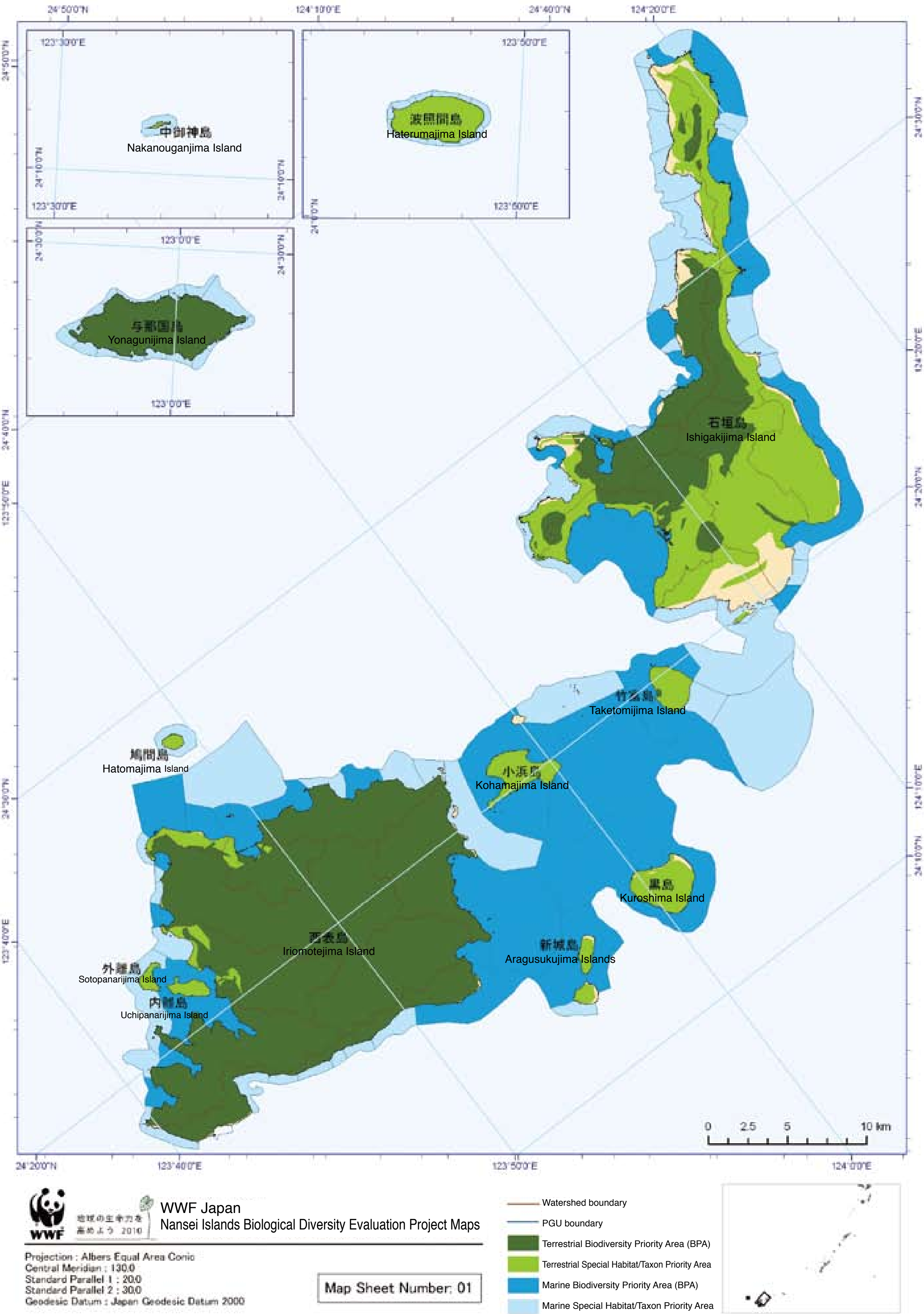
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Map Sheet Number: 03

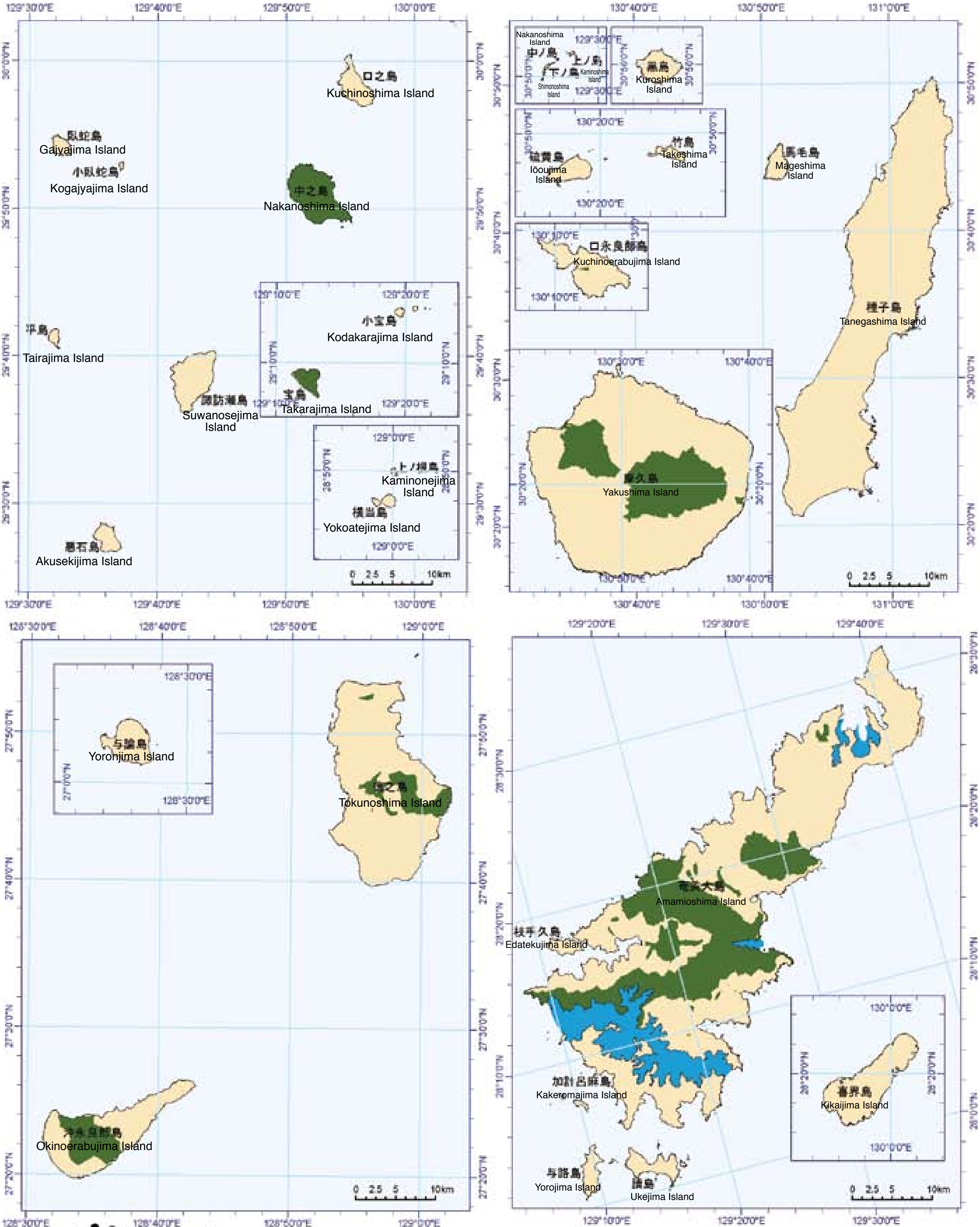
- Watershed boundary
- PGU boundary
- Terrestrial Biodiversity Priority Area (BPA)
- Terrestrial Special Habitat/Taxon Priority Area
- Marine Biodiversity Priority Area (BPA)
- Marine Special Habitat/Taxon Priority Area


Uotsurijima Island
魚釣島
久場島
Kubashima Island
大正島
Taishojima Island
池間島
Ikemajima Island
伊良部島
Irabujima Island
下地島
Shimojishima Island
水納島
Minnajima Island
多良間島
Taramajima Island
宮古島
Miyakojima Island
来間島
Kurimajima Island
0 2.5 5 10 km
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Map Sheet Number: 02
Watershed boundary
PGU boundary
Terrestrial Biodiversity Priority Area (BPA)
Terrestrial Special Habitat/Taxon Priority Area
Marine Biodiversity Priority Area (BPA)
Marine Special Habitat/Taxon Priority Area



中御神島
Nakanouganjima Island
波照間島
Haterumajima Island
与那国島
Yonagunijima Island
石垣島
Ishigakijima Island
竹富島
Taketomijima Island
鳩間島
Hatomajima Island
小浜島
Kohamajima Island
黒島
Kuroshima Island
西表島
Iriomotejima Island
新城島
Aragusukujima Islands
外離島
Sotopanarijima Island
内離島
Uchipanarijima Island
0 2.5 5 10 km
WWF Japan
Nansei Islands Biological Diversity Evaluation Project Maps
Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000
Map Sheet Number: 01
Watershed boundary
PGU boundary
Terrestrial Biodiversity Priority Area (BPA)
Terrestrial Special Habitat/Taxon Priority Area
Marine Biodiversity Priority Area (BPA)
Marine Special Habitat/Taxon Priority Area

Appendix J. Maps for Comparison (thresholds set at 10%, 20%, 40%, and 50%)



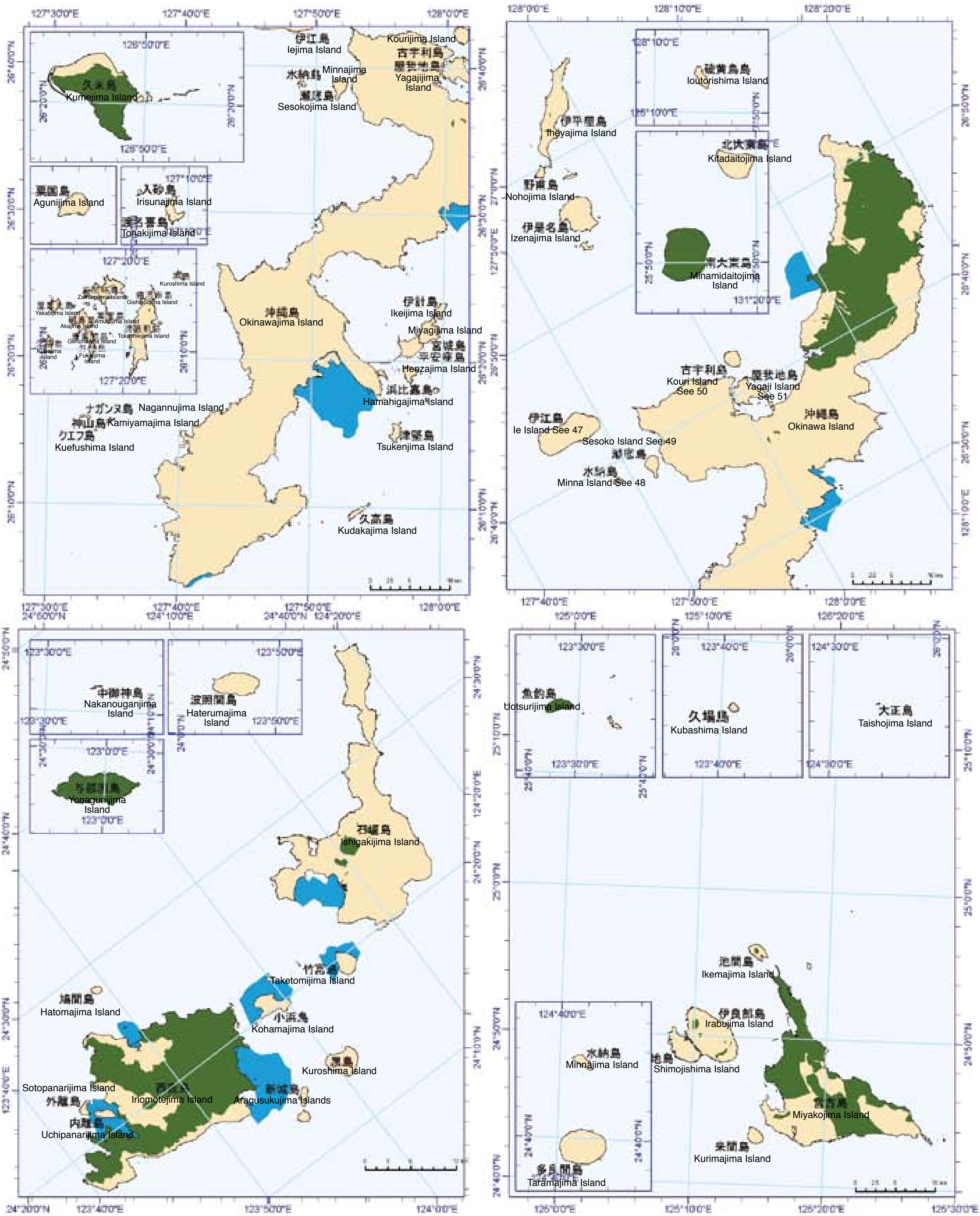
The Nansei Islands Biological Diversity Evaluation

Maps for Comparison (threshold at 10%)

Legend

- Terrestrial BPA's yielded with a threshold of 10%
- Marine BPA's yielded with a threshold of 10%

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000



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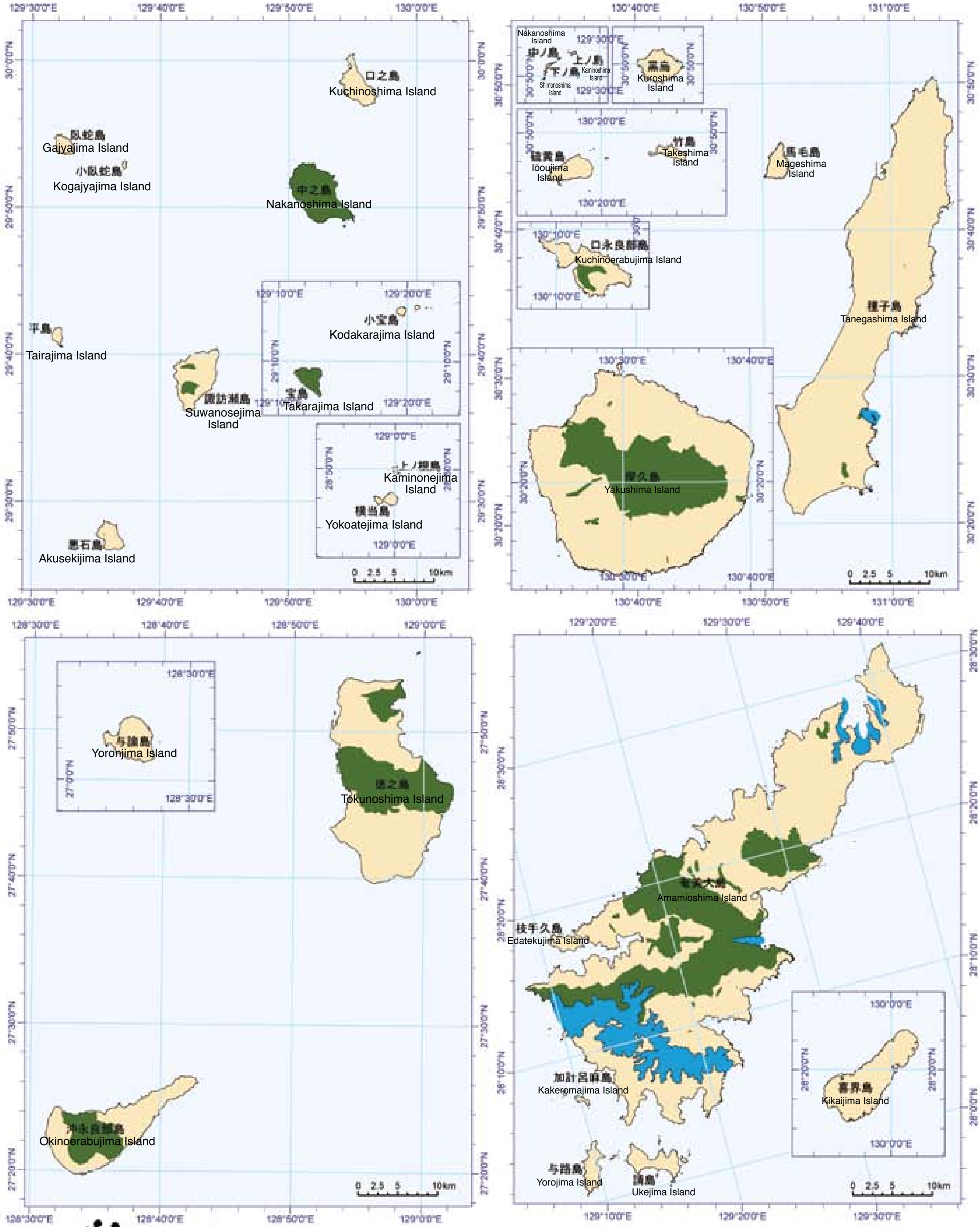
Maps for Comparison (threshold at 10%)

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Terrestrial BPA's yielded with a threshold of 10%

Marine BPA's yielded with a threshold of 10%



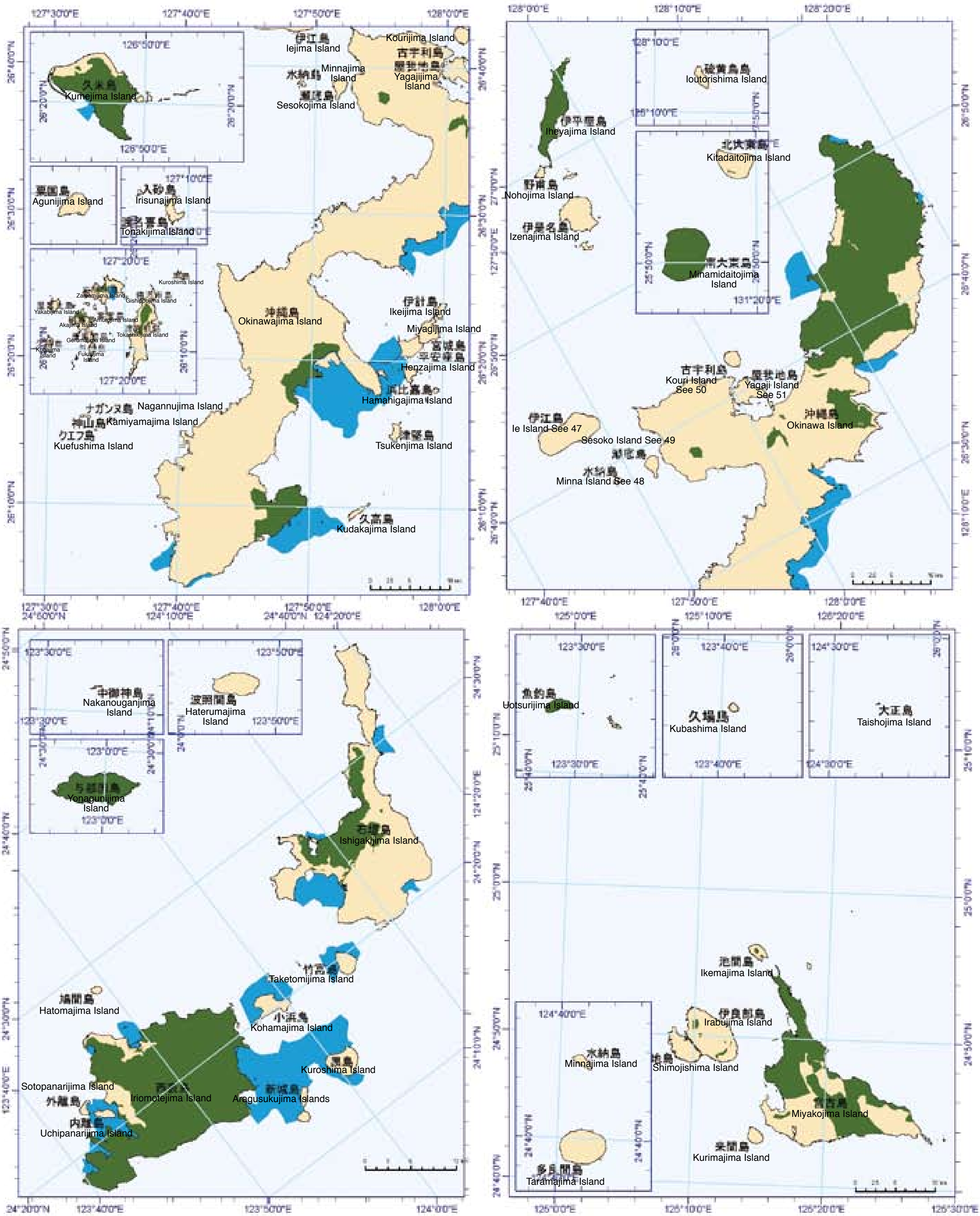
The Nansei Islands Biological Diversity Evaluation

Maps for Comparison (threshold at 20%)

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend

- Terrestrial BPA's yielded with a threshold of 20%
- Marine BPA's yielded with a threshold of 20%



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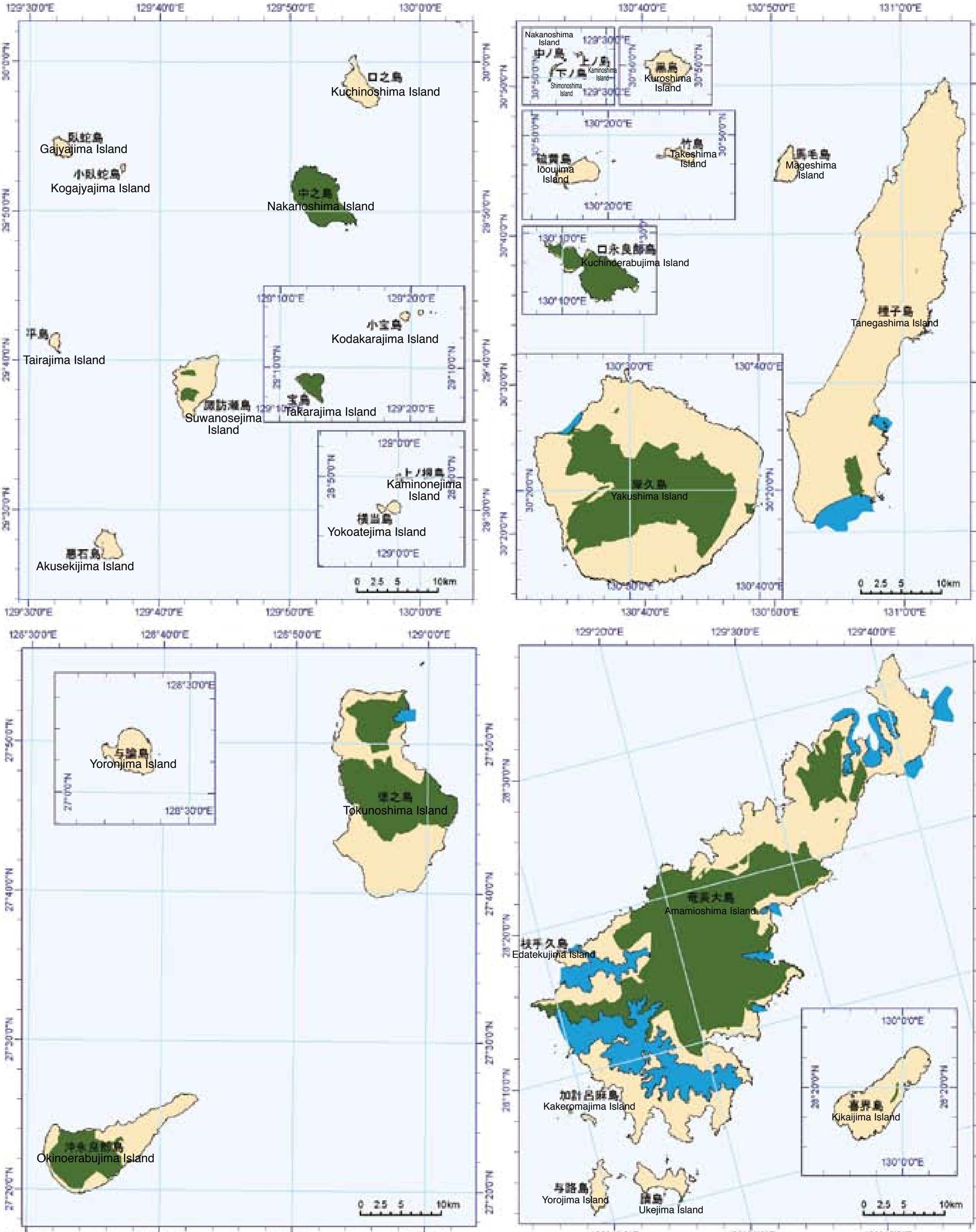
Maps for Comparison (threshold at 20%)

Terrestrial BPA's yielded with a threshold of 20%

Marine BPA's yielded with a threshold of 20%

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000



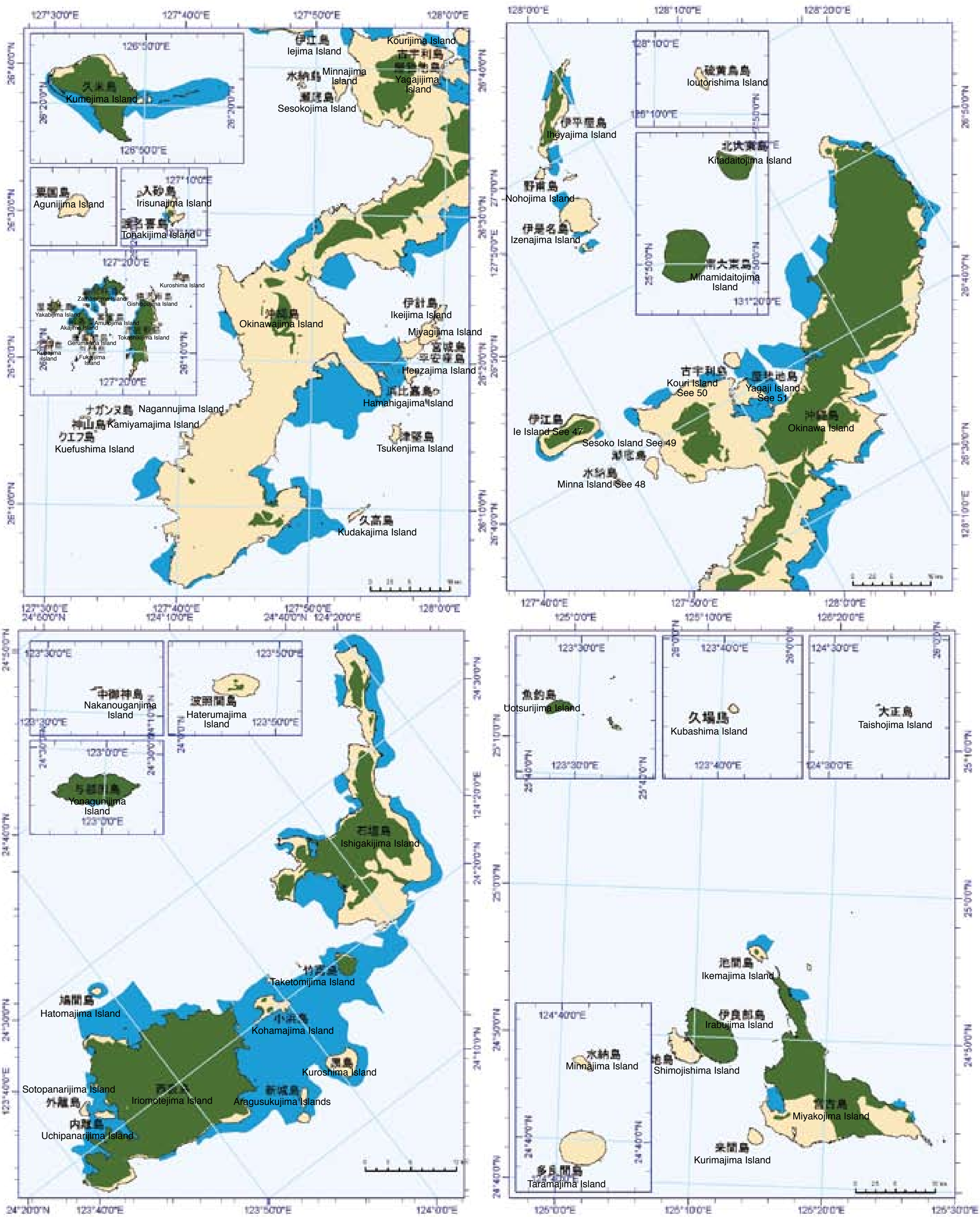
The Nansei Islands Biological Diversity Evaluation

Maps for Comparison (threshold at 40%)

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend

- Terrestrial BPA's yielded with a threshold of 40%
- Marine BPA's yielded with a threshold of 40%



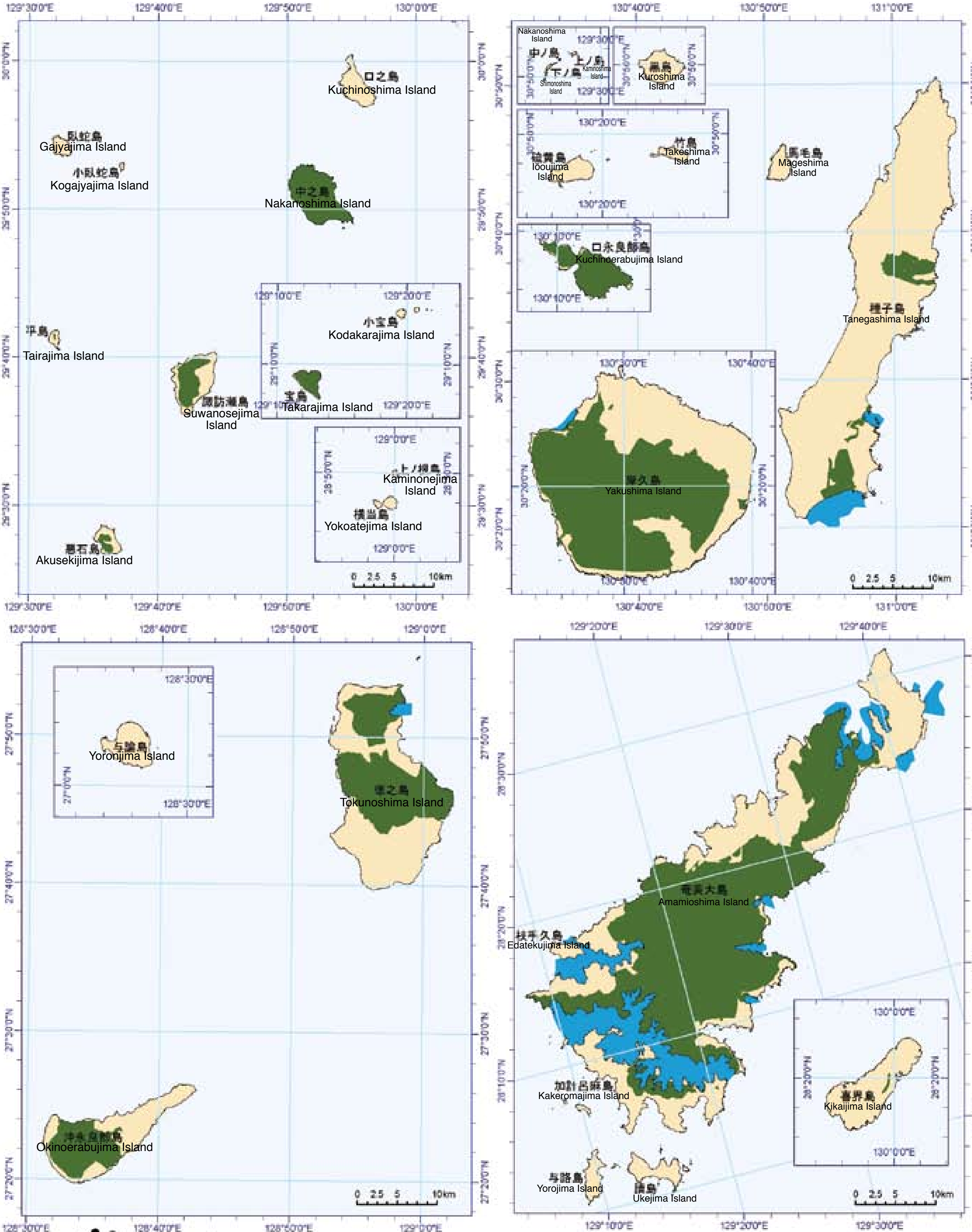
The Nansei Islands Biological Diversity Evaluation

Maps for Comparison (threshold at 40%)

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Terrestrial BPA's yielded with a threshold of 40%

Marine BPA's yielded with a threshold of 40%



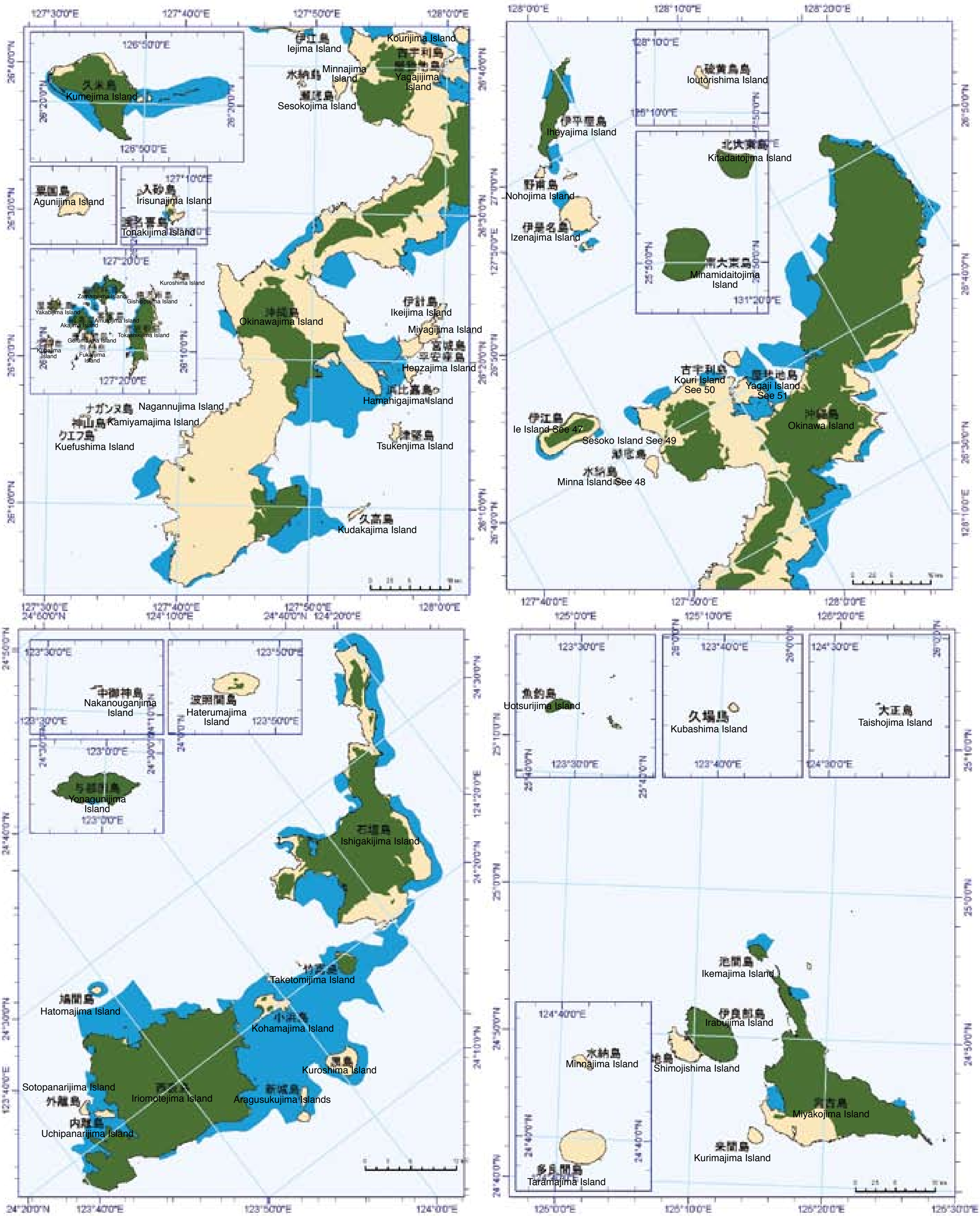
The Nansei Islands Biological Diversity Evaluation

Maps for Comparison (threshold at 50%)

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Legend

- Terrestrial BPA's yielded with a threshold of 50%
- Marine BPA's yielded with a threshold of 50%



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The Nansei Islands Biological Diversity Evaluation

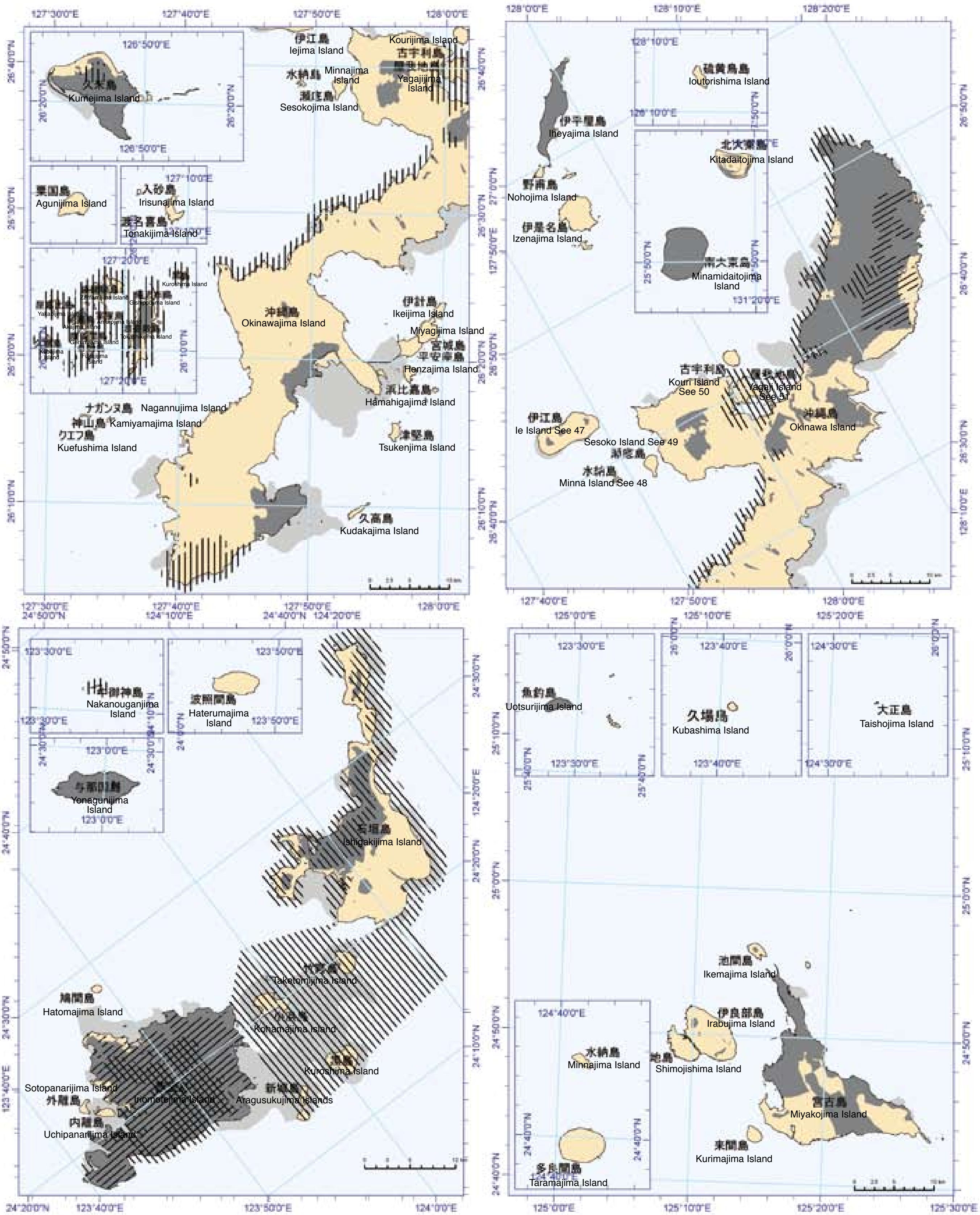
Maps for Comparison (threshold at 50%)

Terrestrial BPA's yielded with a threshold of 50%

Marine BPA's yielded with a threshold of 50%

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

Appendix K. Protected Areas/National Forests



The Nansei Islands Biological Diversity Evaluation

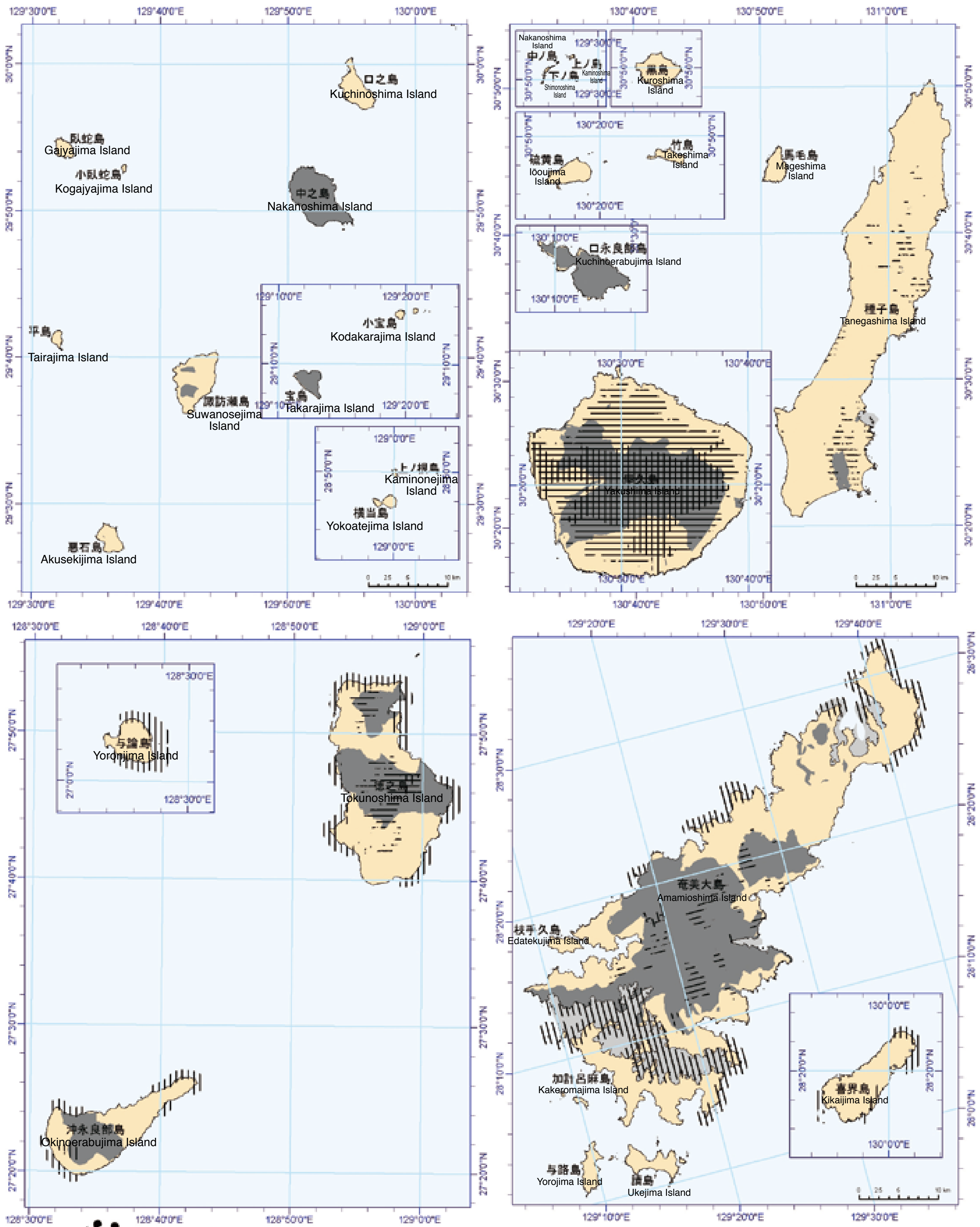
Overlaps with Protected Areas/National Forests

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

These maps indicate areas thought to be important based on information available at the time of this project. They do not exhaustively indicate important areas for species of organisms overall.

Legend

- Protected Areas (lines running parallel to the meridian lines)
- National Forests (lines running parallel to the latitude lines)
- Terrestrial BPA's
- Marine BPA's



The Nansei Islands Biological Diversity Evaluation

Overlaps with Protected Areas/National Forests

Projection : Albers Equal Area Conic
Central Meridian : 130.0
Standard Parallel 1 : 20.0
Standard Parallel 2 : 30.0
Geodesic Datum : Japan Geodesic Datum 2000

These maps indicate areas thought to be important based on information available at the time of this project. They do not exhaustively indicate important areas for species of organisms overall.

Legend

- Protected Areas (lines running parallel to the meridian lines)
- National Forests (lines running parallel to the latitude lines)
- Terrestrial BPA's
- Marine BPA's

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Acknowledgements

This project provided us with the maps which show biodiversity priority areas in Nansei Islands, Japan. It had been questioned whether this kind of maps ought to be released or not even since the planning stage of this project. There are concerns that the non-priority areas may be mistaken for (or intentionally misinterpreted as) areas for development which are not worth protecting. However, even without any time or technological limit, drawing perfect maps which are completely free from these concerns would be impossible. Instead, it is important that the interested persons who protect or use the areas will utilize these maps as a shared tool for making discussions, we believe.

This project was carried out with the participation and cooperation of many specialists and government officials. We would like to express our deep appreciation to all the people who had been engaged in this project for three years despite our failings and lack of ability.

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◆Photo Credits

Kawauchi Norihiro; Maezono Yasunori; Yasuda Masahiro; Yasumura Shigeki

◆Collaborating Organizations

KYUSYU Regional Forest Office, Forestry Agency, Japan; Kagoshima District Forest Office, Forestry Agency, Japan; Okinawa District Forest Office, Forestry Agency, Japan; Iriomote Forest Environment Conservation Center, Forestry Agency, Japan; Biodiversity Policy Division, Ministry of the Environment, Japan; Biodiversity Center of Japan, Ministry of the Environment, Japan; Amami Ranger Office, Ministry of the Environment, Japan; Naha Nature Conservation Office, Ministry of the Environment, Japan; Nature Conservation Division, Kagoshima Prefectural Government, Japan; Nature Conservation Division, Okinawa Prefectural Government, Japan; Okinawa Coral Reef Conservation Council; Ishigaki City, Japan; Amami Chamber of Commerce & Industry; Amami Tourists Liaison Council; Amami Ornithologists' Club; Aero Photo Center; Naigai Map Co., Ltd.

◆Supporting Organizations

SOFTBANK MOBILE Corp., Pro Natura Foundation-Japan

◆Abbreviations

BPA	Biodiversity Priority Area
CBD	Convention on Biological Diversity
COP	Conference of Parties
COT	Crown Of Thorns Starfish
ECH	Ecologically Critical Habitat
GIS	Geographic Information System
MPA	Marine Protected Area
NGO	Non Governmental Organization
PGU	Physio-Graphic Unit
RDB	Red Data Book
TPA	Taxon Priority Area

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Nansei Islands Biological Diversity Evaluation Project Report

Editor: Shigeki Yasumura, WWF Japan

Layout: Makoto Iwai

Published in April 2010 by WWF Japan.

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