OIST

Marine Science

Research, Conservation, Education

Credit: Gyorgy Kiss

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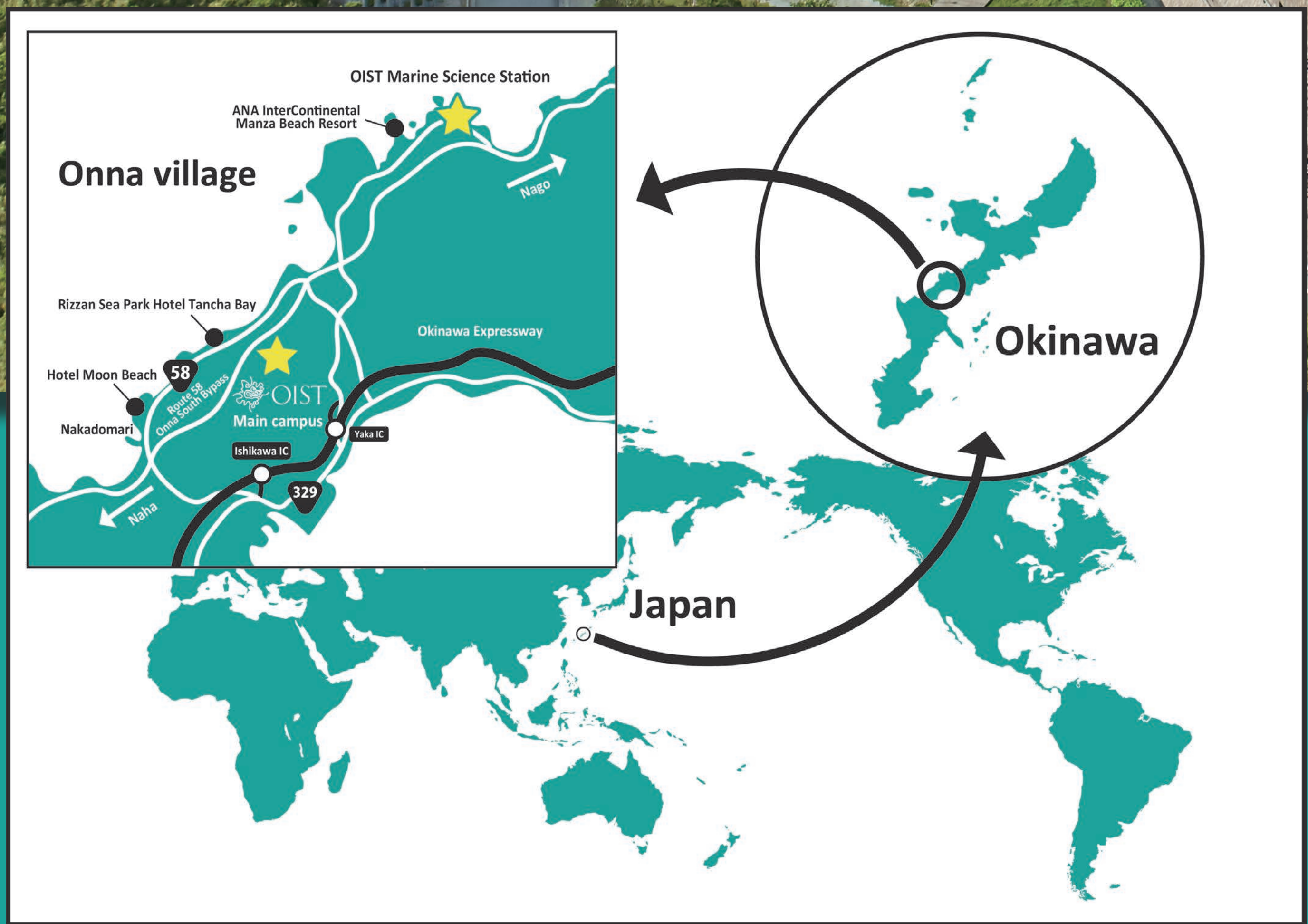

Okinawa Institute of Science and Technology Graduate University
Aerial view of the OIST main campus

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Okinawa, Japan 904-0495

Design: Kaori Serakaki

Message from the President

The ocean covers more than 70% of the Earth's surface and produces more than 50% of the world's oxygen. Yet this vast and vital territory holds mysteries that scientists are only beginning to explore.

Understanding the ocean is critical to tackling some of the greatest challenges facing the world today, such as climate change, biodiversity loss, and how humans affect Earth's ecosystems.

Here at Okinawa Insititute of Science and Technology Graduate University (OIST), we are building a world-class environment for marine science research and education. The OIST Marine Science Station is home to top-level scientists from around the world. We now have nine research units whose work spans a wide range of topics, including climate change, genetics, marine biophysics, and more. Our marine laboratories are equipped with technologically-advanced research facilities and staffed by research support experts poised to empower the innovative, interdisciplinary research that is characteristic of OIST.

Okinawa's unique location, surrounded by the Pacific Ocean on one side and the East China Sea on the other, makes it a perfect place to study marine science. The island is home to a rich and diverse array of marine environments, including beautiful coral reefs, peaceful mangrove forests and deep-sea hydrothermal vents.

Marine science research at OIST has the potential not only to deepen our knowledge of the ocean and its inhabitants, but also to inform strategies for conserving marine environments and resources on both a local and global scale.

President
Okinawa Institute of Science and Technology Graduate University

Peter Gruss

Corals are animals made of several individual polyps. Symbiotic microbes live inside the coral tissue and provide it with nutrients and other benefits.

Evolution, Cell Biology, and Symbiosis Unit

Professor Filip Husnik
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"Through conducting studies in the field, in the lab, and with computers, my Unit tries to understand how symbiotic interactions between multiple species originate, how the symbionts are maintained at the cellular level over hundreds of millions of years, and how they eventually either become organelles within cells, or go extinct."

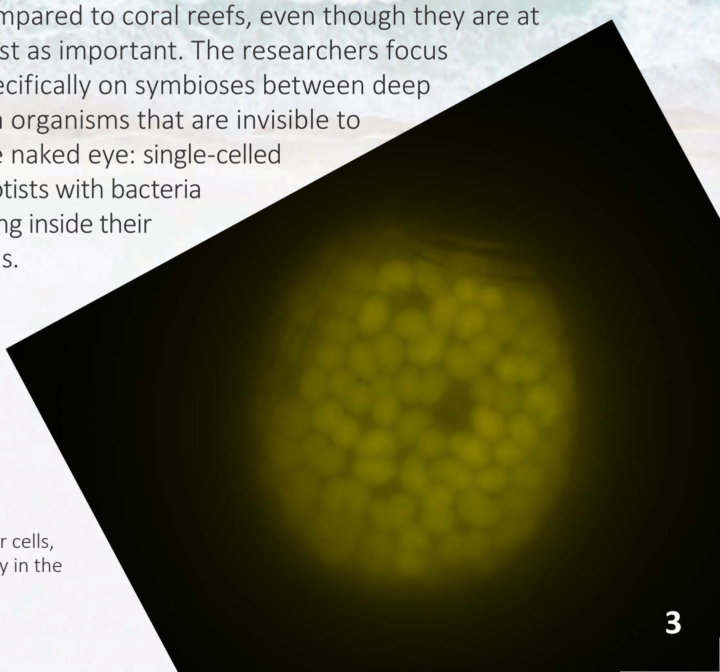
- Professor Filip Husnik

The Evolution, Cell Biology, and Symbiosis Unit studies how symbiosis – a very tight interaction between two or more unrelated organisms – affects evolution. The researchers within this Unit are particularly fascinated by how symbiosis drives major evolutionary innovations, such as the origin of the eukaryotic cell and its compartments of bacterial origin; mitochondria and plastids. However, they also study numerous other, more recent, symbiotic interactions among bacteria, archaea, single-celled eukaryotes (protists), plants, and animals.

This research lies at the interface of evolutionary biology, cell biology, genomics, microbiology, and biochemistry. Not all the research projects relate to marine science, but the researchers especially enjoy studying two marine ecosystems easily accessible from Okinawa and OIST: coral reefs and the deep sea.

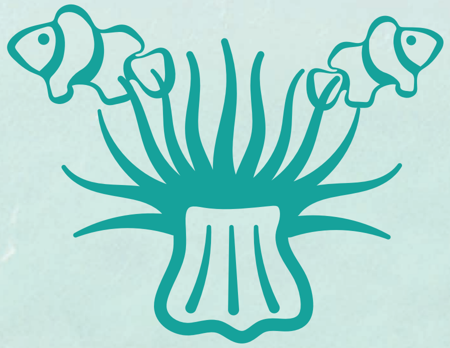
Coral reefs are among the most diverse ecosystems on the planet, and a beneficial symbiosis between coral and a type of microalgae, known as zooxanthellae, sustains them. In this symbiosis, the coral polyps serve as houses for the zooxanthellae, which, in return, provide photosynthetic products to their hosts – allowing corals to thrive in ocean waters that are generally poor in nutrients. Zooxanthellae are corals' most common symbionts, but corals also form other symbiotic interactions with microbial eukaryotes such as corallicolids, bacteria, and archaea. The research in OIST's Evolution, Cell Biology, and Symbiosis Unit focuses especially on these other, less understood, symbioses.

The second symbiotic oasis the researchers study is the deep sea. Unlike coral reefs, this ecosystem is almost lightless, so many deep-sea microorganisms use inorganic compounds such as hydrogen gas or hydrogen sulfide as their source of energy for chemosynthesis. This environment is also teeming with life, and symbiotic interactions are one of the main reasons why. Unfortunately, knowledge about the functioning of deep-sea communities is lacking compared to coral reefs, even though they are at least as important. The researchers focus specifically on symbioses between deep sea organisms that are invisible to the naked eye: single-celled protists with bacteria living inside their cells.



Single-celled eukaryotes (protists) often house other microbes inside their cells, but the functional role of these symbioses is poorly understood, especially in the deep sea.

It takes about 15 days for an *A. ocellaris* larva (left) to metamorphose into a juvenile.
Credit: Natacha Roux



Marine Eco-Evo-Devo Unit

Professor Vincent Laudet
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“My Unit investigates the evolution of metamorphosis – that is, the transformation of a larva into a juvenile – in coral reef fish. We are particularly interested in three areas: how hormonal signals shape the course of an organism’s evolutionary history, how the environment shapes an organism’s developmental trajectory, and how color patterns develop and evolve specific functions.”

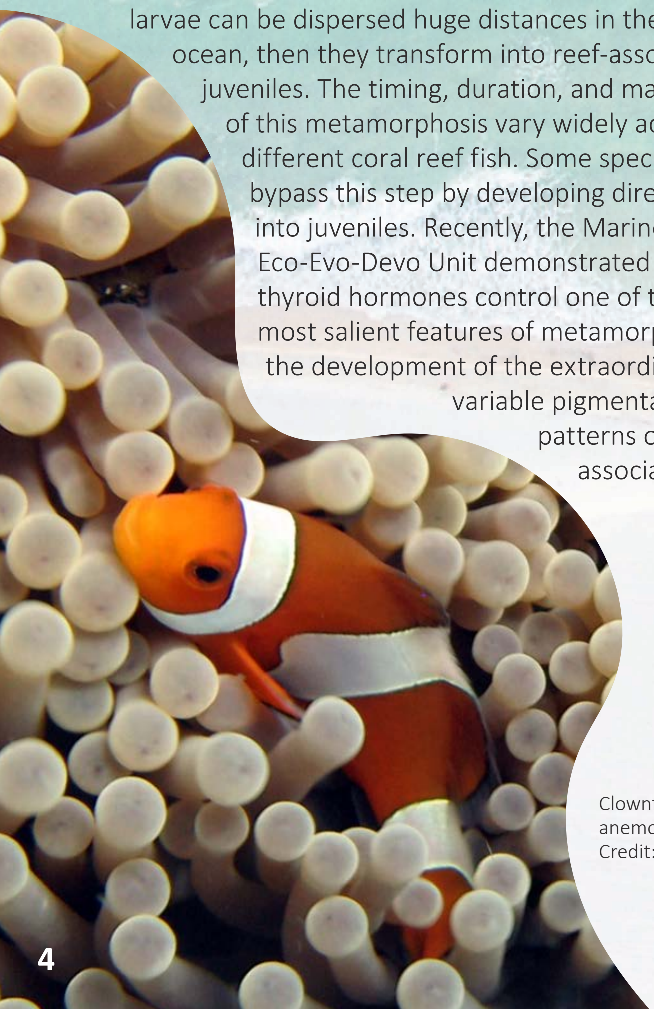
- Professor Vincent Laudet

Most coral reef fish have a two-part lifecycle. They first go through a pelagic larval phase, in which larvae can be dispersed huge distances in the open ocean, then they transform into reef-associated juveniles. The timing, duration, and magnitude of this metamorphosis vary widely across different coral reef fish. Some species even bypass this step by developing directly into juveniles. Recently, the Marine Eco-Evo-Devo Unit demonstrated that thyroid hormones control one of the most salient features of metamorphosis: the development of the extraordinarily variable pigmentation patterns of reef-associated fish. The effect of these hormones on fish color patterns varies widely. In some species, such as the common clownfish (*Amphiprion ocellaris*), the thyroid hormone regulates pigmentation, whereas in others, such as the manini (*Acanthurus triostegus*), it does not.

Researchers within this Unit combine ecological fieldwork, functional analysis, and genomics and transcriptomics to explore how hormones control metamorphosis in these two species. They are also studying the life history of *A. ocellaris*, to establish it as a new model species for the research community.

In a separate line of work, the researchers are comparing global gene expression during metamorphosis in different fishes to understand their different strategies. They focus on fishes like batfish and groupers, as well as on several species of gobies – small freshwater fish whose larvae migrate between fresh and salt water and who exhibit highly diverse life histories in Okinawa waters.

Researchers within this Unit are also investigating the symbiotic relationship between anemonefishes and sea anemones. They study the evolutionary history of this relationship by characterizing sea anemone genomes and by exploring how the sea anemone host affects the pigmentation and metabolism of anemonefishes.



Clownfish in their sea anemone in Bali.
Credit: Marleen Klann

Genomics and Regulatory Systems Unit

Professor Nicholas Luscombe
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Okinawan coastal waters are rich in undescribed zooplankton which the Unit samples using plankton nets.

“Through international collaborations, we are characterizing diverse zooplanktonic populations from around the world. By applying the insights gained at the molecular level to whole organisms, populations, and ecosystems, we will better understand the outstanding ecological significance of these animals, which will be increasingly important as the world’s climate continues to change.”

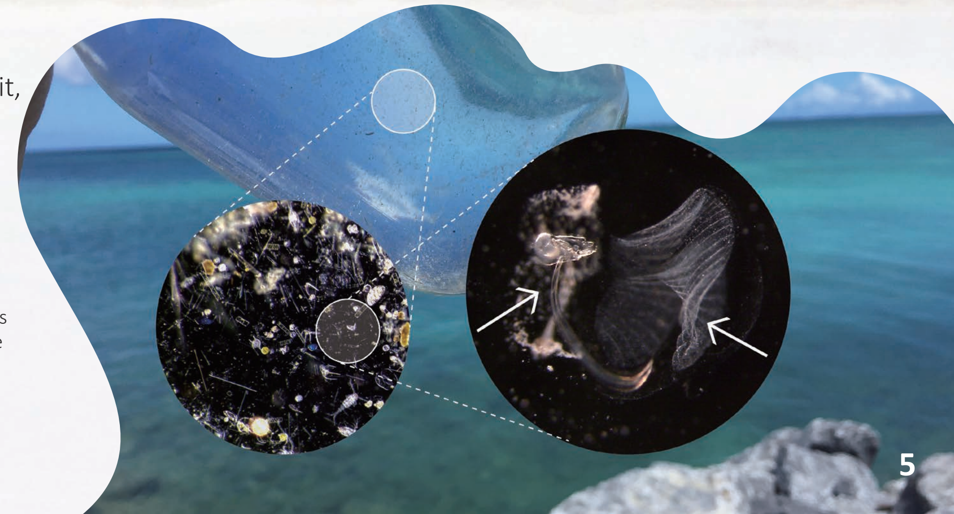
- Professor Nicholas Luscombe

Researchers within this Unit study the genomics and ecological interactions of cosmopolitan marine zooplankton. Marine zooplankton are a diverse group of organisms found in all the world’s oceans and serve as a key food source for many animals. Their tremendous abundance contributes a significant portion of global biomass and acts as an important carbon sink. Although zooplankton occupy crucial positions in marine food webs, relatively little is known about their genetic diversity and population structures.

Larvaceans are a particularly interesting type of zooplankton. They are free-living filter-feeders that comprise up to 10% of planktonic biomass. Their bodies – commonly less than a centimeter in size – consist of a trunk and a tail, and they live within a complex house that they create from cellulose and other adhesive materials. Using currents generated by the tail, these organisms use their house to filter particles of food from seawater. Despite their tadpole-like appearance, larvaceans are among the closest living relatives of vertebrates among zooplankton (for example, their tails contain a nerve cord like vertebrate spinal cord).

In the Genomics and Regulatory Systems Unit, researchers have established specialized methods for sampling larvaceans in the ocean and cultivating them in the lab. In the waters surrounding Okinawa, they have discovered previously undescribed species, including giant larvaceans and those of diverse colors. Even the Okinawan larvaceans that look similar to those from elsewhere in Japan possess completely different genomes, highlighting the uniqueness of our local ecosystems.

The Unit integrates genomics, molecular biology, and computational biology to investigate what kinds of larvaceans there are, both in Okinawa and globally, as well as how their genetics relate to their behaviors and roles in the marine ecosystem. DNA sequencing technologies in their lab and at the OIST sequencing facility allows them to sequence the genome of these animals. To do so requires analyzing a tremendous amount of data, for which they employ OIST supercomputing facilities. They then apply advanced statistical analysis to understand how the genetic properties relate to physical characteristics such as sensitivity to sea water temperatures, and response to pollutants like microplastics.



Each glass of seawater contains an amazing collection of plankton, which can be observed under a microscope (left inset). The researchers are especially fascinated by larvaceans which are tadpole-shaped animals (left arrow) that live inside self-constructed cellulose houses that they use for filter-feeding (right arrow).

A garden eel in a tank specially designed to replicate naturally occurring ocean currents.

Marine Biophysics Unit

Professor Satoshi Mitarai
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“My Unit investigates how physical forces at play in the ocean – such as waves, currents, and typhoons – shape the biology of marine organisms. Through this research, we aim to help promote the conservation of three unique ecosystems abundant in the waters surrounding Okinawa: coral reefs, mangrove forests and deep-sea hydrothermal vents.”

- Professor Satoshi Mitarai

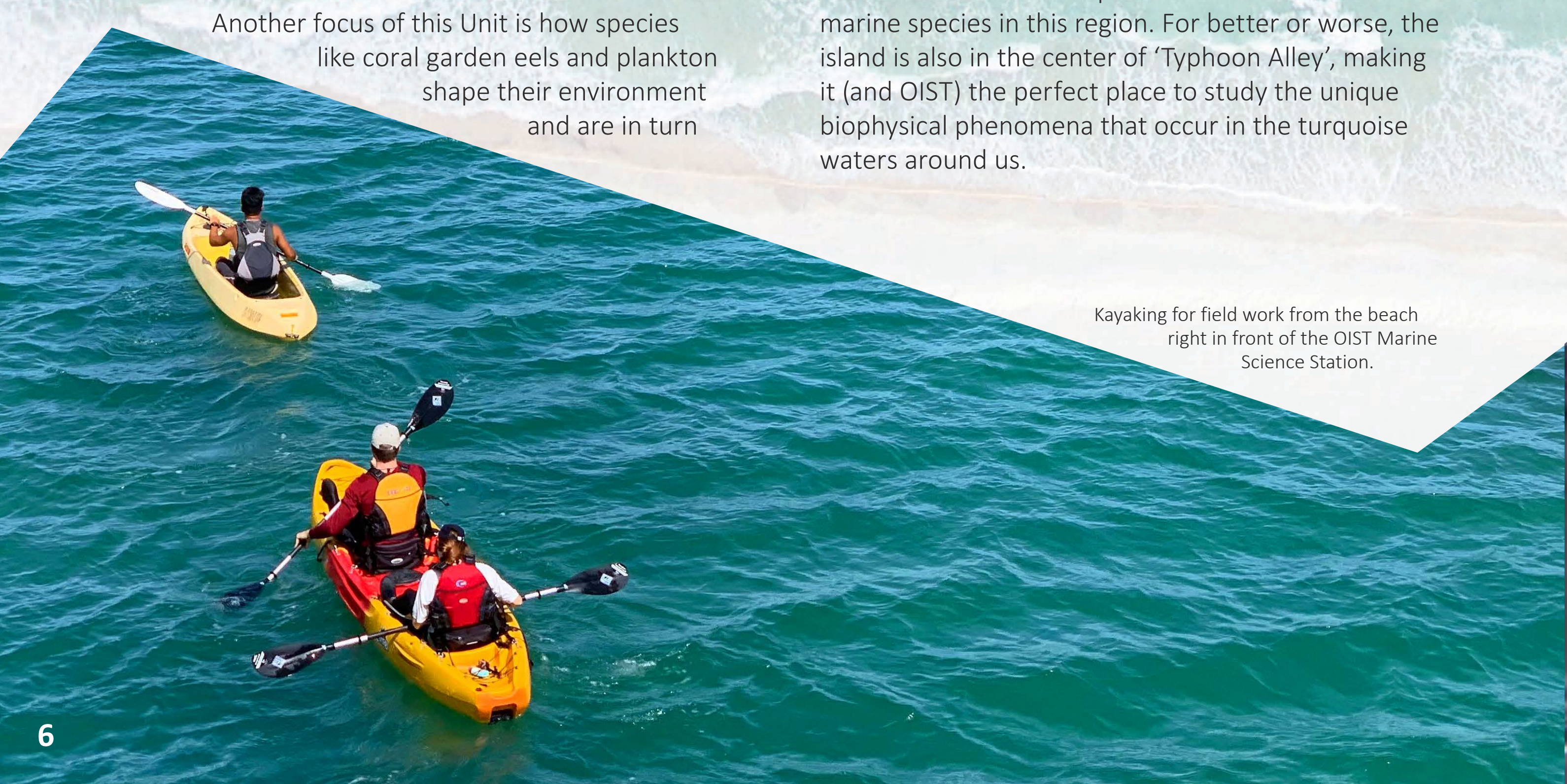
The Marine Biophysics Unit integrates biochemistry, hydrodynamics, genomics, marine ecology, and other disciplines to understand how environmental changes affect the dynamics of marine ecosystems.

These ecosystems are often separated by hundreds of kilometers of open ocean, and many marine species that inhabit them rely on currents to disperse juveniles across these distances to extend their populations. The researchers within the Marine Biophysics Unit study how the physics of ocean currents and the biology of these species make this dispersal possible. They also investigate the genetic connectivity between these scattered populations of marine organisms to better understand these species' ecological history and to design an optimal network of marine protected areas.

Interactions between biology and physical oceanography occur not only across large distances but also on the scale of individual animals and bacteria. Another focus of this Unit is how species like coral garden eels and plankton shape their environment and are in turn affected by it. For example, the surface of planktonic marine bacteria may influence how efficiently they pull nutrients from seawater, while environmental parameters may also affect the bacteria's surface structures and overall health.

The researchers also study how the ocean interacts with human activities. For example, human land use on Okinawa island results in soil washing into the coastal coral lagoons, a process known locally as 'red-soil runoff'. The biological response to the presence of this red soil in the ocean has complex effects on ocean life and may also have implications for human health. The researchers combine field observations and highly controlled experiments in the field to explore this interaction and to identify ways to protect vulnerable ecosystems near Okinawa and around the world.

Okinawa is adjacent to the 'Kuroshio' current, a warm-water current that is responsible for the diverse marine species in this region. For better or worse, the island is also in the center of 'Typhoon Alley', making it (and OIST) the perfect place to study the unique biophysical phenomena that occur in the turquoise waters around us.



Kayaking for field work from the beach right in front of the OIST Marine Science Station.

Marine Climate Change Unit

Professor Timothy Ravasi
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“Understanding the resilience of fish populations in coral reefs to environmental changes – both in Okinawa and worldwide – will allow for better protection of these ecosystems. To develop this understanding, my Unit collaborates extensively with colleagues at OIST, at other national and international universities, and in government agencies such as the Okinawa Prefectural Sea Farming Centre.”

- Professor Timothy Ravasi

The Marine Climate Change Unit aims to understand how coral reef fish adapt to environmental changes such as climate change, heatwaves, overfishing, and urbanization. Earth's oceans are warming and acidifying due to increasing anthropogenic CO_2 production, and extreme events such as marine heatwaves are increasing in frequency, duration and magnitude. Coral reef fish are especially vulnerable to spikes in temperature because they are already living close to their thermal limits. Determining which species can adapt to rapid environmental change, and how they will do so, is critical for predicting the ecological effects of climate change and their impact on the world economy.

In the laboratory, the researchers investigate how short term changes, as well as heritable changes in gene expression in multiple fish species are affected by increases in sea level temperature and acidity. They study animals that are descended from wild breeding pairs and have been reared in OIST's aquariums over several generations. Using a unique device called the Heatwaves Simulator aquarium system based at OIST's Marine Science Station, they expose fish to specific conditions, including the temperature and acidity level predicted to occur in seawater by the end of the century. They combine these manipulations with a range of advanced genomic technologies to identify the cellular mechanisms that allow coral reef fish communities in Okinawa, and around the world, to acclimate and adapt to changing conditions.

The researchers also investigate how different fish populations adapt to changes in their natural ecosystems. Recently, they gained access to several global locations at which natural volcanic CO_2 seeps located in coral reefs bubble out to act as analogues of climate change. These sites include Iwotorishima and Shikine Islands in Japan, Milne Bay in Papua New Guinea, Bouraké Bay in New Caledonia, and White Island in New Zealand. There, CO_2 dissolves into the seawater surrounding the reef, creating a natural laboratory for studying the effects of projected future ocean acidification on tropical fish communities.

Billy Moore, a student from the Marine Climate Change Unit, tests the metabolic performance of the local clownfish species, *Amphiprion ocellaris*, under a heatwave scenario.

Computational Neuroethology Unit

Professor Sam Reiter
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A squid viewed from the top. Its large brain is visible underneath its transparent skin, slightly behind its green eyes.

An octopus adopts a bold skin pattern after catching a crab to eat. In addition to their other functions, cephalopod skin patterns potentially reflect emotional states like excitement.

“ OIST provides an ideal setting for this work. The ocean surrounding Okinawa contains among the greatest numbers of cephalopod species worldwide. Within five kilometers of OIST we can study cephalopods in the field and bring them into the lab. ”

- Professor Sam Reiter

The Computational and Neuroethology Unit is interested in uncovering general principles of animal behavior and its neural basis. The researchers study coleoid cephalopods, a group of marine invertebrates that includes octopus, cuttlefish, and squid. These animals have a particularly striking array of behaviors. Cuttlefish change their color, shape, and texture in a fraction of a second to camouflage with their surroundings. Octopuses can solve complex tasks, like opening a bottle, through precise coordination of their eight arms. Squid communicate with each other using changes in skin patterning that they control with their thoughts.

Researchers in this Unit study cephalopods because their behavior is complex and because it differs significantly from that of vertebrates. Cephalopods diverged from the vertebrate lineage more than 500 million years ago, and amongst invertebrates they have by far the largest brains and most complex behaviors. By looking for similar rules governing behavior in animals so evolutionarily distant from humans, the researchers hope to uncover truly general principles. To do so they design and build specialized filming chambers to record cephalopods in naturalistic environments at high resolution. Using modern machine learning tools, they are examining many of these natural behaviors quantitatively for the first time. By analyzing the resulting high-dimensional datasets they attempt to form accurate and interpretable descriptions of these behaviors.

The researchers are also investigating the neural mechanisms underlying these behaviors. Although studies of the squid giant axon and synapse have been central to the understanding of cellular neurophysiology across the animal kingdom, scientists know almost nothing about how neural circuits in the brain give rise to cephalopod behaviors. The Unit is therefore adapting modern systems neuroscience tools to the study of cephalopod neuroanatomy and neurophysiology. By recording neural activity from the cephalopod brain during behaviors that they can describe precisely, they hope to better understand how neural representations are transformed into behaviors in cephalopods, and in general.

Researchers in the Unit are installing world class husbandry facilities designed specifically for cephalopods, both at the OIST Marine Science Station and in a newly built laboratory on the main campus. They also rely on the institution’s world-class facilities for mechanical engineering, high performance computing, imaging, and genome sequencing, which enable them to conduct truly innovative research.

A cuttlefish camouflages itself within a coral reef near the OIST Marine Science Station. Credit: Keishu Asada

Sampling in Yakushima Island. Credit: Aki Masunaga

Molecular Genetics Unit

Professor Daniel Rokhsar
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“ My Unit uses genomic and genetic approaches to understand the evolutionary processes by which early animals arose and diversified in the early oceans. Genomes provide more than a genetic blueprint for the development, physiology, and behavior of an organism; they also contain a partial record of past evolutionary events that can be revealed by comparative analysis. ”

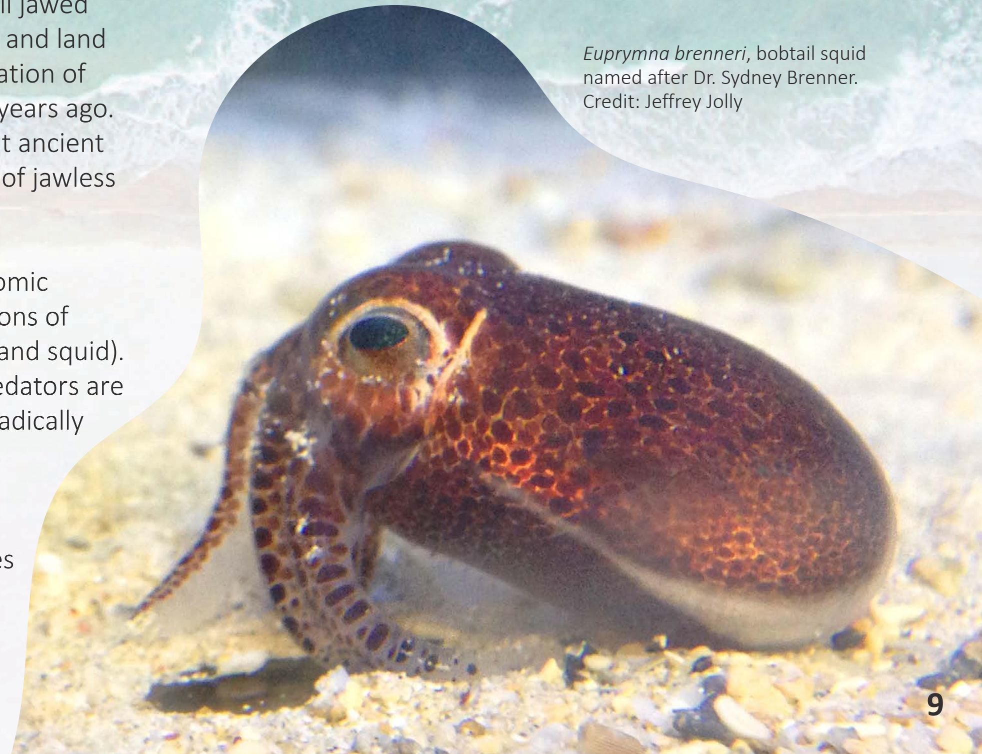
- Professor Daniel Rokhsar

The first wave of animals evolved complex body plans and nervous systems as they invaded and created new ecosystems. By comparing diverse animal genome sequences, the Molecular Genetics Unit have discovered remarkably stable genomic characteristics across a broad range of marine invertebrates from across the tree of life. This deep conservation allows the researchers to look half a billion years into the past and computationally reconstruct genomic properties of some of the earliest animals.

From this foundation the researchers in this Unit have also reexamined the early origins of vertebrates, and begun to decipher the nature of early genome-doubling events in the lineage of humans. Remarkably, despite the incomplete early fossil record of vertebrates, they inferred that all jawed vertebrates (bony and cartilaginous fishes and land vertebrates) arose by the ancient hybridization of two now-extinct species over 450 million years ago. An earlier duplication occurred in the most ancient proto-vertebrates, before the emergence of jawless vertebrates (lampreys and hagfish).

The Unit also aims to understand the genomic underpinnings of the remarkable adaptations of coleoid cephalopods (octopus, cuttlefish, and squid). The complex behaviors of these active predators are coordinated by nervous systems that are radically different than those found in vertebrates, with many decentralized components whose functions remain mysterious. By comparing the octopus and squid genomes they have characterized the evolution of key gene families associated with neural complexity and their enigmatic use of RNA editing, as well as with cephalopod-specific features such as adaptive coloration and complex visual systems.

To develop a tractable small cephalopod model, the researchers have characterized the remarkable diversity of bobtail squid in the waters around Okinawa. In the process they discovered at least one new squid species, which they named *Euprymna brenneri* in honor of OIST’s founding president and Nobel-prize-winning molecular geneticist Sydney Brenner. They are characterizing the ecology and evolution of these species by combining genomic, genetic, and behavioral studies, using animals bred and raised at OIST.



Euprymna brenneri, bobtail squid named after Dr. Sydney Brenner. Credit: Jeffrey Jolly

Pearls produced by the pearl oyster, *Pinctada fucata*.
Credit: Mikimoto

Marine Genomics Unit

Professor Noriyuki Satoh
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> My Unit uses genome sequencing to study the environmental dynamics and evolutionary history of a variety of marine organisms. OIST's Sequencing Section and IT Division provide extensive support for all our work and we collaborate widely with colleagues in Onna Village, Okinawa Prefecture, the University of Tokyo, the Australian Institute of Marine Science, and other institutions.
>
> - Professor Noriyuki Satoh

The Marine Genomics Unit focuses on four major areas. In one line of research, they are investigating the environmental genomics of coral reefs. Over the past decade, the Unit has decoded the genomes of corals, marine plankton called dinoflagellates, which live symbiotically with corals, and the crown-of-thorns starfish – a coral predator. By studying their genomes closely, these researchers can explore how corals and dinoflagellates affect each other. Future studies of coral will explore how bleaching events affect gene expression and how different genomic features of symbionts might protect coral from the effects of bleaching.

The researchers within this Unit are also using genomic information to examine the evolution of chordates – a large super-phylum of animals, including mammals, that have a notochord. They have decoded genomes of animals in two chordate phyla – urochordates (commonly called tunicates or sea squirts) and cephalochordates (small eel-like organisms commonly called lancelets) – as well as two closely related phyla – hemichordates (marine worms closely related to chordates) and echinoderms (which include spiny-skinned marine animals such as starfish). By comparing the genomes and the gene expression patterns of these organisms, the researchers seek to understand the evolutionary origin of the notochord.

In addition to these sea creatures, researchers within the Marine Genomics Unit are also examining the functional genomics of several organisms that are important to the Japanese aquaculture industry, including the pearl oyster, Okinawa brown algae (mozuku), and sea grapes (umi-budo). Based on the genome sequences they obtained for these organisms, they are investigating questions such how the pearl oyster crystalizes minerals in the environment to create its shell, and how they can develop DNA markers to enhance mozuku cultivation in Okinawa. They are also interested in how tunicates create their outer coat from cellulose, because they are the only animal to produce this material.

Finally, the researchers are sequencing the genomes of a long list of metazoan organisms in order to explore the evolutionary trajectory of this taxon. To date, they have sequenced two jellyfish (cnidaria), an acoel flatworm, a mesozoan, a brachiopod, a nemertean and a phoronid, and will continue to sequence additional marine invertebrate taxa.

The Evolutionary Neurobiology Unit investigates the evolution of neurons and the brain by studying several marine invertebrates at the base of the evolutionary tree. Clockwise from top center: *Trichoplax adhaerens, Nematostella vectensis, Vallicula sp, Bolinopsis mikado, Ephydatia fluviatilis*

Evolutionary Neurobiology Unit

Professor Hiroshi Watanabe
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> Our research takes place at the intersection of multiple areas, including marine ecology, neuroscience, cell and developmental biology, computational biology, and genomics. OIST's highly interdisciplinary research environment provides crucial support for our studies, allowing us to discuss nascent ideas with leading scientists in these disparate fields and providing us with expert technical support.
>
> - Professor Hiroshi Watanabe

The Evolutionary Neurobiology Unit investigates the evolution of neurons. These specialized cells, which allow animals to sense and respond to environmental cues, evolved in animals more than 600 million years ago, yet researchers know next to nothing about the physiological and genetic characteristics of those ancient neurons. To understand the origin of neurons, and their early evolutionary history, the researchers are studying the nervous systems of existing species of marine invertebrate lineages – including Porifera (sponge), Ctenophora (comb jellies), Placozoa, and Cnidaria (corals and jellyfishes) – that branched off from the common ancestor of humans very early in animal evolution.

Ctenophores are the most ancient animals bearing a nervous system. Very little is known about their anatomy and physiology, or about how their nervous system develops. This is mainly because there has been no definitive method for labeling ctenophore neurons that would allow them to be compared with neurons of other species. The researchers recently analyzed signaling molecules functioning as neurotransmitters in a Japanese ctenophore called *Bolinopsis mikado* and, for the first time, identified such markers in ctenophore neurons. They are using these markers to study these evolutionarily ancient neurons at the molecular level.

Researchers within the Evolutionary Neurobiology Unit are also investigating how organisms evolved a brain. They are studying the organization of the nervous system in Cnidaria, the closest sister group to Bilateria, which includes all higher animals that have bilateral symmetry. By comparing gene expression and development of the cnidarian nervous system to that of the bilaterian central nervous system, they can glean insights into anatomical, physiological, and genetic features of the nervous system that existed in the common Cnidaria/Bilateria ancestor.

OIST Marine Science Station
Credit: Yoko Shintani

OIST Marine Science Station

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> “Marine science is cross-cutting and complex – covering ecology, genomics, environmental management, and everything in between. At the OIST Marine Science Station, we have the resources and the expertise to support research across these fields. We are creating a world-leading facility that attracts scientists dedicated to discovering solutions to global issues.”
>
> - Mr. Yoshikatsu Nakano
> Research Support Leader,
> Okinawa Marine Science
> Support Section (OMSSS)

Diverse expertise

Alongside the operation of the OIST Marine Science Station (OMSS), the staff in the OMSSS assist with the maintenance and management of marine monitoring systems and other equipment and provide technical support and consultation across multiple research areas.

Research Support Leader, OMSSS
Mr. Yoshikatsu Nakano
Research expertise
Marine ecology and conservation

Research Support Specialist, OMSSS
Dr. Kosuke Mori
Research expertise
Physical Oceanography

Research Support Specialist, OMSSS
Dr. Nobuo Ueda
Research expertise
Marine Molecular biology

Cutting-edge resources

Although only established in 2016, OMSS already houses an essential molecular biology laboratory and space for animal husbandry. In June 2020, OIST built an underground tunnel that carries clean, fresh seawater from the ocean directly to the facility, creating the ideal conditions for keeping marine organisms.

OIST’s vision is to develop OMSS into a world-leading research station, fully equipped with a scientific research vessel, diving facilities, a state-of-the-art husbandry system, and an aquarium.

Ideal location

The marine ecosystems surrounding Okinawa are rich and diverse, providing researchers with unique opportunities and fascinating challenges. Within just a few miles of OIST facilities are mangrove forests, deep-sea hydrothermal vents, and one of the world’s northernmost regions of coral reefs, which has a high level of coral diversity.

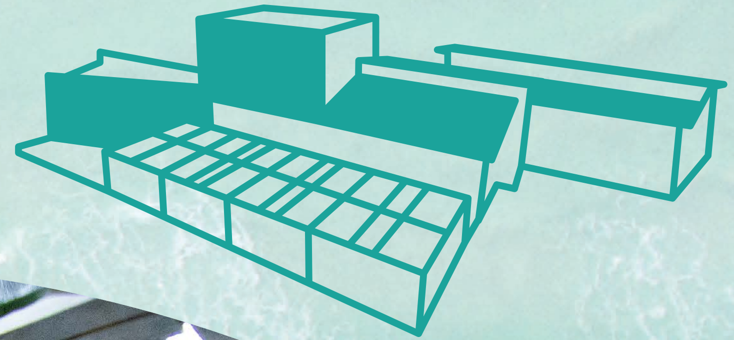
These ecosystems are confronting a changing environment. The coral reefs that exist very close to Okinawa’s shoreline are exposed to ongoing intensive coastal development. Across the world, aquaculture and artificial coastal defenses are replacing mangrove forests, and plans are in place to mine the deep-sea hydrothermal vents around Japan.

The unique environment around Okinawa, and the pressures it faces, allows researchers to directly investigate the impacts of sediment runoff, urbanization, and climate change—and to discover innovative, real-world solutions to these issues.

Beyond the lab

Okinawa’s people have a culture strongly connected to the ocean, and OIST’s marine scientists firmly believe in involving the local community in the development of OMSS and its research.

Located close to a busy fishing port, OMSS sits within Onna village, a region whose economy revolves around the fishing and tourism industries. OIST is working with local and regional authorities to establish a museum and education programs and to further engage the community in marine science, conservation, and the area’s coastal development plans.



The OMSS provides researchers with space for animal husbandry and support to carry out observations and experiments. In this instance, a technician is feeding the cuttlefish.