

AN EXECUTIVE SUMMARY OF

Pacific Ocean Synthesis

Scientific Literature Review of Coastal and
Ocean Threats, Impacts, and Solutions

CENTER FOR
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SOLUTIONS



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The Center for Ocean Solutions is a collaboration between Stanford University (including the Hopkins Marine Station) (www.stanford.edu), the Monterey Bay Aquarium, and the Monterey Bay Aquarium Research Institute (MBARI) (www.mbari.org). The Center for Ocean Solutions is administered by the Woods Institute for the Environment at Stanford University.

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Cover Photo: Schooling Tuna (Danilo Cedrone, Courtesy of United Nations Food and Agriculture Organization)
Photo on the right: School of fish in Palau (David Burdick)

Welcome

In August 2008, a group of over 30 natural, physical, and social scientists from around the Pacific convened in Honolulu, Hawaii to review a synthesis of more than 3,400 scientific articles and reports regarding the threats, impacts, and solutions to negative trends facing the Pacific Ocean. The meeting, convened by the Center for Ocean Solutions (COS) in collaboration with the World Conservation Union (IUCN) and Ocean Conservancy resulted in a consensus statement signed by more than 400 scientists. This document, entitled "*Ecosystems and People of the Pacific Ocean – Threats and Opportunities for Action*," identifies four major threats to the health and productivity of the Pacific Ocean.

Now, we present the entire synthesis of this Pacific Ocean research—a comprehensive and systematic survey of published scientific literature, government publications, and other peer-reviewed reports from throughout the Pacific. Identified within are both regional, and Pacific basin-wide threats, as well as their environmental and socioeconomic impacts. Solutions, drawn from existing published literature, provide an initial "road map" and are presented here as a hopeful indication of humankind's resolve to address these pressing issues. This Executive Summary is a distillation of our key findings.

Unless prompt action is taken, we expect to see significant declines in the health of the Pacific Ocean over this century. We welcome your united efforts and collaboration in advancing solutions towards a healthy Pacific Ocean.

Sincerely,



Meg Caldwell
Executive Director, Center for Ocean Solutions

The Pacific Ocean

The Pacific Ocean is our planet's largest single geographic feature. It comprises half the world's ocean area and one third of the Earth's surface. Supporting ocean-based economies that produce a wealth of resources for local and global consumption, the Pacific occupies 155.6 million square kilometers (60.1 million square miles) and encompasses the shorelines of some 50 countries and territories. This is the engine room of Earth's climate, playing an irreplaceable role in our planet's carbon and water cycles. Host to countless complex ecosystems — in turn supporting vast storehouses of our planet's biodiversity — the health of the Pacific is essential to the survival of innumerable species, including our own.

Despite its importance, the Pacific Ocean is not being managed sustainably. Our climate, communities and economies are linked directly to the health of the ocean. Unfortunately, threats continue to expand as over-harvesting of resources and runoff from land to sea increase, affecting life from shallow corals, mangroves, and seagrasses to previously inaccessible deep-sea beds and seamounts. Rapidly declining populations of large tuna, sharks and sea turtles reveal the



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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progressive depletion of the top predators of the Pacific. This in turn affects economies, local livelihoods and food security across the globe. Climate change exacerbates these threats and increases the vulnerability of coastal and ocean ecosystems, resources, and the people who depend upon them.

REGION	COUNTRIES OR TERRITORIES	
North East Pacific Ocean	Canada, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, United States	9
North West Pacific Ocean	China (including Taiwan), Japan, North Korea, South Korea, Russia	5
Pacific Ocean & East Asian Seas	Brunei Darussalam, Cambodia, East Timor, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam	9
Micronesia	Commonwealth of Northern Mariana Islands, Guam, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Palau, Other U.S. Remote Islands	7
Melanesia	Australia, Fiji, New Caledonia (France), Papua New Guinea, Solomon Islands, Vanuatu	6
Polynesia	American Samoa, Cook Islands, French Polynesia (France), New Zealand, Niue, Pitcairn Islands (United Kingdom), Samoa, Tokelau (New Zealand), Tonga, Tuvalu, Hawaiian Islands (United States)	10
South East Pacific Ocean	Chile, Colombia, Ecuador, Peru	4
Total		50



Our Approach

The methodology for the Pacific Ocean synthesis report followed seven main steps.

1. **Scale:** We organized the Pacific Ocean into seven regions and systematically reviewed literature on the Pacific, the seven individual regions, and each country or territory by coastal and ocean threats, impacts, and solutions. This organization is drawn from both the UN Marine Assessment of Assessments and direct consultation with more than 30 scientists from across the Pacific who convened in Honolulu in August 2008.
2. **Literature Review:** We reviewed the literature (a total of more than 3,400 papers and reports¹) by region, country, threat, impact, and solution and documented key findings on these topics.
3. **Threat Identification:** We documented when an article identified an issue as a present or future threat.
4. **Impact Assessment:** We examined impacts and assessed their frequency, resiliency, and scale on both environment and socioeconomic factors, including human health and livelihood. Threats were classified as severe, moderate, or low.

5. **Synthesis Regional Tables:** We synthesized the results of steps 2, 3, and 4 and developed regional threat and impact tables based on the literature. We ranked the environmental and socioeconomic impact as severe, moderate, or low according to the criteria discussed above.
6. **Solution Identification:** When available in the literature, we identified and documented examples of solutions within the regions.
7. **Pacific Ocean Summaries:** The final synthesis is divided into eight sections: the Pacific Ocean overview and seven regional summaries. We established regional and overall Pacific trends for primary threats and impacts by averaging the impacts of the primary threats within each region and then identifying cross-cutting threats among all regions. Finally, we incorporated working solutions into the Pacific Ocean and regional summaries.

¹ These articles and reports are now available online through a fully searchable bibliographic database, www.centerforoceansolutions.org/library.

Photo: Humpback Whale (*Megaptera novaeangliae*) The calf weans at about ten to eleven months of age and the two are virtually inseparable until the calf's second winter (OAR/National Undersea Research Program, NURP)

Photo: Typhoon Sinlaku moving through the North West Pacific, south of Japan. Among the impacts of climate change are increased tropical storm frequency and intensity. Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC)



Major Threats Facing The Pacific Ocean

In both the synthesis and the consensus statement, a review of environmental threats across the Pacific Ocean shows remarkable similarity between the problems experienced in poor and rich countries and territories alike, in densely settled areas and in rural coastlines, in populous nations and on small islands. Across these seven diverse regions, three (first three listed below) rank as the most pervasive and serious threats. A fourth emerging threat, climate change, imperils all Pacific ecosystems. These threats, if left unchecked, interact with each other to damage natural ecosystems, reduce biological and human economic diversity, decrease productivity, and hinder human use of the sea.

Pollution

Organic pollutants from sewage, nutrient pollution from fertilizer runoff, plastic marine debris, toxic dumping and oil spills, urban runoff, and other pollutants combine to create one of the most critical classes of ocean threats.

Habitat Destruction

Productive marine and coastal habitats are lost to destructive fishing practices, poor agricultural land use, inappropriate coastal development, and industrial wastewater discharges.

Overfishing and Exploitation

Unsustainable resource use reduces fish stocks throughout the Pacific, limiting fish catches, and often causing ecological shifts that further reduce biodiversity and productivity.

Climate Change

Carbon dioxide (CO_2) discharged to the atmosphere is both altering seawater chemistry resulting in ocean acidification

and causing the ocean to warm leading to sea level rise, habitat shifts, increased storm intensity, altered precipitation patterns, and coral bleaching.

ADDITIONAL PRIORITY CONCERNs

In addition to the major threat categories listed above, the literature points to the following as additional threats that require immediate attention:

Invasive Species

Invasive species are non-indigenous species introduced into the environment either intentionally or incidentally as a result of human activities. These invasives compete with other species for habitat and food, can induce disease and can even alter the functions of entire ecosystems. Habitats already disturbed by human activity are particularly prone to invasions. Although invasive species concerns can be addressed as both pollution and habitat destruction, the pervasiveness of this threat warrants independent consideration.

Multiple Stressors

Marine species and ecosystems are adapted to cope with a significant level of stress. However, when subjected to multiple stressors, or threats, synergistic impacts can result. In the case of marine life, such multiple stressors come in the form of pollution, habitat destruction, overfishing, and climate change, and can cause the collapse of ecologically and economically important species and ecosystems.



A Summary of Pacific Ocean Solutions

These solutions represent both tried and proposed approaches for addressing the severe threats facing the Pacific Ocean and are based on the following principles:

- Maintaining ecosystem health and sustainability is a priority on par with economic development.
- New technologies, innovative market mechanisms, and financial tools that promote the adoption of sustainable practices can empower local communities.
- Sustainable development must maintain the cultural richness of Pacific Ocean countries and territories.
- Reduction of the human footprint on the Pacific is essential.
- Both mitigation and sustainable adaptation strategies for ecosystems and human communities are required in the face of climate change.
- An understanding that effective and enduring solutions will require capacity building within the Pacific Ocean community.

²Ecosystem-based management (EBM) is a management approach that:

- Integrates ecological, social, and economic goals and recognizes humans as key components of the ecosystem.
 - Considers ecological—not just political—boundaries.
 - Addresses the complexity of natural processes and social systems and uses an adaptive management approach in the face of resulting uncertainties.
- Source: EBM Tools Network (www.ebmtools.org/about_ebm.html)

The following major themes emerge from the literature:

Ecosystem-Based Management inclusive of Integrated Coastal and Ocean Zone Management (ICOZM)

As many coastal and ocean activities conflict with each other and endanger both marine and human populations, a holistic approach to management is required to alleviate threats to these systems. Ecosystem-based management (EBM)², which integrates ecological, social, and economic goals (recognizing humans as key components of the ecosystem) offers such an approach. One particularly promising framework for EBM is in integrated coastal and ocean zone management (ICOZM), as it addresses the ecological and human complexities of interconnected systems. With an emphasis on zoning, ICOZM attempts to divide geographic areas, on varying scales, into districts within which various activities are permitted and clearly defined.

Regional Governance, Agreements, and Approaches

Because the waters of the Pacific are transboundary in nature (many fish stocks and pelagics migrate beyond the jurisdiction of any one country, for example), regional cooperation and policy structures are necessary for sustainable use and management of ocean resources both within exclusive economic zones (EEZs) and on the high seas. Such cooperation can effectively protect the marine ecosystem and sidestep conflicts that could further deteriorate ecological and socioeconomic conditions. Overall, international and regional institutions are currently weak, but efforts of the public, NGOs, national governments, international institutions, and transnational scientific networks are strengthening regional environmental

governance. Additionally, studies have identified the importance of regional economic intergovernmental institutions and agreements, such as Asia-Pacific Economic Cooperation (APEC) and North American Free Trade Agreement (NAFTA), in protecting marine resources such as fisheries.

Regulation and Enforcement

Agreements and policies are mere words on paper without corresponding regulation and enforcement. Such mechanisms are crucial aspects of marine conservation efforts in the Pacific, yet throughout much of the region they remain weak, uncoordinated, conflicting, or nonexistent. However, there are exemplary efforts in some regions that warrant consideration for other regions of the Pacific.

Fisheries Management

In recent decades the growth of aquaculture and fisheries sectors in many regions of the Pacific has outpaced regional agreements and enforcement. While individual countries and territories do implement measures aimed at reducing fishing impacts, there is an overall lack of regional governance. Regional approaches that include market-based incentives like individual transferable quotas (ITQs) are important tools for fisheries and ecosystem-based management. Regional management plans may also help alleviate the socioeconomic effects of El Niño-Southern Oscillation (ENSO) events. Enforcing regulations on illegal and destructive fishing is essential.

Integration of Climate Change Adaptation and Mitigation into Coastal and Ocean Policy, Planning and Management

With the growing threat of global climate change, adaptation is a key response strategy to minimize potential impacts of climate change and reduce adverse effects on human and ecological systems. Adaptation strategies need to be integrated into coastal and ocean policy, planning, and management frameworks. Other adaptation strategies must be built into fisheries, aquaculture, and other marine-based industries.

Alternative Livelihoods

Acute poverty exists throughout much of the Pacific region, including Latin America, Asia, and the developing island countries and territories. The immediate needs of the people who depend on marine resources for subsistence often conflict with the need to protect these resources. For example, in order to reduce the impact of commercial fishing there should be a focus on reducing fishing effort while increasing alternative livelihoods for fishers. Successful alternative livelihoods to date have included fish farming, marine protected areas (MPAs) monitoring, and ecotourism.

Marine Managed Areas: Networks, Marine Protected Areas, Reserves and Locally Managed Marine Areas

Throughout the Pacific, MPAs, MPA networks, marine reserves and other marine management areas are recognized solutions for coastal and ocean protection. These various management units have been shown to have beneficial ecological and socioeconomic impacts. MPAs in particular can

significantly contribute to poverty reduction via fish “spillover”, job creation, food security, nutrition and health. Despite progress, MPAs still have a long way to go in parts of the Pacific, and enforcement is crucial. Impacts such as destructive fishing, sedimentation, and pollution threaten many existing protected areas.

Community Involvement and Community-Based Conservation

Research shows that community-based conservation, which takes into account local peoples' traditional resource use and livelihoods while conserving areas, offers a potential solution to threats facing parts of the Pacific. Community-based MPAs, for example, have shown some levels of success as the people who stand to benefit from sustainable resource use are those directly involved in managing the resources. With respect to fisheries, studies support the need for comprehensive fisheries management that promotes both sustainable fishing practices as well as shared management and enforced responsibilities between communities and the state. In some regions, a strengthening of self-regulation of coastal communities, so that they accept greater responsibilities than the state governments currently undertake, may stimulate active participation in managing and conserving their local marine resources.

Strengthening Institutions and Building Capacity

Tremendous social, cultural, political, and environmental diversity exists within the Pacific. With these differences comes tremendous variation in local capacity and institutions. Some regions, such as North America and Australia, generally have strong leadership, capacity and institutions. However, in other areas great need exists in terms of developing a body of skilled professionals and institutions with the capacity to implement their management and research mandates. Overall, knowledge on the long-term effects of current actions and all aspects of ocean, coastal, and watershed management, research and monitoring needs to be strengthened. Capacity building should be made a high priority. This will entail a great effort on the part of national, regional, and international education and training institutions, and will require significant funding.

Infrastructure Development

In many areas throughout the South East Pacific, the environmental and socioeconomic impacts of infrastructure (dams, roads, port facilities, sewage treatment plants, etc.) have not been adequately considered, leading to drained wetlands and other coastal habitat loss, beach erosion and pollution.



Photo: Close up of Orange Cup Coral (*Tubastraea coccinea*) polyps with tentacles extended. While native to the East Asian Seas, it is an invasive species in the Eastern Pacific and elsewhere, competing with native sponges and corals for habitat.
(© www.willisgreinerphoto.com)

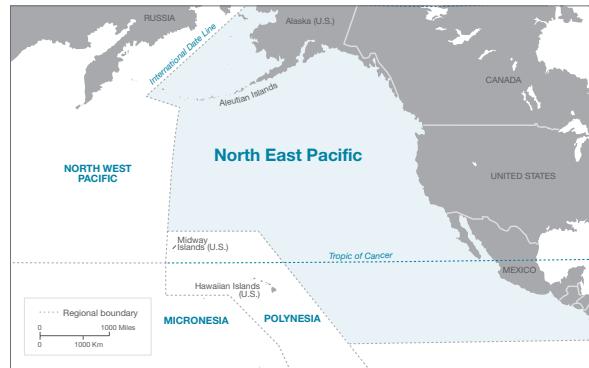
North East Pacific Ocean



Photo: Alaska offers an example of successful ecosystem-based management, inclusive of protections for deep water corals from destructive fishing practices. (Gulf of Alaska 2004. NOAA Office of Exploration)

GEOGRAPHIC OVERVIEW

The North East Pacific Ocean, stretching from Alaska and the Aleutian Islands to Panama, encompasses the largest north-to-south ecosystem of this study. It includes the Pacific Coast of North America and Central America, and nine countries: Canada, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, and the United States. The coasts of these countries can be divided into two provinces, one influenced by the California Current System and the other, the Central American Pacific Coast, by the Intertropical Convergence Zone. Both provinces are characterized by upwelling zones, support productive fisheries and are among the most biologically rich and important regions of the Pacific Ocean.



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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THREATS

Among the region's threats, pollution (stemming from agriculture and industrial activities) and overfishing (commercial in North America and both commercial and artisanal in Central America) are potentially the most serious. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire North East Pacific region are:

- nutrient pollution identified in all nine countries.
- land-based chemical pollution identified in eight countries.
- artisanal/recreational/subsistence fishing and commercial fishing identified in eight countries.

The threats with overall moderate impacts across the region are:

- land-based sedimentation identified in seven countries.
- coastal development/land reclamation identified in six countries.
- coastal modification from aquaculture identified in six countries.
- by-catch discharge identified in six countries.
- solid waste disposal identified in five countries.
- climate change (sea surface temperature) identified in five countries.
- oil spills and antifouling chemicals identified in four countries.

Key observations regarding research gaps and identified impacts:

- North America is the most comprehensively studied area in this region and in the Pacific Ocean as a whole.
- Canada, Mexico, and the United States contain the highest number of documented threat categories as well as the greatest numbers of moderate to severe impacts in the region.
- The countries in Central America have fewer studies documenting threats and impacts. The threats with the least numbers of both moderate and severe impacts are documented in Guatemala (six), Honduras (five), and Nicaragua (five).
- For the Pacific Coast of Central America, large research gaps exist for climate change, invasive species, pollution (such as offshore oil/mining, radionuclides, ocean waste, and toxic dumping), and habitat destruction. Studies on land-based chemicals and nutrient pollution exist, but they are not comprehensive and do not link to socioeconomic impacts.

SOLUTIONS

North America has among the strongest infrastructure in the region in terms of addressing threats. However, even the United States lacks effective frameworks in different areas—from governing water quality to destructive fishing (a prevalent practice) and aquaculture. Nevertheless, emerging initiatives such as California's Marine Life Protection Act and the multinational Eastern Tropical Pacific Seascape effort between Costa Rica, Panama, Colombia, and Ecuador (initiated by United Nations Education, Scientific, and Cultural Organization (UNESCO) and Conservation International) provide exemplary models of regional and transboundary cooperation, MPA networks, and ecosystem-based management for other regions.

Critical regional solutions include:

- Regional Governance, Agreements, and Approaches
- Regulations and Enforcement
- Integrated Coastal and Ocean Zone Management (ICOZM)
- Marine Managed Areas: Networks, MPAs, Reserves, and Locally Managed Marine Areas
- Market-based Solutions and Alternative Livelihoods

TABLE 1: North East Pacific Threats Based on Scientific Literature and Impact Assessment

✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact	CANADA		COSTA RICA		EL SALVADOR		GUATEMALA		HONDURAS		MEXICO		NICARAGUA		PANAMA		UNITED STATES	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION																		
Aquaculture: Wastewater	✓	●				✓	●	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	●
Land-based Chemicals	✓	●	✓	●	✓	✓	●	✓	✓	●	✓	✓	●	✓	✓	●	✓	●
Fishing Lines/Nets																		✓
Nutrients	✓	●	✓	●	✓	✓	●	✓	✓	●	✓	✓	●	✓	✓	●	✓	●
Offshore Oil/Mining																		✓
Oil Spills & Antifouling Chemicals	✓	●									✓	●		✓	✓	●	✓	●
Radionuclide																		
Solid Waste Disposal	✓	●	✓	●	✓	✓	●					✓	●				✓	●
Thermal	✓	●										✓					✓	●
Ocean Waste & Toxic Dumping	✓	●															✓	●
HABITAT DESTRUCTION																		
Anchor Damage																✓	●	
Aquaculture: Coastal Modification	✓	●				✓	●	✓	✓	✓	✓	✓	✓	✓			✓	●
Coastal Development/Land Reclamation	✓	●	✓	●	✓	✓	●				✓	✓	●	✓	✓	●	✓	●
Destructive Fishing	✓	●	✓	●	✓	●					✓	✓	●				✓	●
Dredging																✓	●	✓
Marine Recreation																	✓	●
Land-based Sedimentation	✓	●	✓	●	✓	✓	●					✓	●	✓	✓	●	✓	●
Ship Groundings	✓	●																
Tsunamis	✓	●																
Typhoons/Cyclones/Hurricanes & Storm Surge	✓	●	✓	●								✓	●					
Wrecks/Military Equipment																		
OVERFISHING & EXPLOITATION																		
Aquaria Trade						✓	●								✓	●		
Artisanal/Recreational/Subsistence Fishing	✓	●	✓	●	✓	✓	●	✓	✓	✓	✓	✓	●	✓	✓	●	✓	●
By-Catch & Discharge	✓	●	✓	●	✓	●			✓	●	✓	✓	●		✓	●	✓	●
Commercial Fishing	✓	●	✓	●	✓	●	✓	✓	●	✓	✓	✓	●	✓	✓	●	✓	●
CLIMATE CHANGE																		
Acidification	✓	●										✓	●				✓	●
Sea Level Rise	✓	●															✓	●
Sea Surface Temperature**	✓	●	✓	●	✓	●					✓	●		✓	●	✓	●	
INVASIVES																		
Invasive Species (Different Vectors)	✓	●													✓	●	✓	●

**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

North West Pacific Ocean

Photo: Lion's mane jellyfish (*Cyanea capillata*) at the rocky reef of the Peter the Great Bay, Sea of Japan. (© Konstantin Tkachenko/Marine Photobank)

GEOGRAPHIC OVERVIEW

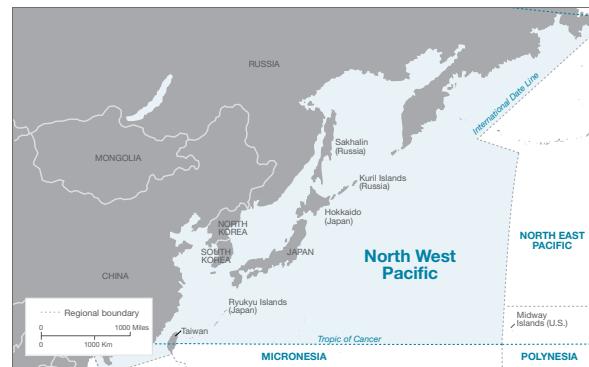
The North West Pacific Ocean region comprises the countries of China (including Hong Kong and Taiwan)³, Japan, North Korea, South Korea, and Russia. Covering a vast area, the North West Pacific contains some of the most diverse and commercially productive marine ecosystems and seas. Each country and sea is unique; from the globally significant coral reefs among the southern Japanese archipelagos, to the intertidal mudflats of the Yellow Sea – important to migratory shorebirds, and the upwelling and seasonal sea ice in the Bering Sea, driving high productivity. The Sea of Okhotsk, surrounded by Russia and northern Japan, contains some of the world's richest fishery resources, with approximately 340 fish species, while Korea's waters harbor an amazing diversity of 850 species of fish. Meanwhile the two million square kilometers of the Bering Sea support many endangered whale and seabird species, along with commercially valuable fisheries such as salmon and king crab.

THREATS

Of all the regions, the North West Pacific contains the greatest number of overall moderate to severe impacts. All four broad threats (overfishing and exploitation, climate change, habitat destruction, and pollution) have severe to moderate impacts across the region, with studies on invasive species found only in China. Significantly, none of these threats operate in isolation, but rather function as multiple, compounded stressors that together can devastate marine and human systems. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire North West Pacific region are:

- commercial overfishing identified in all countries.
- sea surface temperature increase and land-based chemical pollution identified in all countries, with a majority of severe impact ratings.
- nutrient pollution identified in all countries.
- land-based sedimentation identified in all countries.
- solid waste disposal identified in all countries.
- destructive fishing identified in all countries.
- oil spills, antifouling chemicals, ocean waste, and toxic dumping found in all countries.



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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The threats with overall moderate impacts across the region are:

- sea level rise identified in all countries.
- coastal modification from aquaculture identified in three countries.
- wastewater pollution from aquaculture identified in three countries.
- coastal development/land reclamation identified in three countries.
- radionuclides identified in three countries.
- artisanal/recreational/subsistence fishing identified in three countries.
- offshore oil/mining identified in two countries.

Key observations regarding research gaps and identified impacts:

- The North West Pacific is one of the largest regions, and the countries' marine environments are some of the least protected, and most exploited, in the Pacific Ocean.
- China contains the greatest total number of impacts in the region, most of which are moderate (nine) and severe (13).
- Large gaps in the research include studies on habitat destruction in Russia, invasive species, and the impacts of threats in Russia and North and South Korea.
- Russia contains the least documented number of identified threat categories, as well as the least total number of documented impacts.

³ Because scientific studies often report results in this manner, in this report we have grouped North and South Korea as one country and China, Hong Kong and Taiwan as one country.

SOLUTIONS

Countries in this region have embraced aspects of ICOZM since the 1990s. Major initiatives include *The China Ocean Agenda 21*, which aims to develop China's marine economy while enhancing the role of a healthy, productive marine environment; and a regionally coordinated MPA network spearheaded by WWF for the Yellow Sea ecoregion. Meanwhile, international initiatives such as the Asia-Pacific Economic Cooperation forum provide some progress in transboundary cooperation, a specific area in need of strengthening due to the prevalence of transboundary semi-enclosed seas.

Critical regional solutions include:

- Integrated Coastal and Ocean Zone Management
- Marine Managed Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Regulatory Frameworks

TABLE 2: North West Pacific Threats Based on Scientific Literature and Impact Assessment								
✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact <small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>	CHINA		KOREA (NORTH & SOUTH)		JAPAN		RUSSIA	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION								
Aquaculture: Wastewater	✓	●	✓	●	✓	●		
Land-based Chemicals	✓	●	✓	●	✓	●	✓	●
Fishing Lines/Nets	✓	●			✓	●		
Nutrients	✓	●	✓	●	✓	●	✓	●
Offshore Oil/Mining	✓	●					✓	●
Oil Spills & Antifouling Chemicals	✓	●	✓	●	✓	●	✓	●
Radionuclide			✓	●	✓	●	✓	●
Solid Waste Disposal	✓	●	✓	●	✓	●	✓	●
Thermal	✓	●	✓	●				
Ocean Waste & Toxic Dumping	✓	●	✓	●	✓	●	✓	●
HABITAT DESTRUCTION								
Anchor Damage								
Aquaculture: Coastal Modification	✓	●	✓	●	✓	●		
Coastal Development/Land Reclamation	✓	●	✓	●	✓	●		
Destructive Fishing	✓	●	✓	●	✓	●	✓	●
Dredging	✓	●	✓	●				
Marine Recreation	✓	●						
Land-based Sedimentation	✓	●	✓	●	✓	●	✓	●
Ship Groundings								
Tsunamis					✓	●		
Typhoons/Cyclones/Hurricanes & Storm Surge	✓	●			✓	●		
Wrecks/Military Equipment								
OVERFISHING & EXPLOITATION								
Aquaria Trade	✓	●			✓	●		
Artisanal/Recreational/Subsistence Fishing	✓	●	✓	●	✓	●		
By-Catch & Discharge	✓	●	✓	●	✓	●	✓	●
Commercial Fishing	✓	●	✓	●	✓	●	✓	●
CLIMATE CHANGE								
Acidification								
Sea Level Rise	✓	●	✓	●	✓	●	✓	●
Sea Surface Temperature**	✓	●	✓	●	✓	●	✓	●
INVASIVES								
Invasive Species (Different Vectors)	✓	●						

**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

East Asian Seas



Photo: Fisherman in Northern Sulawesi, Indonesia (© Wolcott Henry 2005/Marine Photobank)

GEOGRAPHIC OVERVIEW

The East Asian Seas encompass the countries of Brunei Darussalam, Cambodia, East Timor (north coast), Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. Of the various seas, the South China Sea alone covers an area of 3.3 million square kilometers, supports a population of more than 270 million people (many of whom live near or below the poverty line) and is home to some of the fastest growing industries in the world. Habitats of the region include mangrove forests, coral reefs, seagrass beds, and wetlands, which are all threatened to various degrees. A large portion of this region falls within the Indo-Pacific Coral Triangle, home to the world's richest coral reef biodiversity, including 75% of all reef-building, hard coral species known to science. Indonesia alone contains 18% of the world's coral reefs, providing an estimated USD \$1.6 billion in annual economic benefits. However, the majority of these reefs are at moderate to severe risk.

THREATS

Here, as in other Pacific regions, all four broad threats (overfishing and exploitation, climate change, habitat destruction, and pollution) impose severe to moderate impacts region-wide. Of these, nutrient pollution, with the potential to create dead zones and algal blooms, and commercial fishing, which reduces fish stocks and threatens food supply, appear particularly prevalent. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire Pacific Ocean and East Asian Seas region are:

- land-based chemicals identified in seven countries, with a majority of high impact ratings.
- nutrient pollution identified in seven countries, with a majority of high impact ratings.
- commercial overfishing identified in seven countries, with a majority of high impact ratings.
- coastal development/land reclamation identified in seven countries, with a majority of high impact ratings.

The threats with overall moderate impacts across the region are:

- land-based sedimentation identified in six countries.
- artisanal/recreational/subsistence fishing and destructive fishing identified in six countries



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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- wastewater from aquaculture identified in six countries.
- oil spills and antifouling chemicals identified in six countries.
- coastal modification from aquaculture identified in six countries.
- sea level rise identified in seven countries.
- aquaria trade identified in four countries (in three countries with a severe impact).
- sea surface temperature increase resulting from climate change identified in six countries.
- by-catch identified in four countries.
- discharge identified in four countries.

Key observations regarding research gaps and identified impacts:

- This region is densely populated, with coastal communities that are highly dependent on marine resources.
- Indonesia and Vietnam contain the greatest number of severe impacts (eight and 10, respectively).
- Vietnam contains mostly threats with severe impacts (10), one with moderate impact, and none with low impacts.
- There are large research gaps in Brunei, Cambodia, and East Timor. These countries also have the least number of documented threat categories as well as the lowest number of threats with impacts within the region, all of which are moderate impacts.

SOLUTIONS

Endowed with some of the world's most spectacular and diverse coral reefs, MPAs in this region are acknowledged to be of crucial importance, and several are recognized leaders in park management. The allure of these parks enables a second solution—alternative livelihoods in the form of tourism and park management. Despite progress, MPAs still have a long way to go. Less than 4% of Philippine reefs are protected and various threats continue unabated even within protected areas. On a larger scale, this region has considerable activity towards regional policy mechanisms, with the Association of Southeast Asian Nations (ASEAN), the Coral Triangle Initiative, and the East Asian Seas Action Plan providing major examples. However, implementation has been slow with only moderate progress to date.

Critical regional solutions include:

- Market-Based Solutions and Alternate Livelihoods
- Integrated Coastal and Ocean Zone Management
- Marine Managed Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Regional Governance, Agreements, and Approaches

TABLE 3: Pacific Ocean and East Asian Seas Threats Based on Scientific Literature and Impact Assessment

✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact <small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>	BRUNEI DARUSSALAM		CAMBODIA		EAST TIMOR*		INDONESIA		MALAYSIA		PHILIPPINES		SINGAPORE		THAILAND		VIETNAM	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION																		
Aquaculture: Wastewater							✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Land-based Chemicals			✓	●			✓	●	✓	●	✓	●	●	✓	●	●	✓	●
Fishing Lines/Nets							✓	●	✓	●	●					✓	●	
Nutrients		✓	●				✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Offshore Oil/Mining	✓	●					✓	●	✓	●	●							
Oil Spills & Antifouling Chemicals	✓	●					✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Radionuclide																		
Solid Waste Disposal									✓	●					✓		●	
Thermal							✓	●						✓		●		
Ocean Waste & Toxic Dumping																		
HABITAT DESTRUCTION																		
Anchor Damage																		
Aquaculture: Coastal Modification							✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Coastal Development/Land Reclamation			✓	●			✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Destructive Fishing	✓	●					✓	●	✓	●	●	✓	●			✓	●	●
Dredging																		
Marine Recreation									✓	●	✓	●	✓	●		✓	●	
Land-based Sedimentation	✓	●					✓	●	✓	●	✓	●	✓	●		✓	●	●
Ship Groundings																		
Tsunamis							✓	●										
Typhoons/Cyclones/Hurricanes & Storm Surge																		
Wrecks/Military Equipment																		
OVERFISHING & EXPLOITATION																		
Aquaria Trade							✓	●	✓	●	✓	●	✓	●	●			
Artisanal/Recreational/Subsistence Fishing			✓	●			✓	●	✓	●	✓	●	✓	●		✓	●	●
By-Catch & Discharge	✓	●					✓	●	●							✓	●	●
Commercial Fishing	✓	●					✓	●	✓	●	✓	●	✓	●	●	✓	●	●
CLIMATE CHANGE																		
Acidification																		
Sea Level Rise			✓	●	✓	●	✓	●	✓	●	✓	●	✓	●	●	✓	●	●
Sea Surface Temperature**					✓	●	✓	●	✓	●	✓	●	✓	●	●	✓	●	●
INVASIVES																		
Invasive Species (Different Vectors)															✓	●		

*Due to the recent independence of East Timor, the limited research conducted in East Timor and Timor Sea prior to 2002 is integrated in Indonesia.

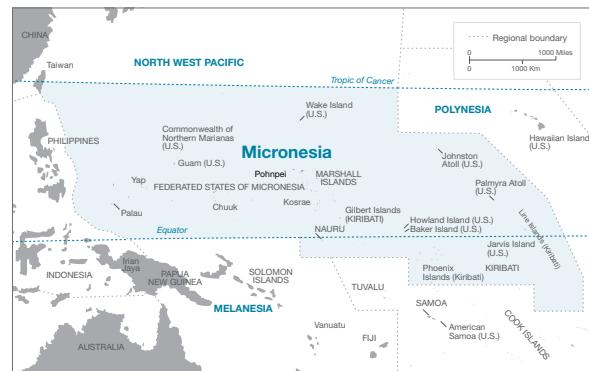
**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

Micronesia

Photo: Bubble coral (*Plerogyra sinuosa*) on the Sankisan Maru wreck at Chuuk Lagoon, Federated States of Micronesia. (David Burdick)

GEOGRAPHIC OVERVIEW

Micronesia, a sub-region of Oceania, comprises hundreds of small islands spread over a large area of the western Pacific. The region includes the Northern Mariana Islands (U.S.), Guam (U.S.), Kiribati, the Marshall Islands, the Federated States of Micronesia (FSM), Nauru, Palau, and other U.S. remote islands. Compared to other regions of the world, Micronesia's marine systems are in good and sometimes excellent condition. Marine biodiversity and endemism are among the highest in the world; the waters being home to 1,300 species of reef fish and 483 coral species (60% of all known corals). Because this region is so vast, the islands vary considerably in geography, culture, and population—from high volcanic islands to single, low-lying atolls, and highly populated to uninhabited islands. Many are charting a new path from subsistence and traditional management systems to market-based economies. Marine resources, especially the highly valued tuna fisheries and other commercial and artisanal fisheries, are critical for the economic well-being of Micronesia, particularly given limited agricultural opportunities.



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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THREATS

In Micronesia, all four broad threats (overfishing and exploitation, climate change, habitat destruction, and pollution) have severe to moderate impacts across the region. One of the most severe threats—commercial fishing—may cause ecological shifts and reduce fish stocks and food supply, thereby endangering human economies and livelihoods. Climate-induced sea surface temperature increase poses a dire threat to Micronesia. Compounded with sea level rise, sea surface temperature warming can destroy marine ecosystems, jeopardize human economies and livelihoods, and create uninhabitable areas. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire Micronesia region are:

- commercial overfishing, identified in six countries or territories.
- sea surface temperature increase resulting from climate change, identified in six countries or territories.

The threats with overall moderate impacts across the region are:

- typhoons and storm surges identified in four out of eight countries or territories.
- artisanal/recreational/subsistence fishing identified in five countries or territories.
- sea level rise identified in four countries or territories.

- oil spills and antifouling chemicals identified across the region as low and moderate impact in seven countries or territories.
- coastal development/land reclamation identified in four countries or territories.
- land-based sedimentation in three countries or territories with high impact.

Key observations regarding research gaps and identified impacts:

- This region is remote, with low population densities compared to other regions.
- The countries and territories in this region have large EEZs to manage.
- Many island people depend on marine resources for food and income and are thus vulnerable to environmental change.
- Research gaps exist throughout the region on climate change and land-based chemicals and nutrient pollution.
- Nauru, Kiribati, and other U.S. remote islands have both the least number of moderate to severe impacts as well as the least number of threat types identified. Sea level rise, however, is a major threat to many low-lying islands and atolls.
- Countries and territories such as Nauru and Kiribati have scant research on threats and only a few documented number of identified threat categories.

SOLUTIONS

Faced with the potential for total loss of island territories, Micronesian countries and territories have become leaders in the global climate change dialogue, working within the UN Framework Convention on Climate Change (UNFCCC), and locally implementing a Climate Change Assistance Programme and a *Framework for Action*. The region has been exemplary for testing regional conservation approaches, notably the Secretariat of the Pacific Regional Environment Programme and the *Micronesian Challenge*. MPAs also exist throughout the region, and Kiribati's Phoenix Island Protected Area (PIPA) is one of the largest in the world. Needs and opportunities exist to strengthen local institutions, regulation and enforcement, and capacity building.

Critical regional solutions include:

- Integrating Climate Change Adaptation and Mitigation into Coastal and Ocean Policy, Planning, and Management
- Marine Management Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Regional Governance, Agreements, and Approaches: The Micronesia Challenge
- Ecosystem-Based Management
- Regulation and Enforcement
- Strengthening Institutions and Building Capacity

TABLE 4: Micronesia Threats Based on Scientific Literature and Impact Assessment

✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact <small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>	COMMON-WEALTH OF THE NORTHERN MARIANAS		FEDERATED STATES OF MICRONESIA		GUAM		NAURU		KIRIBATI		MARSHALL ISLANDS		OTHER US REMOTE ISLANDS		PALAU	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION																
Aquaculture: Wastewater																
Land-based Chemicals					✓	●										
Fishing Lines/Nets				✓	●											
Nutrients	✓	●							✓	●					✓	●
Offshore Oil/Mining																
Oil Spills & Antifouling Chemicals	✓	●	✓	●	●	●	✓	●	✓	●	✓	●	✓	●	✓	●
Radionuclide											✓	●				
Solid Waste Disposal		✓	●	✓	✓	●									✓	●
Thermal																
Ocean Waste & Toxic Dumping		✓	●								✓	●	✓	●		
HABITAT DESTRUCTION																
Anchor Damage	✓	●				✓	●								✓	●
Aquaculture: Coastal Modification																
Coastal Development/Land Reclamation	✓	●	✓	●	●	✓	●								✓	●
Destructive Fishing			✓	●											✓	●
Dredging		✓	●	✓	✓	●	●	✓		●					✓	●
Marine Recreation					✓	●	●							✓	●	
Land-based Sedimentation		✓	●	✓	✓	●									✓	●
Ship Groundings		✓	●												✓	●
Tsunamis																
Typhoons/Cyclones/Hurricanes & Storm Surge	✓	●	✓	●	●	✓	●								✓	●
Wrecks/Military Equipment	✓	●	✓	●	●									✓	●	
OVERFISHING & EXPLOITATION																
Aquaria Trade											✓	●			✓	●
Artisanal/Recreational/Subsistence Fishing			✓	●					✓	●	✓	●	✓	●	✓	●
By-Catch & Discharge																
Commercial Fishing	✓	●	✓	●	●	✓	●		✓	●	✓	●			✓	●
CLIMATE CHANGE																
Acidification																
Sea Level Rise	✓	●	✓	●	●	✓	●		✓	●	✓	●	✓	●		
Sea Surface Temperature**	✓	●						✓	●	✓	●	✓	●	✓	●	●
INVASIVES																
Invasive Species (Different Vectors)	✓	●				✓	●							✓	●	✓

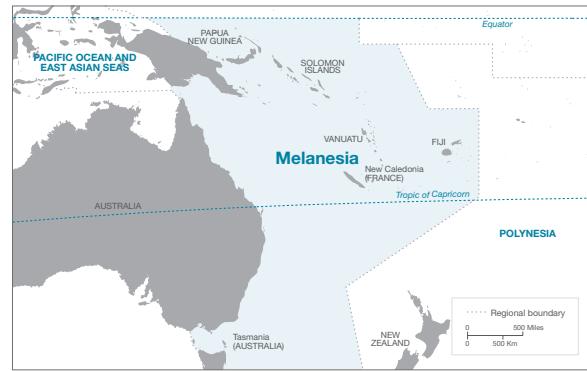
**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

Melanesia

Photo: Solomon Islands. (Joshua Cinner/ARC Centre of Excellence for Coral Reef Studies/Marine Photobank)

GEOGRAPHIC OVERVIEW

Melanesia, a sub-region of Oceania, includes the island countries and territories of Australia, Fiji, New Caledonia (France), Papua New Guinea, Solomon Islands, and Vanuatu. Melanesia is extremely diverse, with both sparsely populated islands and densely populated urban areas. Although Australia contains significant cities and natural resources, many of the other Pacific islands are much poorer and less developed, lack ample natural resources, and depend on the sustainable use of their local resources for survival. An outstanding characteristic of Melanesia is its coral reefs. Australia's Great Barrier reef is the world's largest coral reef system with more than 2,900 individual reefs and a wide diversity of marine life. Fiji, a major tourist destination, has reef-centered marine ecosystem services estimated at USD \$578 million per year, of which tourism accounts for about USD \$115 million. Throughout Melanesia, specifically Papua New Guinea, the Solomon Islands, and Fiji, tenure and ownership of reefs by indigenous peoples are particularly important, though this form of stewardship is slowly breaking down.



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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THREATS

All four broad threats (overfishing and exploitation, climate change, habitat destruction, and pollution) have severe to moderate impacts across Melanesia. One of the most severe threats facing the region is land-based sedimentation. Overfishing and exploitation also jeopardize Melanesian waters, causing ecological shifts and reducing fish stocks and food supply. This in turn endangers human economies and livelihoods. As an added stressor, climate change not only destroys marine ecosystems and can create uninhabitable areas, but also can exacerbate all of the threats above. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire region are:

- land-based sedimentation identified in six countries or territories.
- commercial overfishing identified in six countries or territories.
- artisanal/recreational/subsistence fishing identified in five countries or territories.

The threats with overall moderate impacts across the region are:

- sea surface temperature increase resulting from climate change identified in five countries or territories.
- oil spills and antifouling chemicals identified across the region as low and moderate impact in six countries or territories.
- nutrients identified in four countries or territories.
- sea level rise identified in four countries or territories.
- coastal development/land reclamation identified in three countries or territories.
- land-based chemical pollution in four countries or territories.

Key observations regarding research gaps and identified impacts:

- Papua New Guinea and Fiji have recently conducted more studies on threats, but few link these threats to impacts or prioritize the threats.
- Australia has the most comprehensive research, the greatest total number of impacts, as well as the greatest documented number of impacts associated with identified threat categories.

SOLUTIONS

Much of Melanesia is vulnerable to the same impacts of climate change as discussed for Micronesia. Melanesia has embraced a regional approach through the South Pacific Regional Environment Programme and the United Nations Environment Programme South Pacific Task Team to address this vulnerability. Other regional mechanisms, such as the Pacific Island Forum, take a traditional islander EBM approach to ocean stewardship. Traditional EBM systems are prevalent within insular Melanesia, and efforts are underway to nurture these, particularly through community-based MPA management. Alternatively, Australia has taken an EBM approach using scientific modeling tools, implementing programs such as the Sustainability Assessment for Fishing Effects (SAFE) that assesses fishing impacts and at-risk species. The Great Barrier Reef World Heritage Area is a global model for MPA design and management.

Critical regional solutions include:

- Integrating Climate Change Adaptation and Mitigation into Coastal and Ocean Policy, Planning, and Management
- Ecosystem-Based Management and Integrated Coastal and Ocean Zone Management
- Marine Management Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Strengthening Institutions and Building Capacity
- Regional Governance, Agreements, and Approaches
- Regulation and Enforcement
- Alternative Livelihoods

TABLE 5: Melanesia Threats Based on Scientific Literature and Impact Assessment

✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact <small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>	AUSTRALIA		FIJI		NEW CALEDONIA		PAPUA NEW GUINEA		SOLOMON ISLANDS		VANUATU	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION												
Aquaculture: Wastewater	✓	●	✓	●	✓	●						
Land-based Chemicals	✓	●	✓	●	✓	●	✓	●	✓	●		
Fishing Lines/Nets	✓	●										
Nutrients	✓	●	✓	●	✓	●	●	●	✓	●		
Offshore Oil/Mining	✓	●					✓		✓	●		
Oil Spills & Antifouling Chemicals	✓	●	✓	●	✓	●	✓	●	✓	●	✓	●
Radiouclide												
Solid Waste Disposal				✓	●				✓	●		
Thermal												
Ocean Waste & Toxic Dumping	✓	●	✓	●	✓	●					✓	●
HABITAT DESTRUCTION												
Anchor Damage	✓	●										
Aquaculture: Coastal Modification	✓	●				✓		●				
Coastal Development/Land Reclamation	✓	●	✓	●	✓	●	✓	●				
Destructive Fishing			✓	●					✓	●	✓	●
Dredging	✓	●										
Marine Recreation	✓	●	✓	●		●						
Land-based Sedimentation	✓	●	✓	●	✓	●	✓	●	✓	●	✓	●
Ship Groundings												
Tsunamis						✓	●	✓		●		
Typhoons/Cyclones/Hurricanes & Storm Surge					✓	●	✓				✓	●
Wrecks/Military Equipment							✓	●				
OVERFISHING & EXPLOITATION												
Aquaria Trade	✓	●	✓	●					✓	●	✓	●
Artisanal/Recreational/Subsistence Fishing			✓	●	✓	●	✓	●	✓	●	✓	●
By-Catch & Discharge	✓	●										
Commercial Fishing	✓	●	✓	●	✓	●	✓	●	✓	●	✓	●
CLIMATE CHANGE												
Acidification	✓	●										
Sea Level Rise	✓	●	✓	●					✓	●	✓	●
Sea Surface Temperature**	✓	●	✓	●	✓	●	✓	●	✓	●	✓	●
INVASIVES												
Invasive Species (Different Vectors)	✓	●								✓	●	

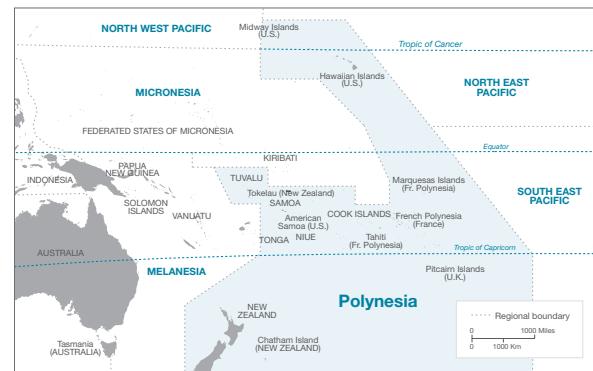
*Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

Polynesia

Photo: The Hawaiian monk seal (*Monachus schauinslandi*) is an endemic and endangered species protected by the Papahānaumokuākea Marine National Monument. (© John Johnson/Marine Photobank)

GEOGRAPHIC OVERVIEW

A sub-region of Oceania, Polynesia comprises more than 1,000 island countries and territories scattered over a very large area: the Cook Islands, French Polynesia (France), Hawaii (US), New Zealand, Niue, Pitcairn Islands (UK), Samoa, Tokelau (New Zealand), Tonga, Tuvalu, and American Samoa. These islands range from large continental islands, high offshore islands, coral limestone islands, to numerous atolls. Some countries and territories, such as Niue, may consist of a single small coral island, while others, including Tonga and French Polynesia, comprise many highly dispersed islands. While New Zealand and Hawaii contain significant urban areas and natural resources, many other Polynesian islands are less developed, have fewer natural resources, and depend on subsistence or small-scale agriculture and fishing. Polynesia is rich in coral reefs, helping to support a robust tourist industry. The overall asset value of Hawaii's 1,660 square kilometers of reef area in the main islands is estimated at nearly USD \$10 billion. Meanwhile the pearl industry, prevalent throughout eastern Polynesia, contributes exports worth USD \$150 million annually. Because of the stark contrasts in the socioeconomic environments of Polynesia, resources are used and managed differently throughout this region.



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
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THREATS

Polynesia has only overall moderate impact threats in all four broad categories (overfishing and exploitation, climate change, habitat destruction, and pollution). Primary among these is coastal development and land reclamation, which lead to the damage or destruction of critical ecosystems that produce invaluable services and products for society. Artisanal, recreational, and subsistence fishing are the main fishing threats in Polynesia, with the potential to cause ecological shifts and reduce fish stocks and food supply, thereby endangering human economies and livelihoods. Climate change-related sea level rise, which can inundate some of the lower-lying islands, is also a concern. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire Polynesia region are:

- No overall severe impact threats exist in this region.

The threats with overall moderate impacts across the region are:

- coastal development/land reclamation identified in eight countries or territories.

- sea level rise identified in eight countries or territories.
- artisanal/recreational/subsistence fishing identified in seven countries or territories.
- sea surface temperature increase resulting from climate change identified in six countries or territories.
- land-based sedimentation and nutrients identified in five countries or territories.

Key observations regarding research gaps and identified impacts:

- It is a vast region, made up of both large and small island countries and territories, some with extreme poverty and others with greater wealth.
- The more densely populated and wealthier islands such as Hawaii and New Zealand have more threats with greater impacts.
- Countries and territories such as Niue, Samoa, Tokelau, Tonga, and Tuvalu have just a few papers and reports on threats. Many small islands, namely the Pitcairn Islands, Niue, Tonga, and Tokelau, have few documented, identified threat categories.

SOLUTIONS

Because of Polynesia's extreme political and socioeconomic diversity, differences exist in terms of solutions and the capacity to implement them. However, as with the two regions of Oceania previously discussed, climate change is a critical issue, and Polynesian countries and territories have responded similarly to their Oceania neighbors, inclusive of the use of regional approaches. Hawaii has received worldwide recognition for the establishment of the Papahānaumokuākea Marine National Monument, an MPA protecting 340,000 square kilometers with 7,000 species of birds, fish, and marine mammals, a quarter of which are endemic. Other MPAs in the region are adopting traditional marine tenure approaches. New Zealand and Hawaii have institutions and capacities for effective coastal and ocean management, but needs exist elsewhere to strengthen institutions, regulation and enforcement, and to build capacity.

Critical regional solutions include:

- Integrating Climate Change Adaptation and Mitigation into Coastal and Ocean Policy, Planning, and Management.
- Marine Management Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Strengthening Institutions and Building Capacity
- Regional Governance, Agreements, and Approaches
- Regulation and Enforcement
- Alternative Livelihoods

TABLE 6: Polynesia Threats Based on Scientific Literature and Impact Assessment

✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact		AMERICAN SAMOA		COOK ISLANDS		FRENCH POLYNESIA		HAWAIIAN ISLANDS		NEW ZEALAND		NIUE		PITCAIRN ISLANDS		SAMOA		TOKELAU		TONGA		TUVALU	
Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts		
<small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>																							
POLLUTION																							
Aquaculture: Wastewater			✓	●	●	✓	●	✓	●	✓	●	✓	●	✓	●								
Land-based Chemicals	✓	●				✓	●					✓	●			✓	●						
Fishing Lines/Nets										✓	●	✓	●			●							
Nutrients	✓	●	✓	●	●	✓	●	✓	●	✓	●	✓	●	✓	●								
Offshore Oil/Mining																							
Oil Spills & Antifouling Chemicals	✓	●	✓	●	●	✓	●	●							✓	●			✓	●	✓	●	
Radionuclide										✓	●												
Solid Waste Disposal			✓	●					✓	●													
Thermal																							
Ocean Waste & Toxic Dumping	✓	●				✓	●													✓	●		
HABITAT DESTRUCTION																							
Anchor Damage										✓		●											
Aquaculture: Coastal Modification							✓	●	✓	●	✓	●	✓	●	✓	●							
Coastal Development/Land Reclamation	✓	●	✓	●	●	✓	●	●	✓	●	✓	●	✓	●	✓	●			✓	●	✓	●	✓
Destructive Fishing																		✓	●				
Dredging										✓		●							✓	●			
Marine Recreation									✓		●												
Land-based Sedimentation	✓	●	✓	●	●	✓	●	●	✓	●	✓	●	✓	●	✓	●							
Ship Groundings																							
Tsunamis							✓	●															
Typhoons/Cyclones/Hurricanes & Storm Surge	✓	●				✓	●								✓	●				✓	●		
Wrecks/Military Equipment									✓	●													
OVERFISHING & EXPLOITATION																							
Aquaria Trade									✓		●								✓	●			
Artisanal/Recreational/Subsistence Fishing	✓	●	●	✓	●	●	✓	●	●	✓	●	●	✓	●	✓	●	✓	●	✓	●	✓	●	✓
By-Catch & Discharge	✓	●	●						✓	●	●	✓	●	✓	●	✓	●	✓	●				
Commercial Fishing	✓	●				✓	●	●	✓	●	✓	●	✓	●	✓	●			✓	●			
CLIMATE CHANGE																							
Acidification	✓	●							✓	●													
Sea Level Rise	✓	●	●	✓	●	●	✓	●	●	✓	●	●	✓	●	✓	●	✓	●	✓	●	✓	●	✓
Sea Surface Temperature**	✓	●	●	✓	●	●	✓	●	●	✓	●	●	✓	●	✓	●	✓	●	✓	●	✓	●	✓
INVASIVES																							
Invasive Species (Different Vectors)	✓	●							✓	●	●	✓	●	✓	●	✓	●						

**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

South East Pacific Ocean

GEOGRAPHIC OVERVIEW

Four South American countries comprise the South East Pacific region: Chile, Colombia, Ecuador, and Peru. The South East Pacific contains high biodiversity in its various coastal and ocean ecosystems, from reefs and islands, to wetlands, estuaries, fjords, and highly threatened mangroves. The Humboldt Current, which flows along the west coast of South America from southern Chile to northern Peru before deflecting offshore to Ecuador's Galapagos Islands, produces a rich ecosystem and the world's largest upwelling area, influencing much of the region. These upwelling waters support some of the most significant fisheries in the world. Throughout the region, aquaculture and fishing are the most important economic activities, second only to the North West Pacific in terms of global fishing production. Periodically, ENSO events disrupt the upwelling that drives this region's productivity, affecting fish abundance and distribution, often leading to fishery stock crashes and negative socioeconomic impacts.

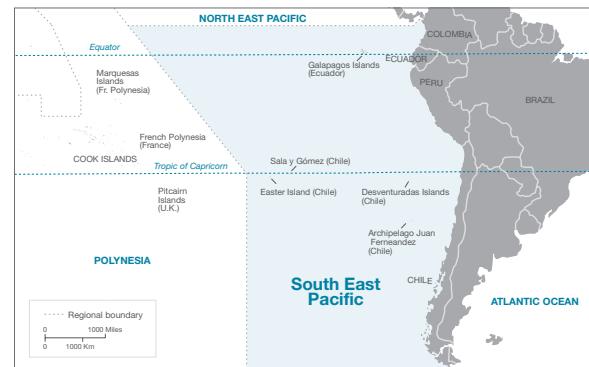
THREATS

All four broad threats (overfishing and exploitation, climate change, habitat destruction, and pollution) have overall severe to moderate impacts across the South East Pacific, with invasive species noted as a moderate impact. An extremely grave threat is pollution — largely from land-based chemicals and nutrients, aquaculture wastewater, and oil spills. This pollution can create dead zones and algal blooms, alter ecosystem structure, and jeopardize human systems. Other primary concerns include land-based sedimentation, a form of habitat destruction that can lead to the degradation of critical ecosystems, and commercial fishing, which causes ecological shifts and reduces fish stocks and food supply, thereby endangering human economies and livelihoods. As in other regions, climate change — in particular sea surface temperature increase — also severely affects all countries in the region. A breakdown of the region's threats with overall severe and moderate impacts can be found in the bullets on this page.

Based on this assessment, the threats with overall severe impacts across the entire South East Pacific region are:

- land-based chemicals and nutrient pollution identified in four countries.
- land-based sedimentation identified in four countries.
- commercial overfishing identified in four countries.
- wastewater from aquaculture, oil spills, and antifouling chemicals across region.

Photo: Regional cooperation via the multinational Eastern Tropical Pacific Seascape Initiative is geared towards protecting entire ranges of highly migratory species such as this Green turtle (*Chelonia mydas*) from the Galapagos. (David Lee, courtesy Conservation International)



Source: International Ocean Commission and The United Nations (www.unep-wcmc.org/gramed)
2008 Lucidity Information Design, LLC

- coastal development/land reclamation across the region.
- climate change, specifically sea surface temperature increase.

The threats with overall moderate impacts across the region are:

- coastal modification from aquaculture, solid waste disposal, thermal pollution, and artisanal/recreation/subsistence fishing.
- invasive species.
- by-catch and discharge.
- offshore oil/mining.

Key observations regarding research gaps and identified impacts:

- These countries' marine environment is one of the least protected, and most exploited, in South America.
- Ecuador has the greatest documented number of moderate (nine) to severe (eight) impacts. Colombia has the lowest number of documented moderate (seven) to severe (four) impacts in the region.
- Large gaps in the research include studies on aquaculture and the impacts of threats in Colombia and Peru as well as ocean-based pollution (ocean waste, toxic dumping, and fishing lines/nets) throughout the region, impacts of climate change, and coastal development/land reclamation.

SOLUTIONS

A number of important MPAs and marine reserves exist in the South East Pacific, protecting important mangroves, wetlands, and oceanic islands such as the Galapagos, Gorgona, and Malpelo. A need exists for a network of MPAs in Chile, but fortunately much of the southernmost islands and fjords are already included in the National System of Protected Areas. Other than the Eastern Tropical Pacific Seascape initiative, discussed under the North East Pacific and relevant to the northern portion of this region, a lack of regional governance exists and is critical to jumpstart, particularly for Chile and Peru's shared Humboldt system. Regulation and enforcement, as well as the mitigation of infrastructure-based impacts also need strengthening throughout this region.

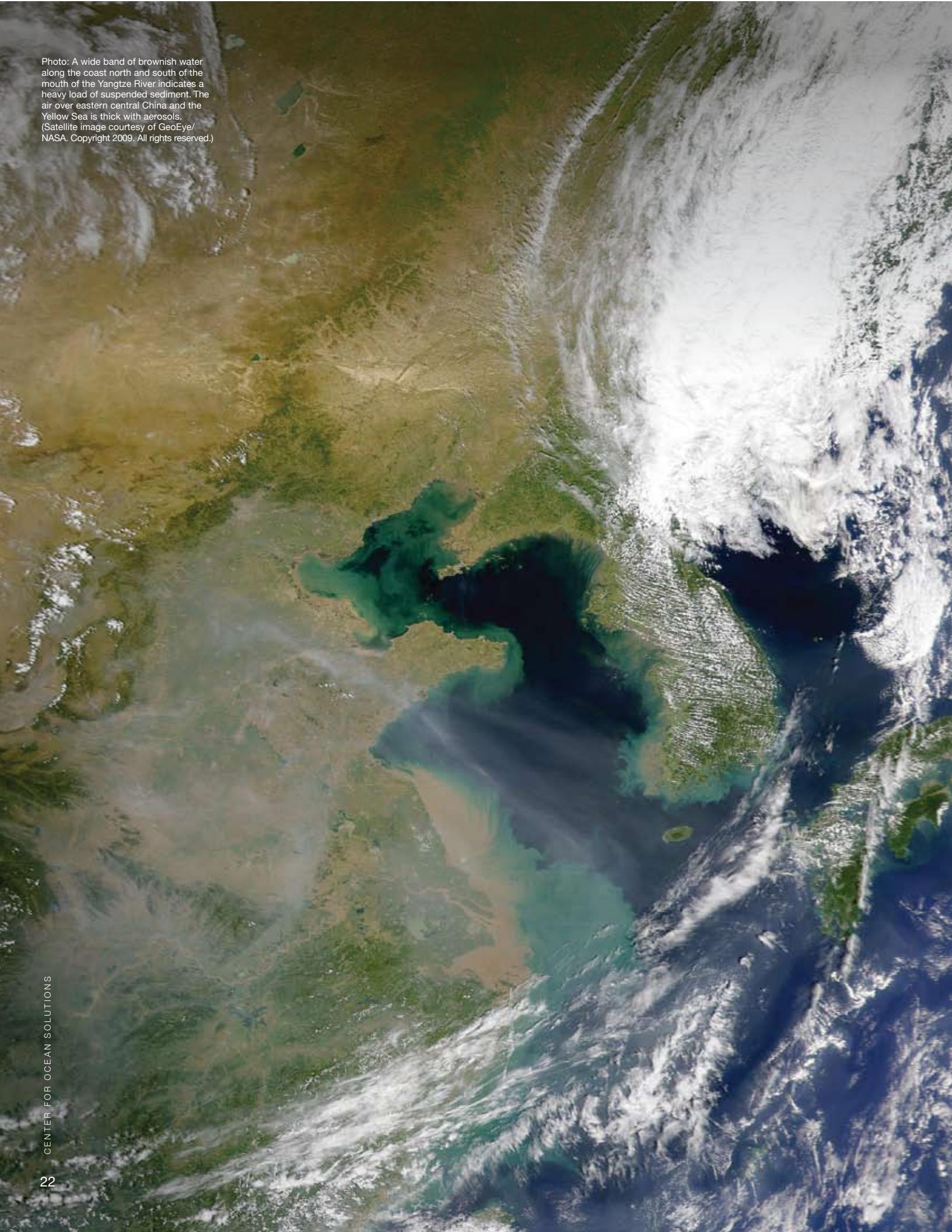
Critical regional solutions include:

- Marine Managed Areas: Networks, MPAs, Reserves, and Locally Managed Areas
- Regional Governance, Agreements, and Approaches
- Regulation and Enforcement
- Infrastructure Development

TABLE 7: South East Pacific Threats Based on Scientific Literature and Impact Assessment								
✓ Identified as Threat ● Severe Impact ● Moderate Impact ● Low Impact <small>It was documented when an article identified an issue as a present or future threat. If no scientific literature was found on the topic, then no check was assigned. This does not necessarily mean the topic is not a threat; rather, it suggests that no scientific literature was found on the topic.</small>	CHILE		COLOMBIA		ECUADOR		PERU	
	Threats	Impacts	Threats	Impacts	Threats	Impacts	Threats	Impacts
POLLUTION								
Aquaculture: Wastewater	✓	●	✓	●	✓	●	✓	●
Land-based Chemicals	✓	●	✓	●	✓	●	✓	●
Fishing Lines/Nets					✓	●		
Nutrients	✓	●	✓	●	✓	●	✓	●
Offshore Oil/Mining	✓	●	✓	●	✓	●	✓	●
Oil Spills & Antifouling Chemicals	✓	●	✓	●	✓	●	✓	●
Radionuclide								
Solid Waste Disposal	✓	●	✓	●	✓	●	✓	●
Thermal	✓	●	✓	●	✓	●	✓	●
Ocean Waste & Toxic Dumping								
HABITAT DESTRUCTION								
Anchor Damage					✓	●		
Aquaculture: Coastal Modification	✓	●	✓	●	✓	●	✓	●
Coastal Development/Land Reclamation	✓	●	✓	●	✓	●	✓	●
Destructive Fishing					✓	●	✓	●
Dredging								
Marine Recreation								
Land-based Sedimentation	✓	●	✓	●	✓	●	✓	●
Ship Groundings								
Tsunamis								
Typhoons/Cyclones/Hurricanes & Storm Surge								
Wrecks/Military Equipment								
OVERFISHING & EXPLOITATION								
Aquaria Trade								
Artisanal/Recreational/Subsistence Fishing	✓	●	✓	●	✓	●	✓	●
By-Catch & Discharge	✓	●	✓	●	✓	●	✓	●
Commercial Fishing	✓	●	✓	●	✓	●	✓	●
CLIMATE CHANGE								
Acidification								
Sea Level Rise	✓	●						
Sea Surface Temperature**	✓	●	✓	●	✓	●	✓	●
INVASIVES								
Invasive Species (Different Vectors)	✓	●	✓	●	✓	●	✓	●

**Changes in SST is strongly associated with El Niño Southern Oscillation (ENSO) events, which are predicted to increase in frequency and intensity over time due to climate change.

Photo: A wide band of brownish water along the coast north and south of the mouth of the Yangtze River indicates a heavy load of suspended sediment. The air over eastern central China and the Yellow Sea is thick with aerosols.
(Satellite image courtesy of GeoEye/
NASA. Copyright 2009. All rights reserved.)



Research Gaps

Throughout the Pacific there is a scarcity of relevant applied natural and especially social science research to inform ocean and coastal policy and management. Throughout this literature review and these tables we highlight research gaps, where needs and opportunities exist to target certain issues to improve understanding of the threat and impact on both the environment and society. We hope by highlighting gaps the scientific community will be more likely to conduct applied research that responds to policy and management needs and questions. This information can then be shared with policy makers and managers to help make better informed coastal and ocean decisions. Our research reveals the following general research gaps:

POLLUTION

Land-Based Chemicals: Chemical pollutants are typically not monitored, and few studies link water quality and, in particular, chemical discharges with the impacts on the marine environment. Because more than 70,000 synthetic compounds are discharged into the ocean (Burke, Kura et al. 2001), it is difficult to ascertain present and future impacts to both the environment and society.

Fishing Lines/Nets, Oil Spills and Antifouling Chemicals, Ocean Waste, and Toxic

Dumping: A few studies have documented fishing line and net debris impacts on the marine environment. Many studies on oil spills and hydrocarbons have been conducted in areas where spills occurred near or in large harbors. Most of these studies discuss impacts to sediment and water quality, but do not link the impact to the marine ecosystem. Finally, toxic dumping is not well documented, especially where it is illegal.

Radionuclides: Radionuclide studies have been conducted in many locations, but not in others where high levels are likely. Additionally, the socioeconomic impacts have not been documented.

Solid Waste Disposal: There is a need to do more research on solid waste disposal and removal, an increasing problem on islands where the threat exists. In Hawaii, solid waste and marine debris are well documented, but in other locations they are not.

Other Threats: Other threats listed in this category have impacts that are poorly documented. Offshore mining, for instance, could increase significantly in the future. Additionally, only a small minority of countries and territories has documented thermal pollution.

HABITAT DESTRUCTION

Aquaculture: Coastal Modification: While many countries and territories engage in intensive aquaculture production, there is scant documentation of coastal modification resulting from aquaculture. Many studies show the environmental impact of aquaculture wastewater, but few have been conducted documenting the cost to society.

Coastal Development/Land Reclamation: The biggest gap in this threat category is the lack of coastal habitat mapping in many parts of the Pacific. Without it, scientists cannot observe changes over time or quantify habitat changes and impacts.

Land-Based Sedimentation: While nutrients and eutrophication are well documented in the Pacific Ocean, sedimentation is not; research gaps exist in Guatemala and Honduras, for example.

Typhoons/Cyclones/Hurricanes/Storm Surges: Some countries and territories have conducted studies examining impacts of tsunamis and typhoons, for example, both on the coastal and ocean environment and society, but few in the most vulnerable islands.

OVERFISHING AND EXPLOITATION

Fisheries statistics are incomplete; only limited studies accurately document by-catch and illegal and destructive fishing activities. More studies throughout the Pacific are also needed to document the fishing effort and value from subsistence, artisanal, and recreational fishing.

CLIMATE CHANGE

While sea surface temperature is well documented throughout the Pacific Ocean, the socioeconomic impacts are not. Many Pacific countries and territories also lack information on sea level rise. For example, many small islands and developing states (SIDS) have only just begun to monitor and analyze sea level data. Because few have documented potential impacts and costs to society, the development of adaptation and mitigation strategies is extremely challenging. Ocean acidification is an emerging issue, and although a few studies have been conducted off the coast of North America and experiments been done on coral reefs, scientists do not know the extent of ocean acidification's impact on marine and human systems. Scientists also need to examine how climate change will affect and/or compound other threats, such as land-based pollution, invasive species, etc., and magnify their impacts. Range shifts related to climate change are also understudied. While scant research has been conducted on this topic, historic and more recent evidence suggests that marine communities, in response to climate change, exhibit geographical range shifts that, in some instances, may lead to significant morphological evolution.

OTHER CRITICAL GAPS:

- Both biodiversity monitoring programs and water quality monitoring programs are inconsistent and not standardized across the Pacific.
- Many studies identify threats, but do not examine the impact on the environment, or compare or prioritize the threat relative to another threat.
- Socioeconomic research and data are minimal. Such information is increasingly important in order to connect the threat to the impact on the environment and society. There is limited socioeconomic impacts data on fisheries, marine protected areas, harmful algal blooms (HABs), climate change, and pollution, for example. A few, but not many, places have documented ecosystem services and the value of such systems.
- Monitoring and analyzing multiple threats is extremely challenging. However, understanding threats in relation to each other is crucial in order to create cause-and-effect relationships between threats and impacts, and properly regulate those threats.



The findings of the Pacific Ocean Synthesis led to a consensus statement signed by over 400 scientists from around the Pacific: *Ecosystems and People of the Pacific Ocean – Threats and Opportunities for Action: A Scientific Consensus Statement*. To view or sign the Consensus Statement visit the Center for Ocean Solutions online at: <http://poi.stanford.edu> or send an e-mail with your name and institution to: **POIstatement@stanford.edu**.

Back Cover Photo: Mollusk (*Order Nudibranchia*) swimming on the flank of Davidson Seamount at 1,498 meters water depth.
(NOAA/Monterey Bay Aquarium Research Institute)



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