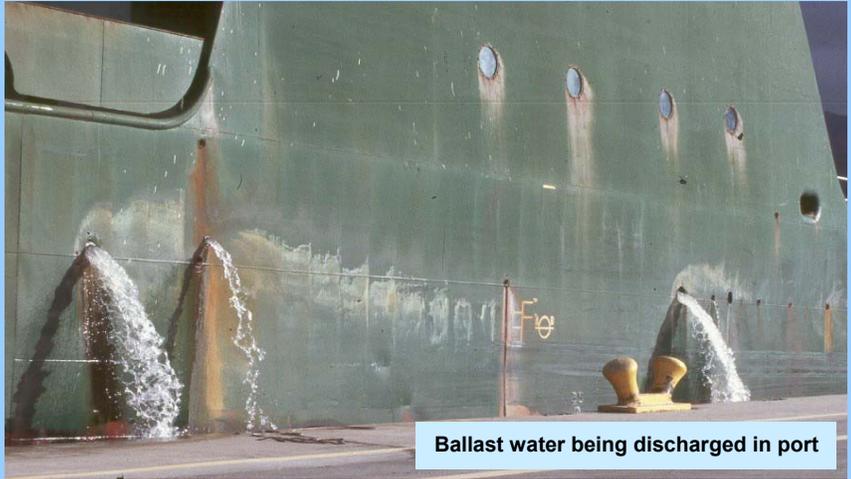
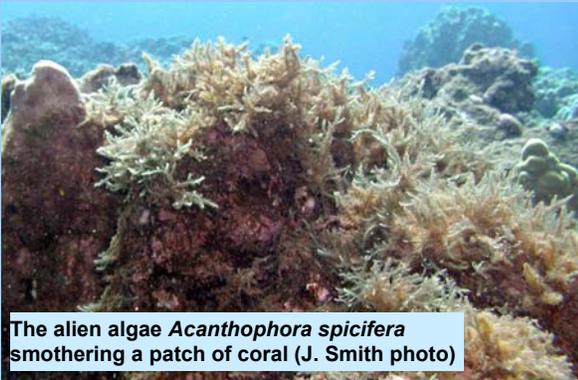


Large commercial vessels come to Hawai'i from all over the Pacific, Atlantic, and Indian Oceans. Foreign fishing vessels visit Hawai'i to re-fuel and/or re-provision. In addition, cruise ships visit Hawai'i from all over the Pacific. This ability of modern ships to cover long distances in a short time period provides a means for nonnative marine species, including algae, invertebrates, and pathogens, to arrive in Hawai'i via hull fouling, ballast water and ballast sediments. These pathways can introduce alien species that can have dramatic economic and environmental consequences. Ballast water has been studied extensively world wide, and numerous invasive introductions are attributed to this mode of introduction. In Hawai'i however, recent studies have shown that more than 70% of invasive marine invertebrates have been introduced by hull fouling.

# BALLAST WATER/ HULL FOULING



Ballast water being discharged in port

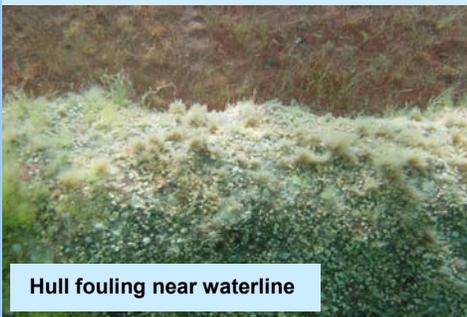


The alien algae *Acanthophora spicifera* smothering a patch of coral (J. Smith photo)

**Ballast water** is usually taken into the ballast tanks when cargo is being offloaded, and discharged when cargo is being loaded. Ballast water quantities are adjusted on the open ocean, to compensate for weather (storms), fuel consumption, and for the overall safety of the ship and its crew. When ships take in water for ballast in port, they also take in whatever organisms (larvae, adults, cysts, pathogens) are present in that water. These organisms are then transported, and are potentially introduced into the waters of the ports along the vessels' routes as ballast tanks are emptied for cargo loading.

**Hull fouling** is the attachment of organisms to the hulls of ships, barges, floating dry docks, and other floating or submerged surfaces. These organisms increase drag, resulting in slower speeds and higher fuel consumption. Hull fouling may be the most underestimated pathway for nonnative introductions. According to recent information, of the 287 introduced marine invertebrates in Hawai'i, as many as 70% may have been brought here via hull fouling.

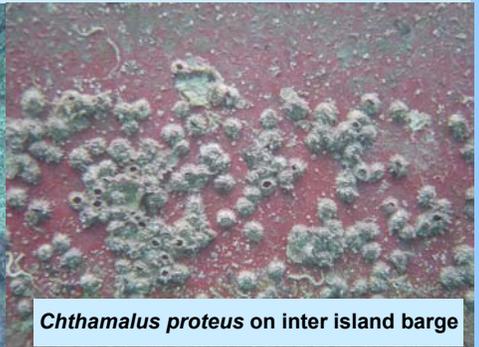
Examples of nonnative species that are considered to have arrived in Hawai'i as a result of hull fouling include *Acanthophora spicifera*, which arrived on the hull of a barge from Guam in 1950, and the introduced barnacle *Chthamalus proteus*, which is now present on all of the main islands, except Kaho'olawe, which does not receive commercial traffic.



Hull fouling near waterline



Hull fouling on bow of a ship



*Chthamalus proteus* on inter island barge



Information and photos provided by Scott Godwin, Bishop Museum