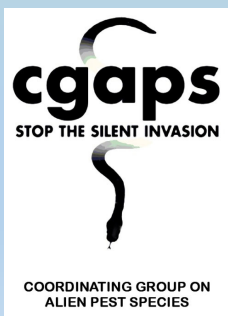




Marine Biosecurity: Pathways

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Hawai'i from the International Space Station by NASA

Marine Invasive Species

There is an **increase** in aquatic non-native species (Bailey et al. 2020)

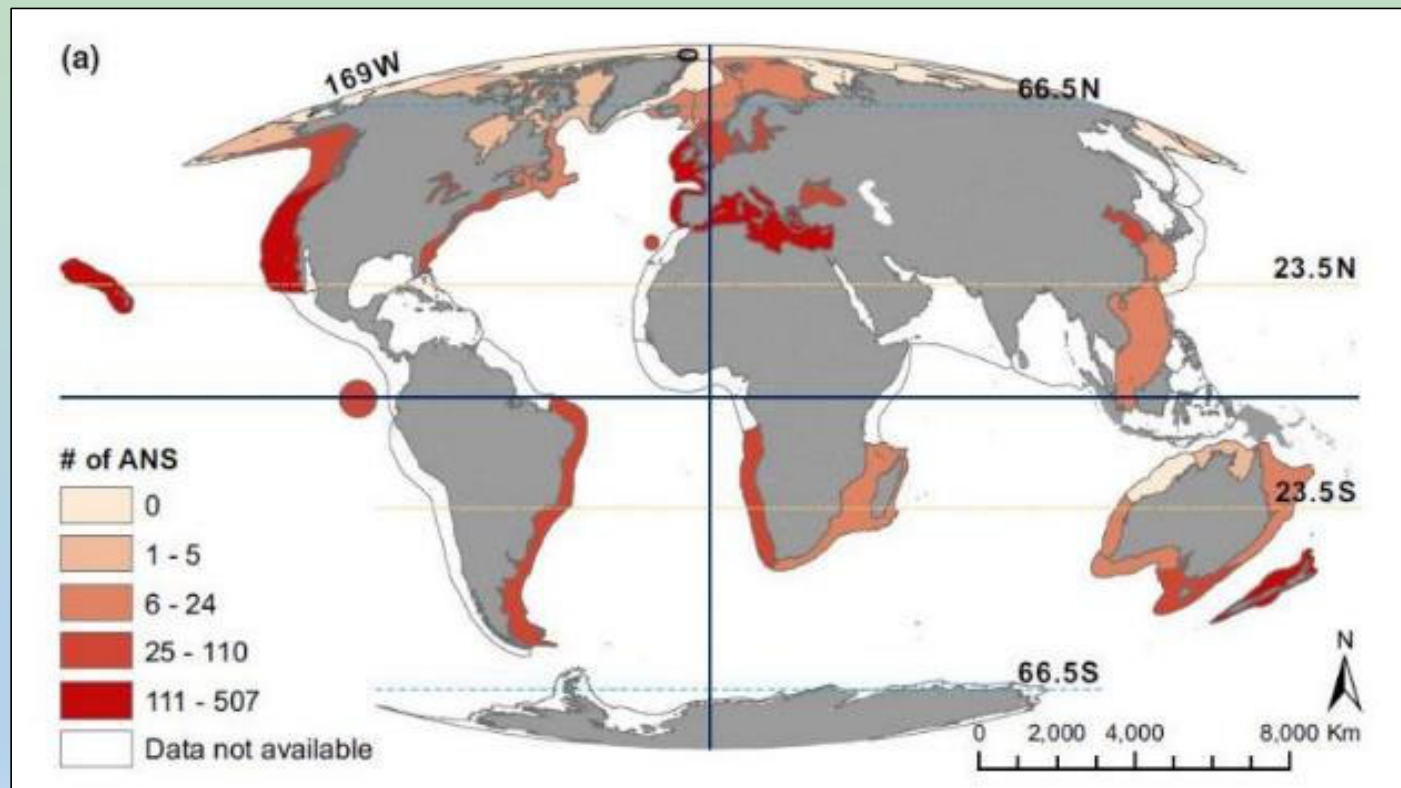
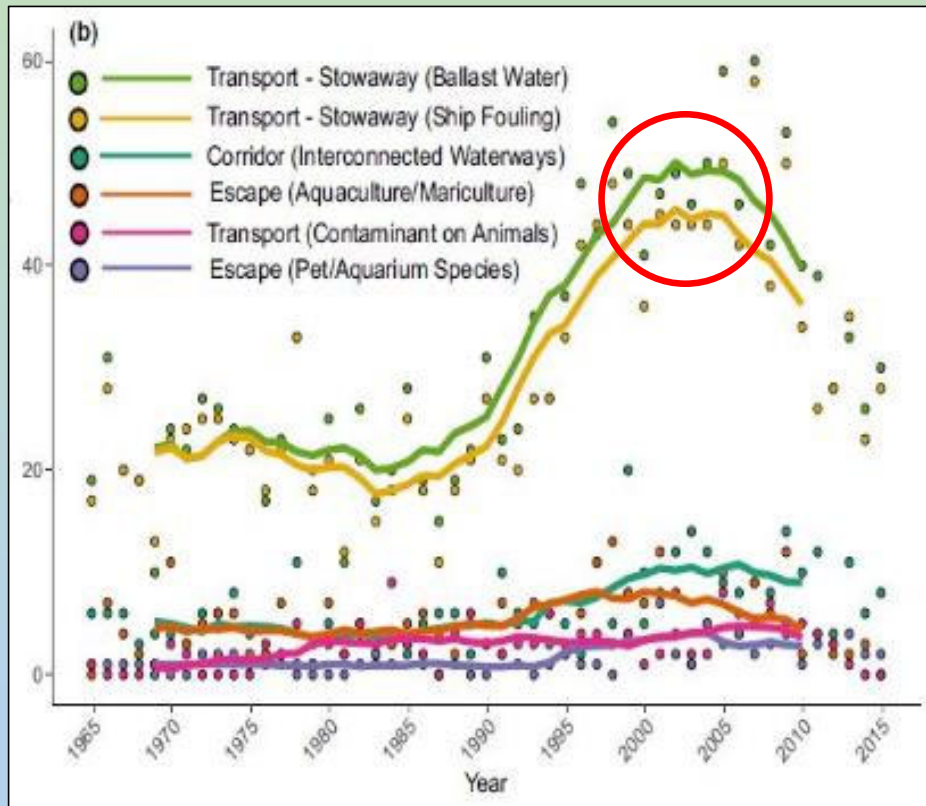


Fig. 1: Records of primary detections of aquatic non-native species (ANS) between 1965 and 2015 in each of 49 coastal marine, estuarine, and freshwater ecosystems. (image from Bailey et al., 2020)

Marine Invasive Species Pathways



- Vessel ballast water
- Vessel biofouling
- Aquaculture/Mariculture release or escape
- Contaminant or hitchhike on other species
- Escaped or released aquarium pets
- Fouling on marine debris

Fig 2: Chronology of primary detection events of ANS across 49 marine, estuarine, and freshwater ecosystems during 1965–2015 [...] the number of primary detection events of ANS by pathway, for the top six pathways (96% of records). Bailey et al., 2020)

Issue: Vessels, marine invasive species, and climate change

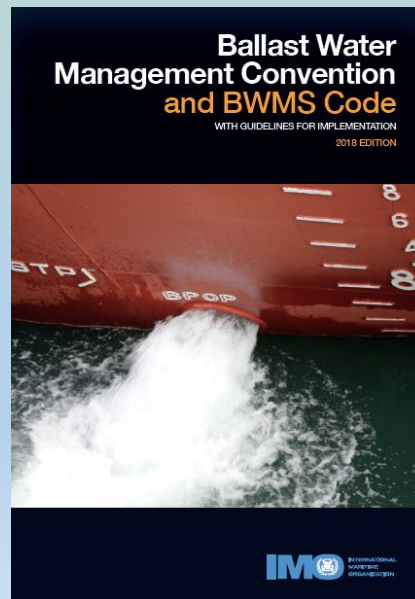
- Global maritime traffic is projected to increase by 240 – 1,209% by 2050 and yield a **3- to 20-fold increase in global marine species invasion risk**
- **Shipping growth will have a far greater effect on marine invasions** than climate-driven environmental changes (both bullets Sardain et al. 2019)



Fig 3: One year of vessel traffic in 2017. [Www.marinetraffic.com](http://www.marinetraffic.com)

1. Vessel ballast water

- International regulations, many national regs
- Ballast water management systems (BWMS)
- U.S. has BWMS testing protocol & performance standards



Ballast water issue: Stony Coral Tissue Loss Disease—SCTLD

- Disease first discovered in South Florida in 2014, now **spread to 28 Caribbean countries**
- Affects 30+ coral species. Once **infected, coral colonies die within weeks to months**. Up to **90% loss** of living coral
- Bacterial or viral microbes suspected but still **not isolated and identified**
- **UV BWMS only 50% effective** at mitigating SCTLD in ballast water (Studivan et al. 2022)
- SCTLD can remain pathogenic in sediments & be spread by moving sediments (Studivan et al. 2022)
- Biofilms are also potential reservoirs (Evans et al. 2022)



SCTLD killing a coral colony in Florida.

Dashboard: <https://oref.maps.arcgis.com/apps/dashboards/54b5df5c111b4fcc986e300c6aea63a3>

2. Vessel biofilms and biofouling

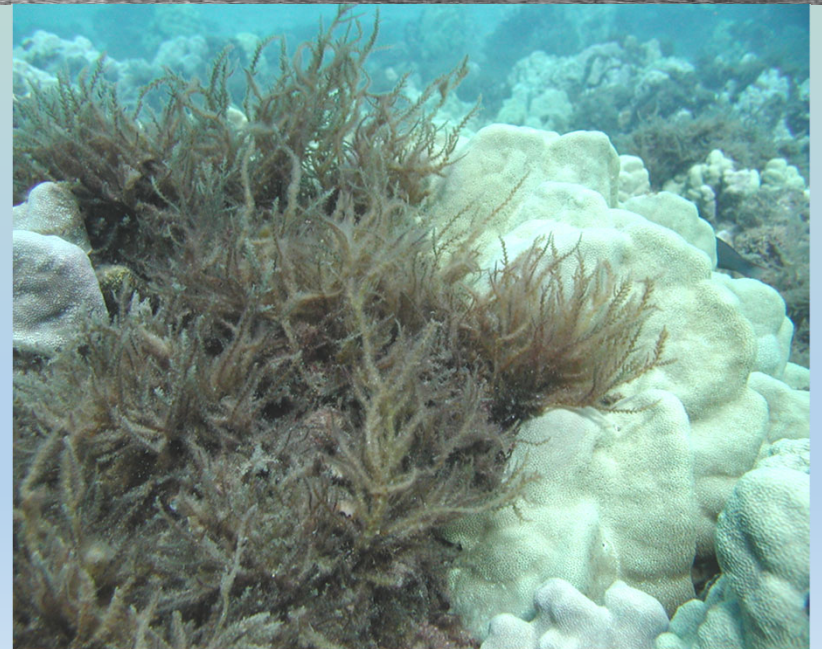
- The growth of marine species on the hull and niche areas, incl. water pipes and “sea chests”.
- Despite anti-fouling paint (which usually contains copper & zinc) or coatings, **biofilm (the bacterial slime-layer)** begins to grow within days and allowing larger **biofouling** species to colonize.
- Unlike ballast water, there are **no binding international regulations** for managing biofouling



Image from: Mario Tamburri

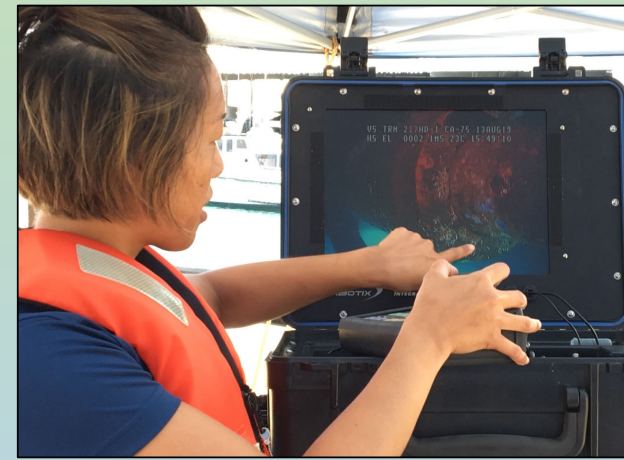
Biofouling: Spiny seaweed (*Acanthophora spicifera*)

- Heavily-fouled fuel barge, the **Yon 146** (right), towed to Pearl Harbor from Apra, Guam, arriving Feb 3, 1950, placed in drydock.
- Identified as a source for possible fish introductions via samples taken (Gosline Brock 1960; 26)
- Identified as a source for Brachyuran crab: *Schizophrys aspere* (Edmondson 1951; 182, 212)
- Identified as source of spiny seaweed: *Acanthophora spicifera* (Doty M.S. 1961 Pacific Science 15, 547–552); spread statewide, **now the most abundant non-native algal species in Hawaii.**

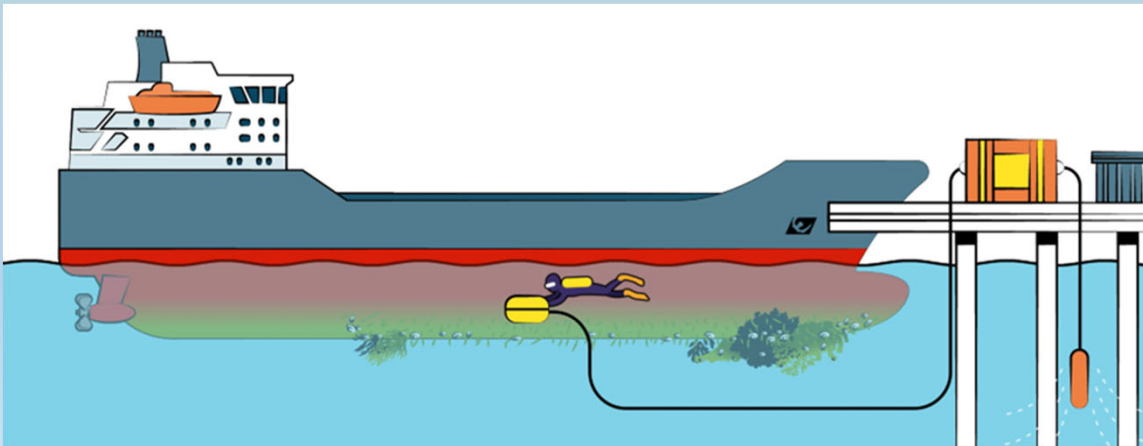


Potential solutions: There are tools available to reduce risk

- Some countries regulate biofouling
- Inspection via ROVs, pole cameras, visual hull-inspection
- Pro-active in-water cleaning with effluent capture and treatment to reduce risk (and reduce emissions, improve fuel efficiency, etc.)



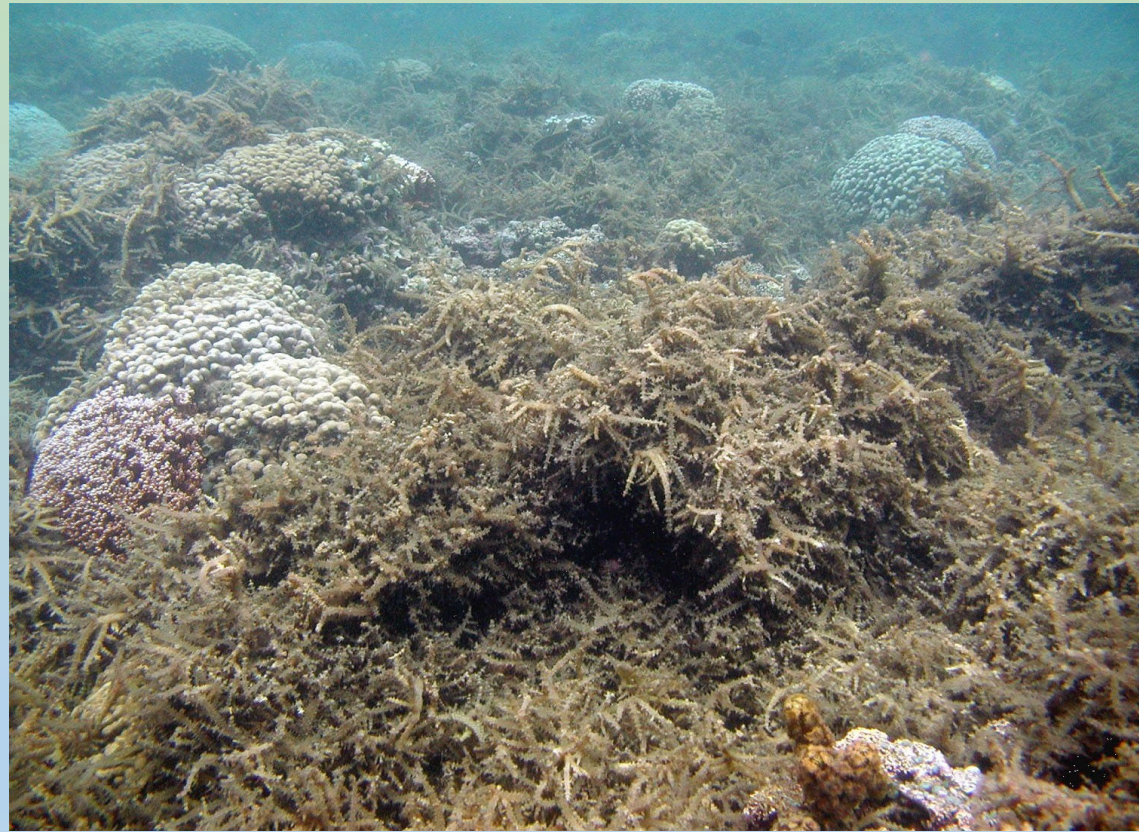
Visual hull inspection (left) and hull inspection via AUV



Left: In-water cleaning with capture graphic.
<https://www.cgaps.org/aquatic-invasive-species/>

3. Aquaculture/Mariculture release / escape

- Aquaculture/mariculture species escapes when biosecurity is lax, when there is equipment failure, or when there is damage during storms
- Businesses failure can result in abandoned ventures (no clean-up)
- Species may be released from captivity to establish local population or because it is the easiest or least expensive option



Kappaphycus spp. Overgrowing coral In Kaneohe Bay, Hawaii.

4. Contaminant / hitchhike on other species

- Parasites or pathogens in live fish, crabs, etc. for food, bait, aquaculture, pets, etc.



Live seafood can potentially carry disease pathogens or parasites.

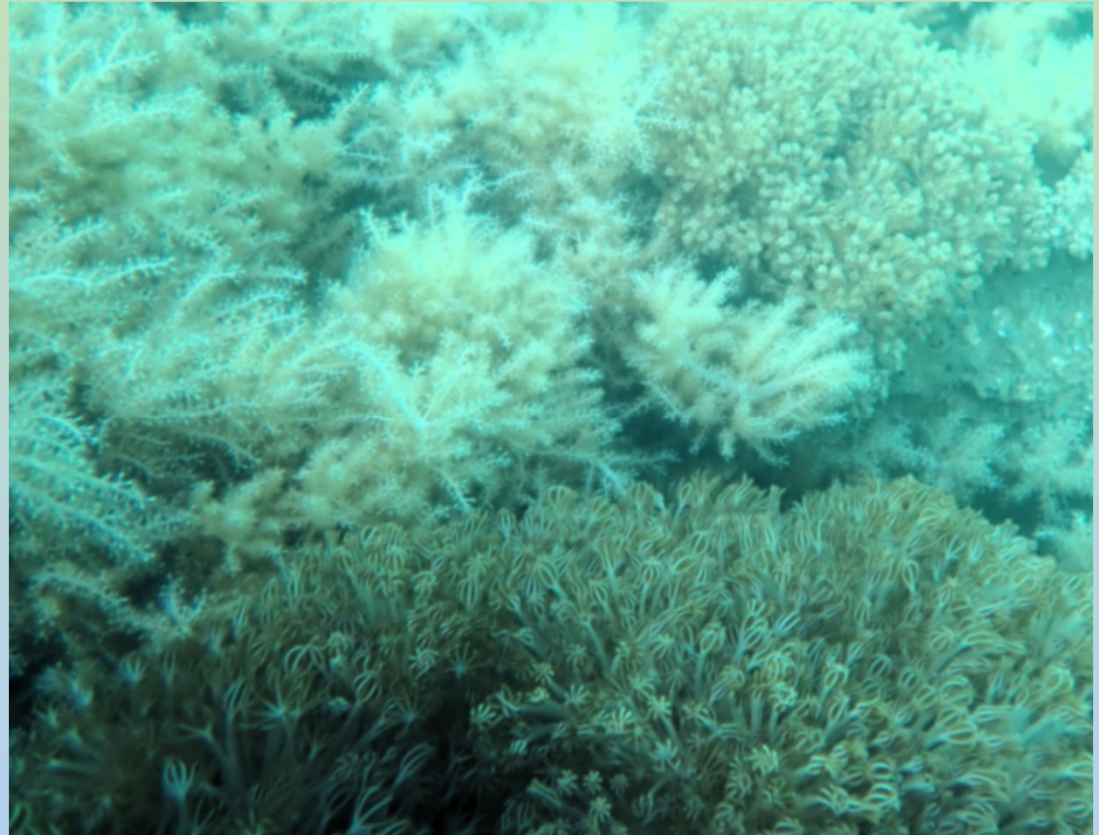
<https://wgme.com/news/local/maine-lobster-in-demand-despite-high-prices>



Zebra mussels found in popular aquarium “marimo” moss balls.

5. Aquarium pet release

- Aquarium pets may be released if owners aren't aware of the possible harm, if they don't have re-homing or amnesty turn-in options
- Despite being illegal to import, possess, and release these species in Hawaii, these likely entered through a loophole where DOD base laws did not mirror state law (BEWARE of this issue!)



Pulse coral (*Unomia stolonifera*) and Kenyan tree coral (*Capnella cf spicata*), non-native octocoral invading Pearl Harbor, Hawaii. These are two of the six species of popular aquarium species found to have been dumped in the harbor.

6. Fouling on marine debris

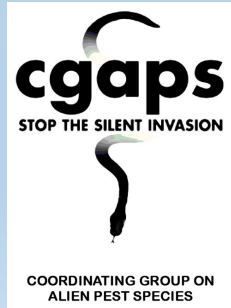
- Marine debris can transport fouling species. Several non-native marine species were found on debris from the 2011 Japan tsunami



A floating dock (left) and a boat and other debris (above) carried multiple species. Some were oceanic, others were nearshore species native to Asia.

Make sure that marine biosecurity is part of your island's plan!

Si Yu'os Ma'āse'!
Mahalo!



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