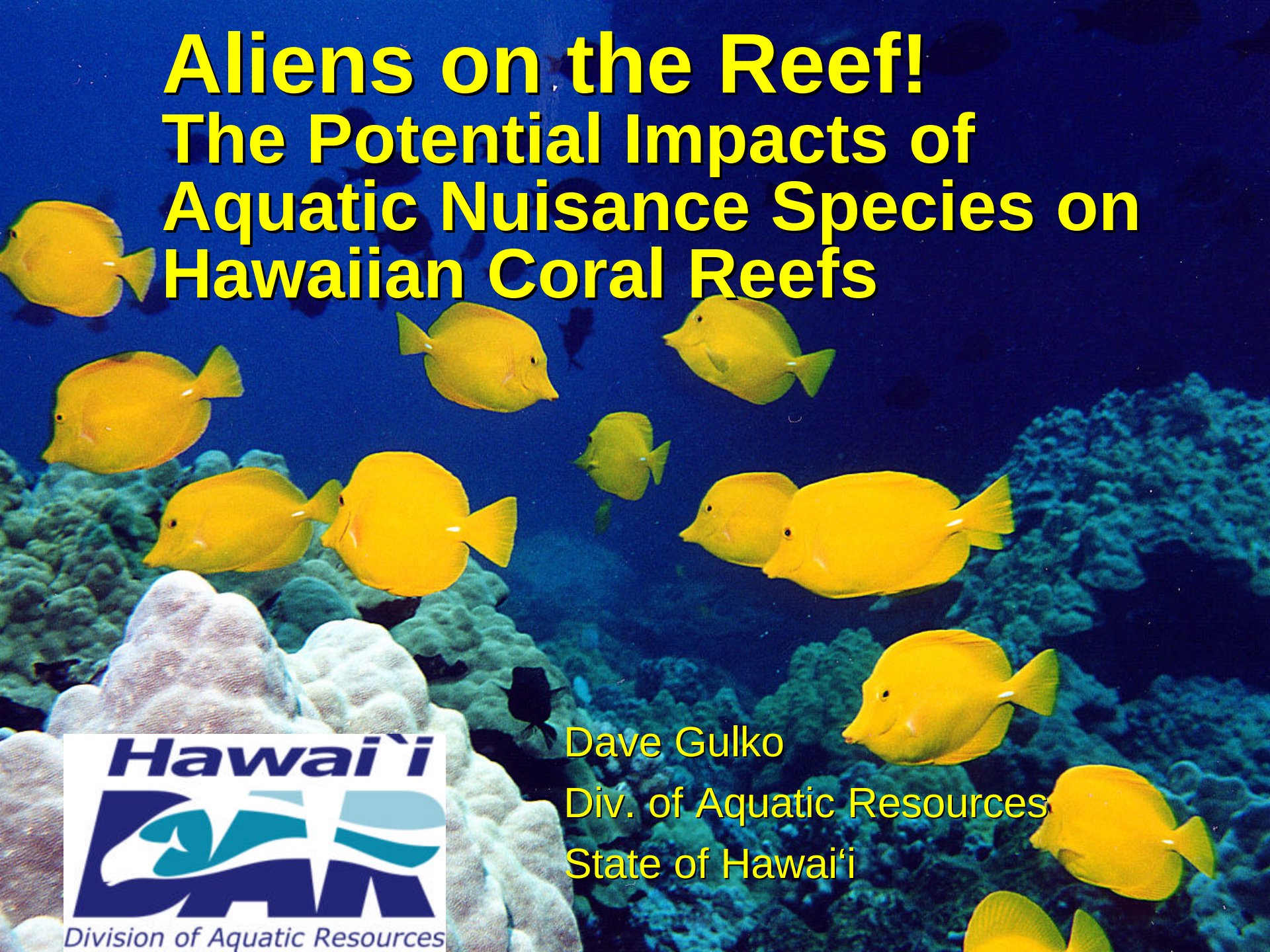
Aliens on the Reef!
The Potential Impacts of Aquatic Nuisance Species on Hawaiian Coral Reefs



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Hawai`i DAR Division of Aquatic Resources

The Issue:

Organisms which are commonly found on coral reefs elsewhere in the world can be devastating if released in Hawai‘i.

Such Hawaiian alien species concerns may hold relevance for management of other coral reef areas.

WHAT ARE MARINE ALIEN SPECIES?

Terminology

- Indigenous/native species: an organism that naturally occurs in an area
- Introduced/non-indigenous/exotic/alien species: an organism that is brought into an area where it does not naturally occur
- Cryptogenic species: an organism of unknown origin
- Invasive/weed/pest/nuisance species: an organism that grows excessively, forms blooms, monospecific stands, dominates landscape

Characteristics of Hawaiian Reefs

- High Endemism

Management Concerns:

- Marine Ornamental Collection
- Alien species

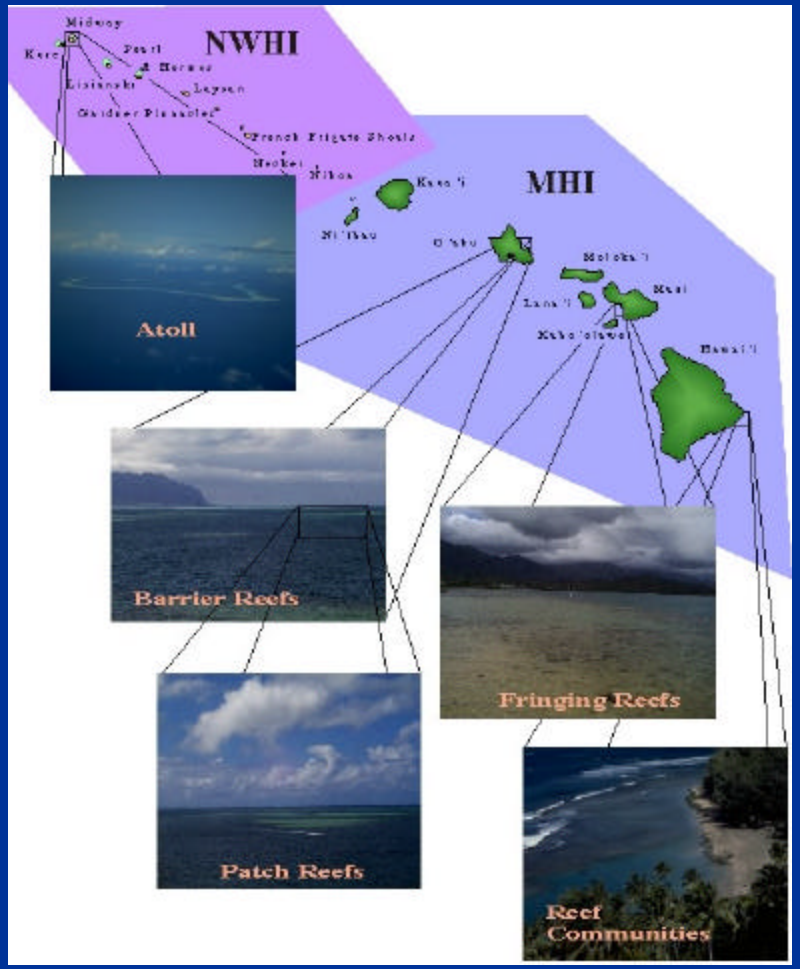
25% of Hawaiian Coral Reef Species are Endemic Across Most Phyla

Characteristics of Hawaiian Reefs

- Range of Reef Types

Management concerns:

- Ecological considerations
- Complexity of Habitats
- Unique Associations (ex. Ark Shell reefs)



Characteristics of Hawaiian Reefs

Ancient Colonies

Reported growth rates for massive corals like *Porites lobata* range from 11 mm in the MHI to 0.3 mm at Kure Atoll (NWHI).

Slower growth rates translates directly to slower recovery rates from human impacts

Characteristics of Hawaiian Reefs

- Protected Species

Alien Species Impacts:

- Displacement of Food Resources
- Resting Habitat
- Mating Habitat


Alien Species Impacts:
- Herbivores (Diet)
- Resting Habitat
- Mating Habitat
- Cleaning Stations
J. Smith (UH-Botany)

QuickTime™ and a
Photo - CD decompressor
are needed to use this picture.

Characteristics of Hawaiian Reefs

- High Endemism
- Range of Reef Types
- Ancient Corals, Slow Recovery Rates?
- Protected Species
- Proximity of Reefs to Shore

The majority of Hawaii's economy is based on tourism; over $800 million per year from marine tourism alone!

HOW DO MARINE ALIENS INVADE A NEW ENVIRONMENT

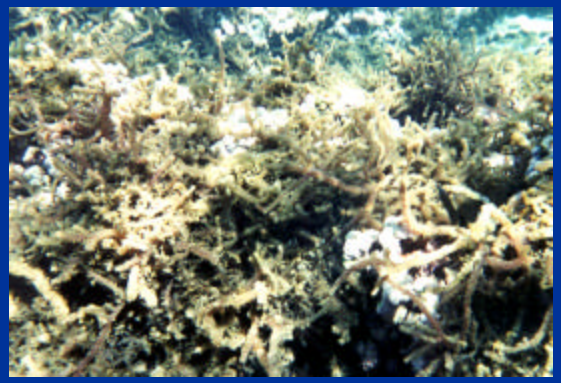
Some Transportation Methods of Introduction:

Commercial and Recreational Vessels, Aquarium Industry, Dry Docks, Marine Debris, Aquaculture and Research

Notes:

While ballast water and hull fouling have been major factors elsewhere, in Hawai'i the major alien impacts on reefs have resulted from aquaculture, research and direct introductions.

Potential Threats



Why Care?

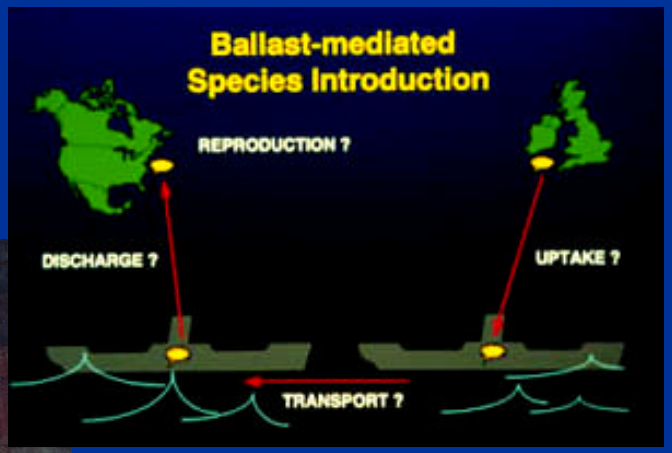
Marine Aliens...

- Compete with native biota: flora and fauna
- May directly kill some species: corals
- May significantly alter ecosystem structure & function
- May reduce biodiversity
- Reduce the aesthetic value of ecosystem
- Translate to economic losses from tourism, fishing, marine ornamental industry
- Cause possible irreversible damage (Extinctions - Kane‘ohe Bay?)

Documented Non-Intentional Introductions Elsewhere

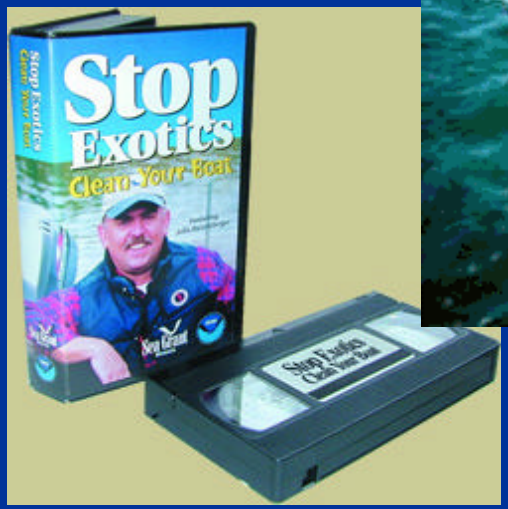
Ballast:

- Transport of water from region to region can introduce exotic species larvae



Aquaria:

- Discharge from public aquariums needs to be closely regulated



Biofouling:

- Organisms can be transported between areas

Aquaculture:

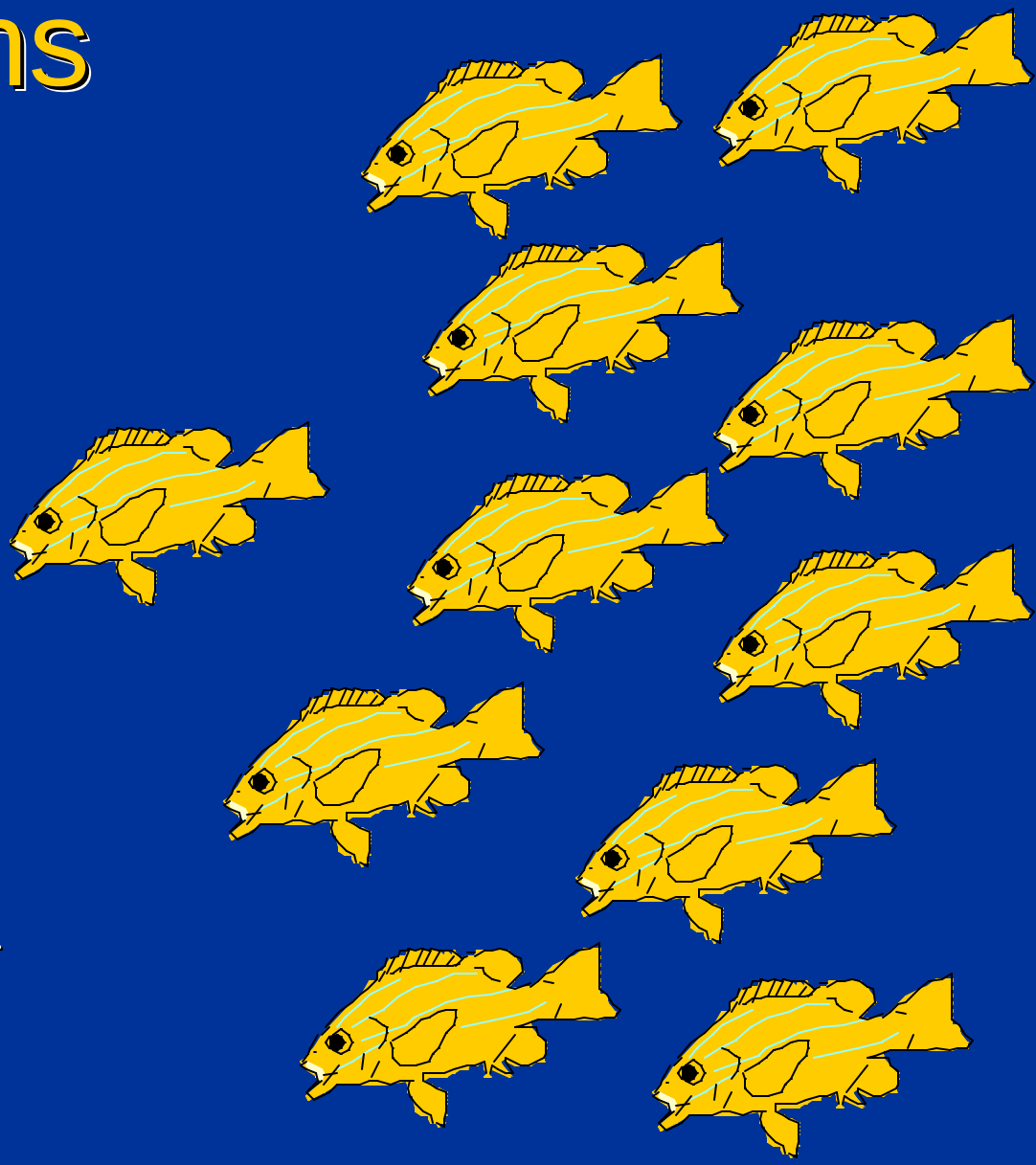
- Other organisms can be introduced through shellfish aquaculture

Documented Intentional Introductions

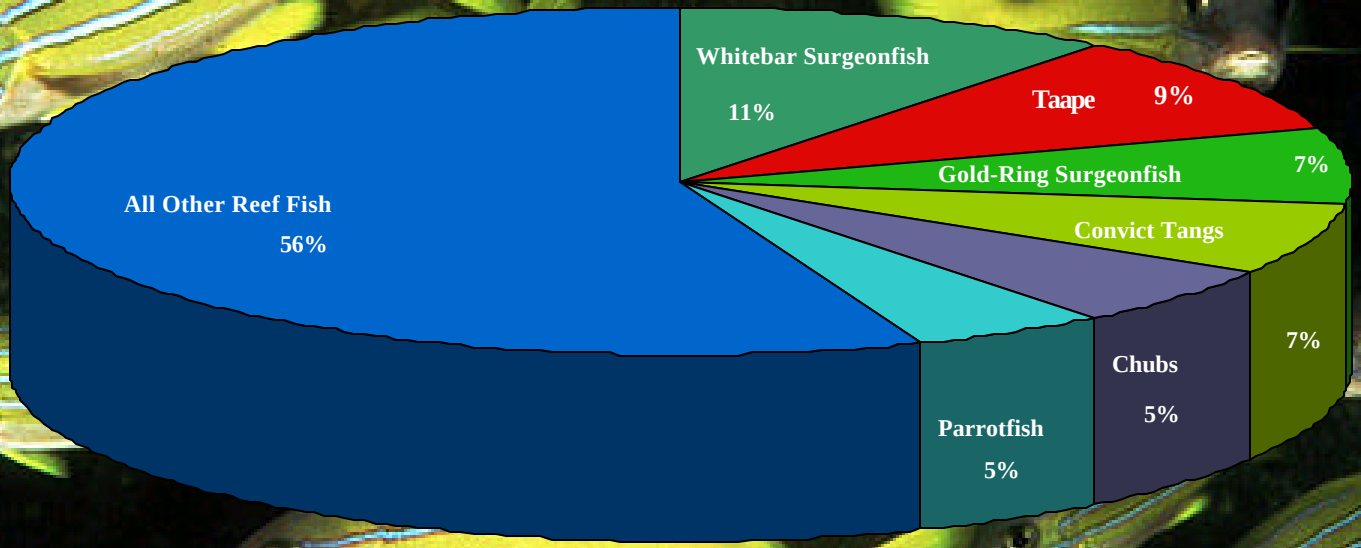
Fisheries Management

- Both Grouper (Roi) & Snapper (Ta‘ape) were introduced by the Territorial Government in the 1950’s

- Over time, these alien apex predators have dominated some reef environments and are now a strong concern for niche displacement and ciguatera

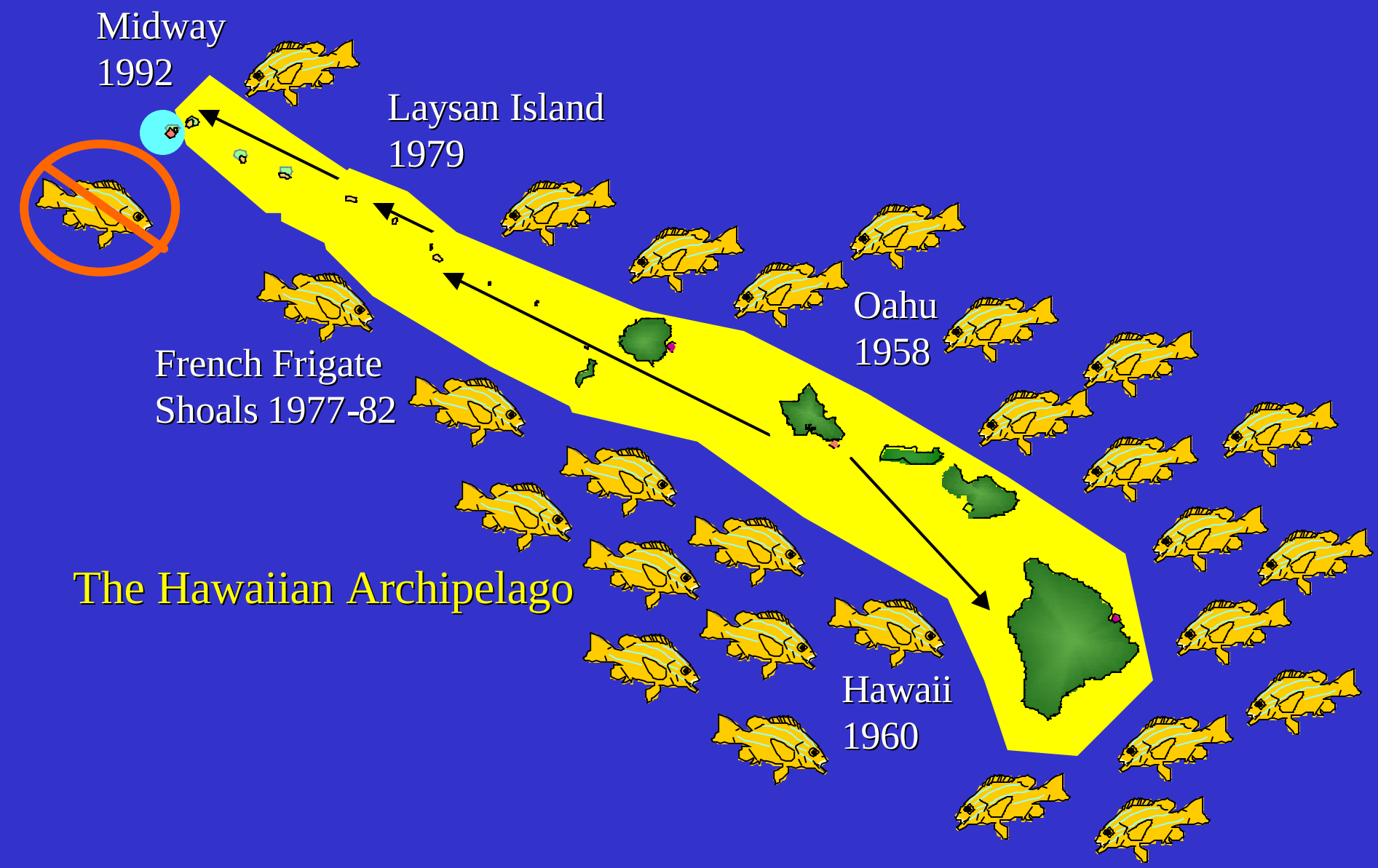


Total Fish Biomass in Hanalei Bay, Kaua‘i



After Friedlander *et al*., 2002

Spread of Ta‘ape (*Lutjanus kasmira*) in Hawai‘i



After Friedlander and Sladek Nowlis, in press

Documented Intentional Introductions

Aquaculture

- Many seaweeds (algae) are introduced into marine environments for both food and extractive products: Carageenen and Agar

Aquarium Industry

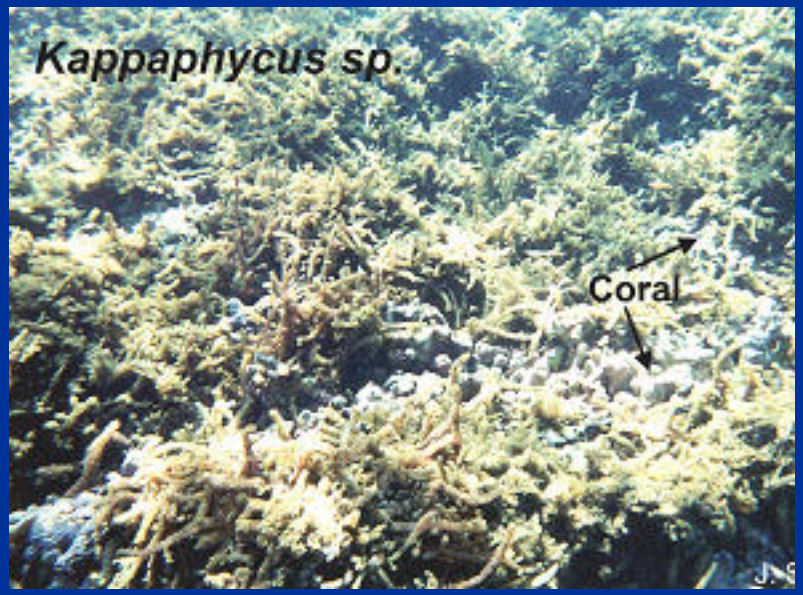
- People may dump unwanted organisms from their home aquaria into the ocean, or try to use reef areas for growing out aliens for harvesting.

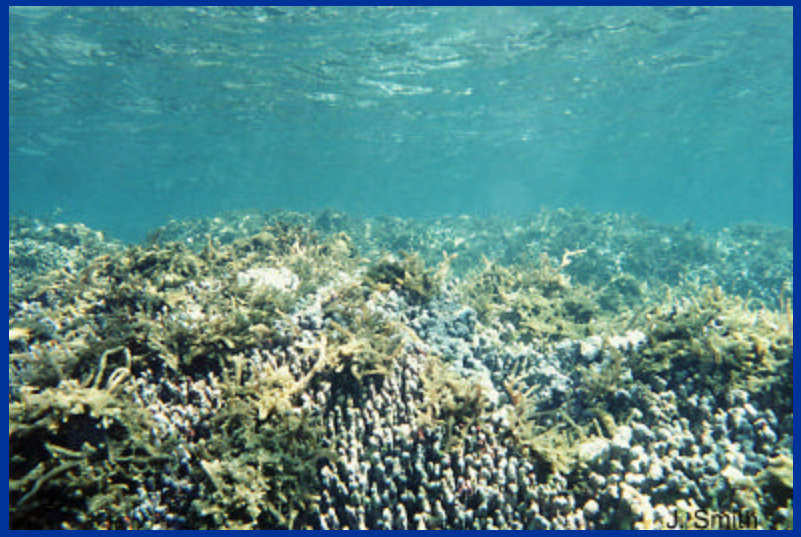
Current Situation

- 19 Species of non-indigenous algae since 1950's
- 5 have become established in Hawaiian waters and pose threats to marine resources
- Native "marine weeds"
- Bloom forming
- Coral overgrowth, possible reduction in diversity, loss of habitat, native species out-competed, economic threats

Negative Economic Effect for Kihei Maui = $72 Million!!!

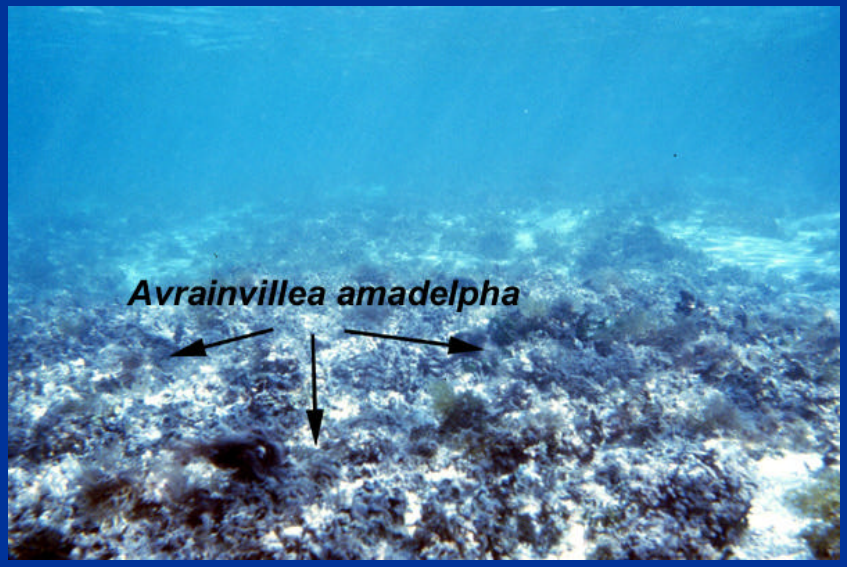
Summary Information for *Kappaphycus*





- Only found in Kane'ohe Bay
- Reproduction: vegetative
- Once established—very competitive
- Fish don't eat it
- Can not spread long distances without human activity?
- Competing with native limu species and coral
- Killing coral
- Changes habitat—3D
- Eradication???

Summary Information for *Avrainvillea*

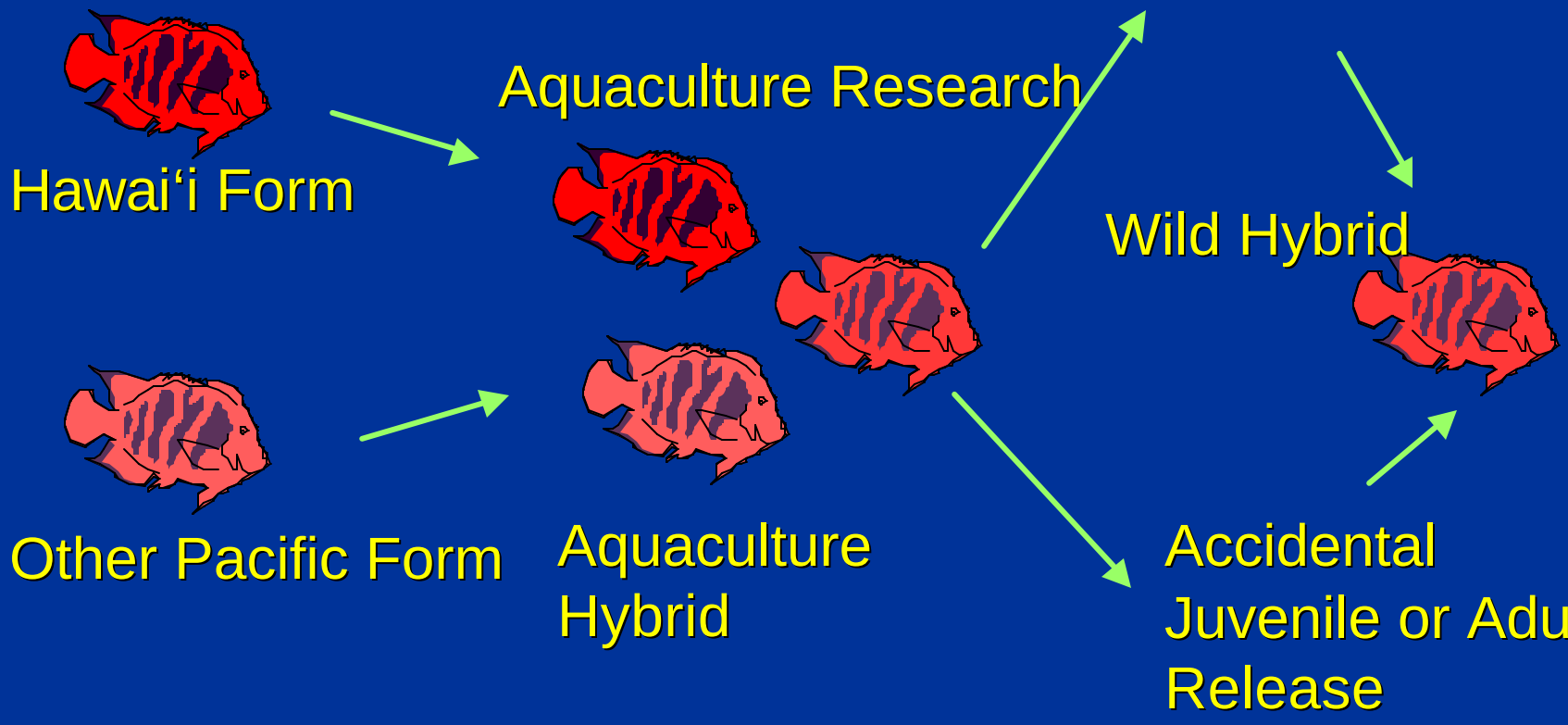


- Only found on Oahu & Kauai
- How did it get here? **Aquarium release?**
- Reproduction: ???
- Once established—very competitive
- Fish don't eat it
- Soft-bottom habitats
- May be competing with native spp. and endemic seagrass
- Changes habitat—3D
- Eradication???

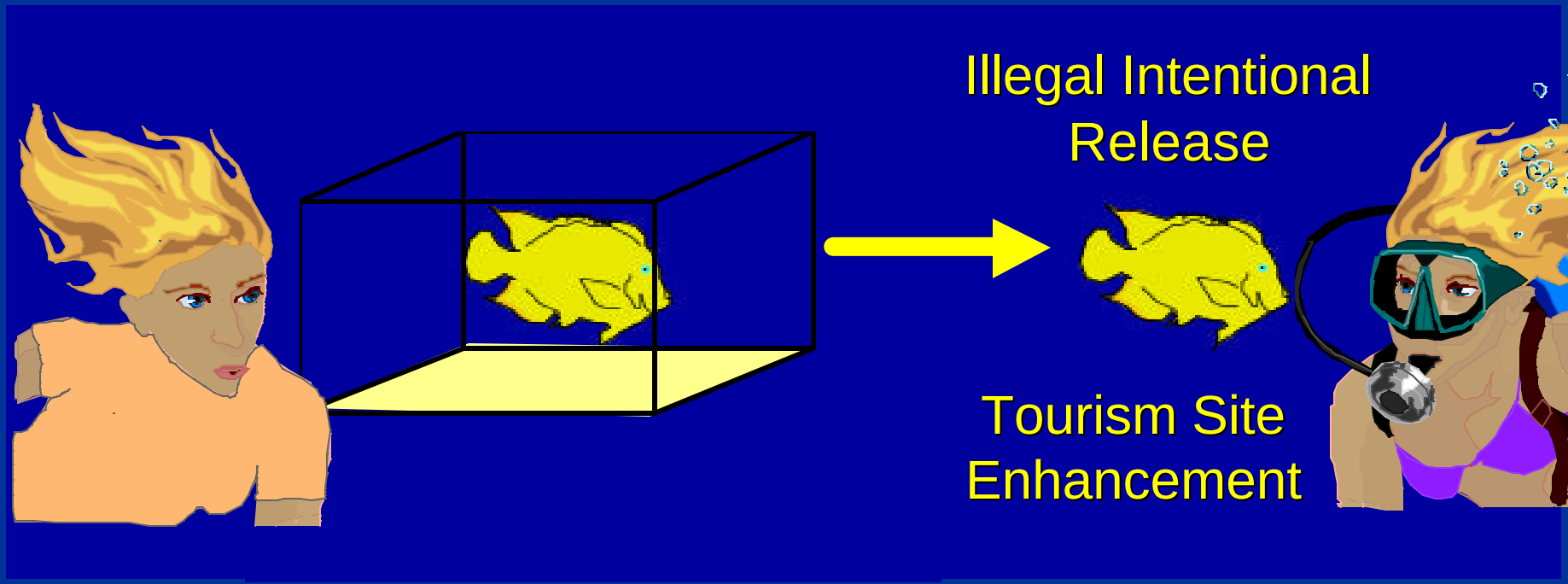
Marine Ornamental Introductions

- Direct Alien Introduction

Hybridization Concerns



Direct Alien Introductions

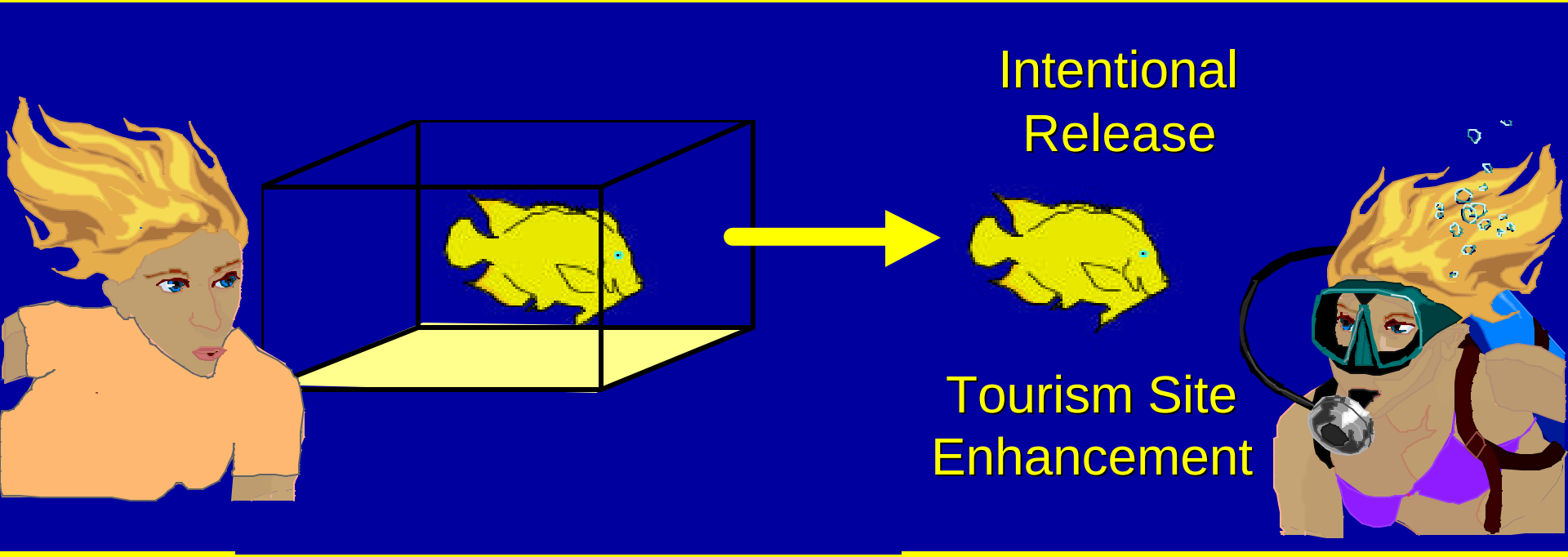


- *Discosoma* (Illegal Import & Intentional Intro)
- *Centropyge flavissimus* (Illegal Aquarium to Tourism Site?)

Direct Alien Introductions

- *Discosoma* (Illegal Import & Intentional Intro)
- *Centropyge flavissimus* (Aquarium to Tourism Site?)
- *Amphiprion* (Intentional Aquarium Release?)

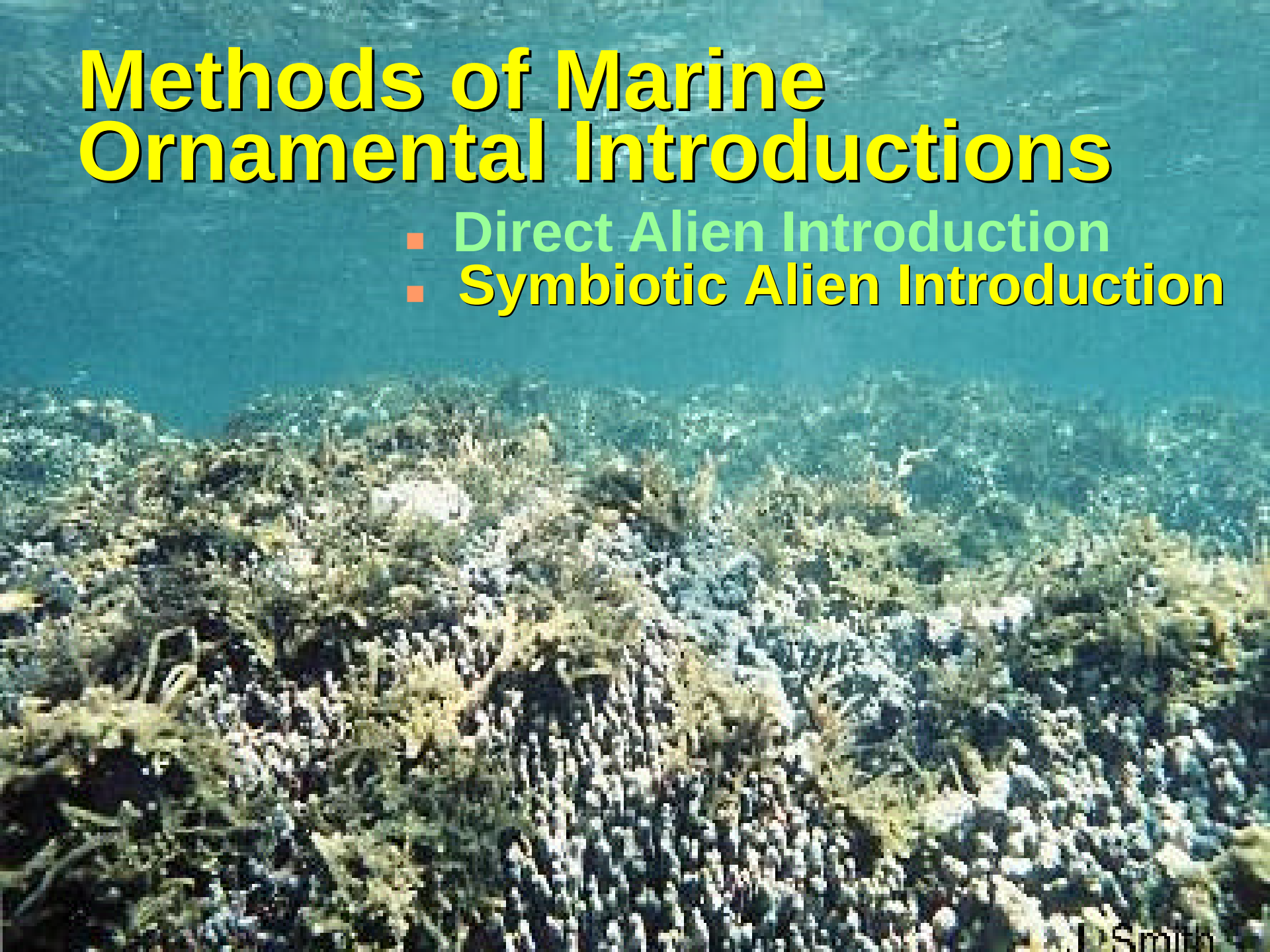
Are these also examples (like that of *Centropyge flavissimus* in Hawai‘i) of purposeful releases to “enhance” tourism sites???



We need more active support and training for multi-agency field investigations to differentiate between natural recruitment and human-caused introductions

Methods of Marine Ornamental Introductions

- Direct Alien Introduction
- Symbiotic Alien Introduction



The Aquarium Trade: Live Rock

Fiji Live Rock:
$5.00/lb

Aquatic Technology

For All Your Reef And Saltwater Aquarium Needs...

Live Rock & Live Sand

Tahiti Live Rock:
$3.99/lb

The Aquarium Trade: Live Rock

Alien Algae

Alien Sessile Inverts

Infaunal Alien Bioeroders

Larval Alien Fish & Inverts

Alien Bacteria

Alien Viruses

Alien Parasites

Alien Endosymbionts

Symbiont Alien Introductions

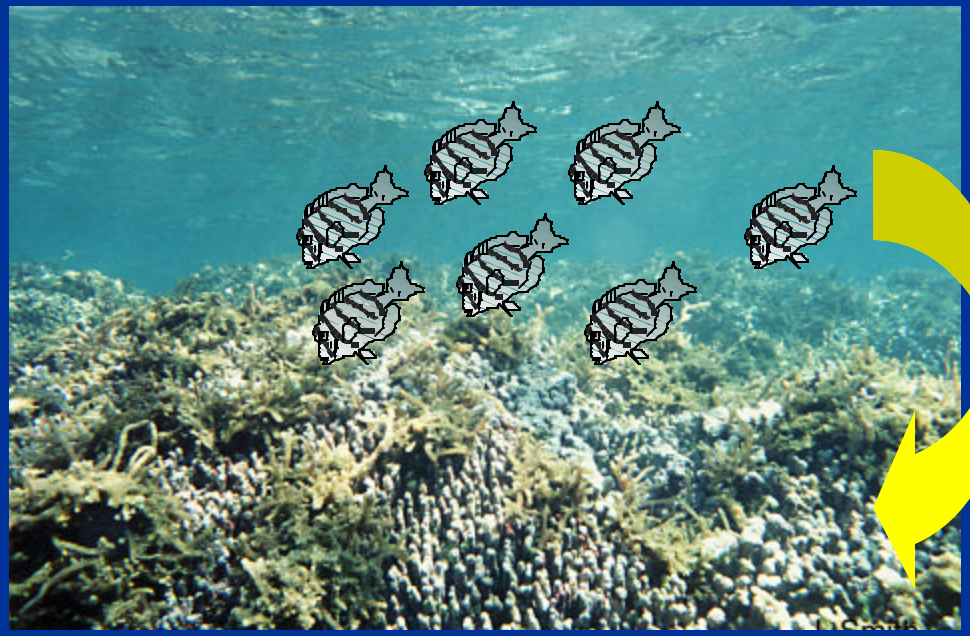
- Zooxanthellae, other endosymbionts
- Ectosymbionts (mutualists, commensals & parasites)
- Microcarnivores

- Alien Soft Coral/Stony Coral Aquaculture
- Illegal/Legal Alien Bivalves
- Live Rock
- Dry Aquarium Sand (Sand Flies)

Methods of Marine Ornamental Introductions

- Direct Alien Introduction
- Symbiotic Alien Introduction
- Facilitated Alien Introduction

Facilitated Introduction



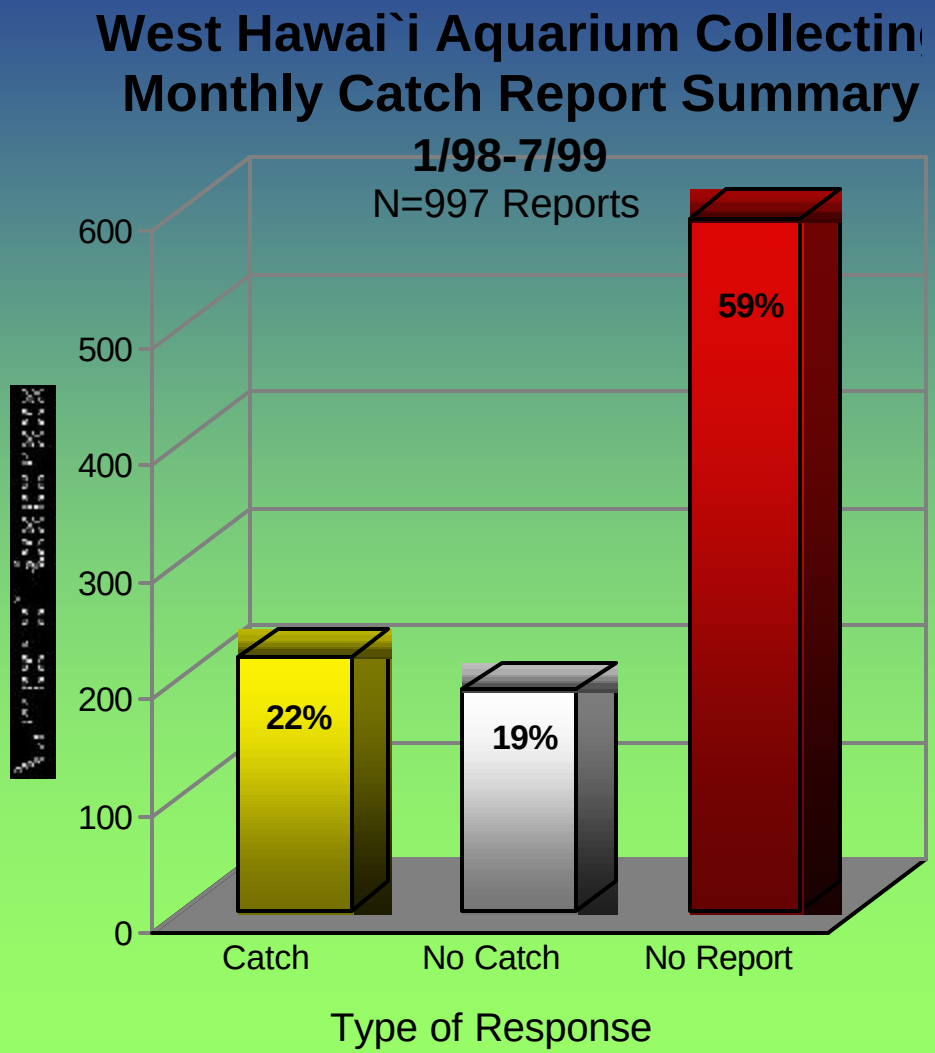
Herbivory by fishes, green sea turtles?

<u>Movement of Organism</u>

- Alien Passage Through Gut

- ***Kappophycus* Spread in Kane‘ohe Bay?**

Concerns About Marine Ornamental Industry Impacts:



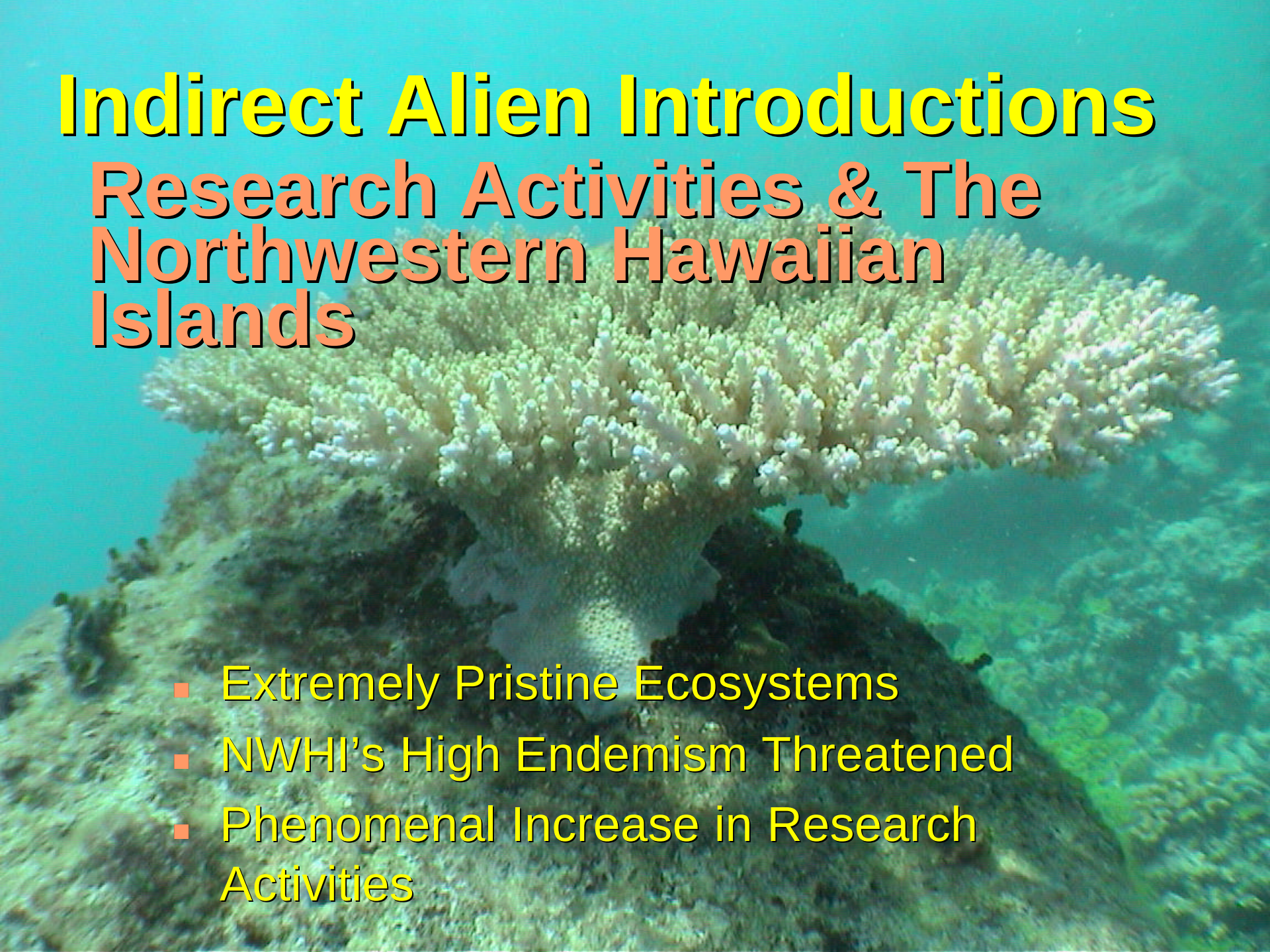
Indirect Alien Introductions

Research Activities - Tilapia

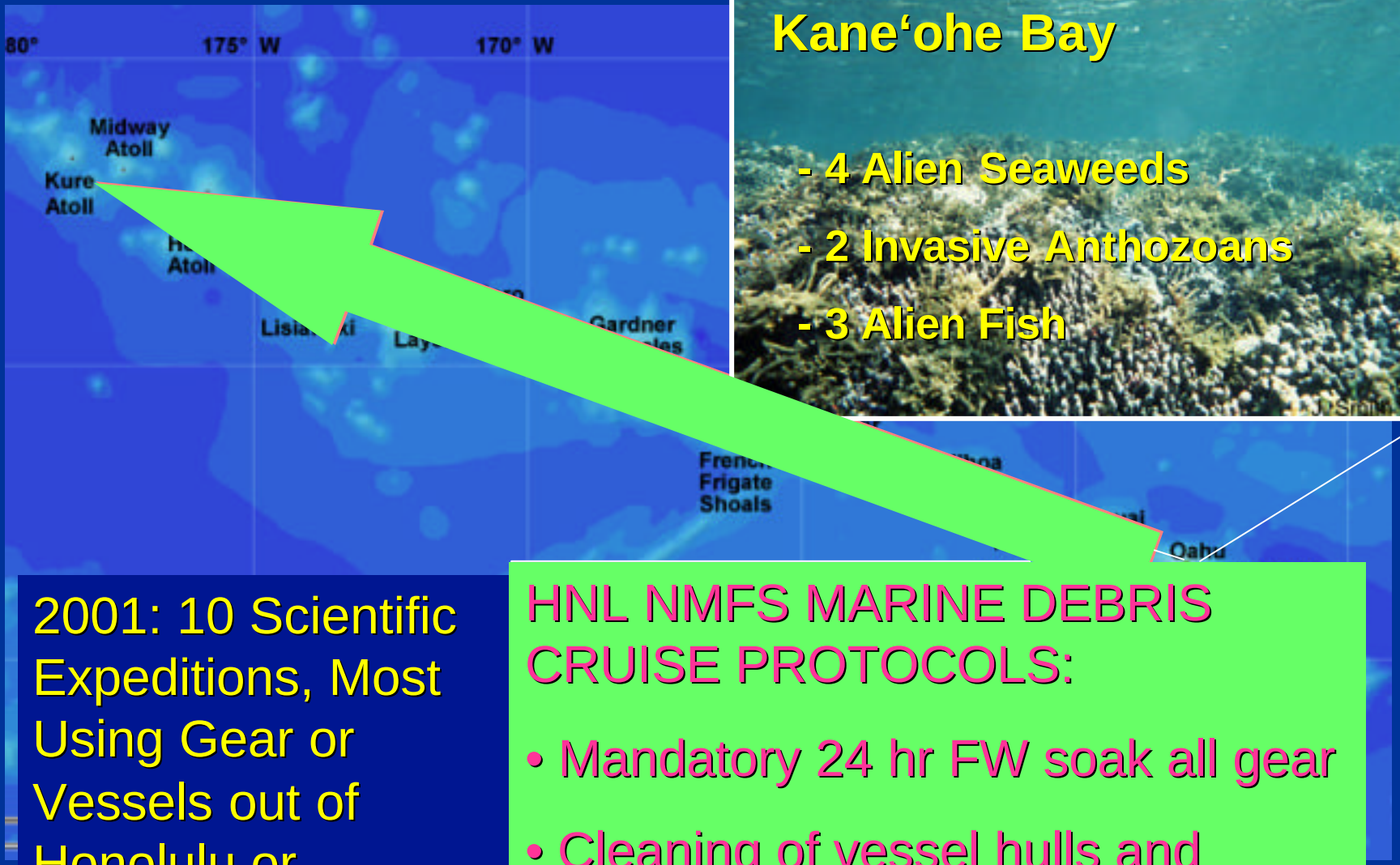
- Extremely Adaptable to Osmotic Changes
- Voracious Predator on Small Inverts and Fish
- A Decade Ago - Hormonal Research with Open Ocean Outfalls

Indirect Alien Introductions

Research Activities & The Northwestern Hawaiian Islands



- Extremely Pristine Ecosystems
- NWHI's High Endemism Threatened
- Phenomenal Increase in Research Activities



Kane‘ohe Bay

- 4 Alien Seaweeds
- 2 Invasive Anthozoans
- 3 Alien Fish

2001: 10 Scientific Expeditions, Most Using Gear or Vessels out of Honolulu or Kane‘ohe Bay

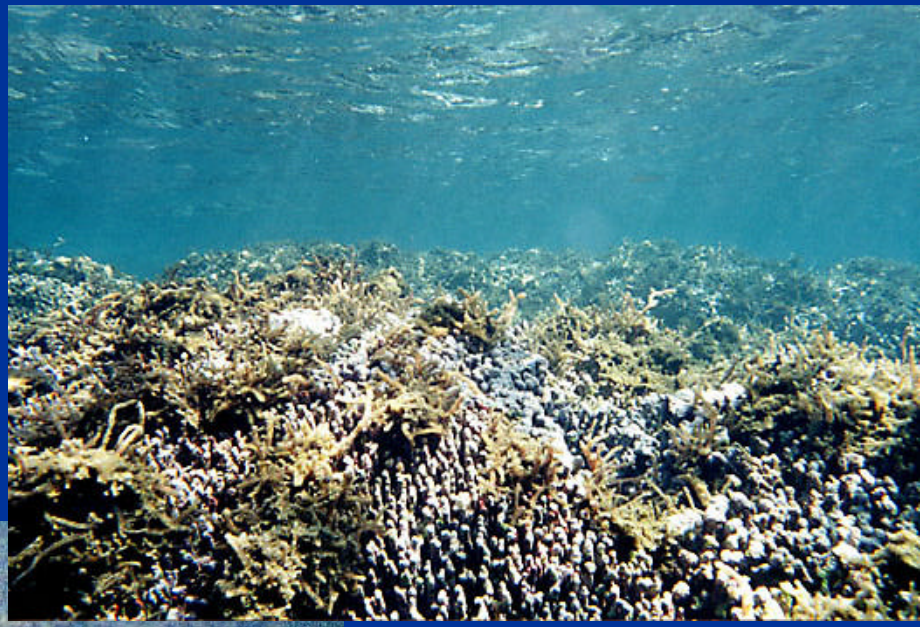
HNL NMFS MARINE DEBRIS CRUISE PROTOCOLS:

- Mandatory 24 hr FW soak all gear
- Cleaning of vessel hulls and outboard engines
- Pre-departure inspections

Ecosystem Impacts

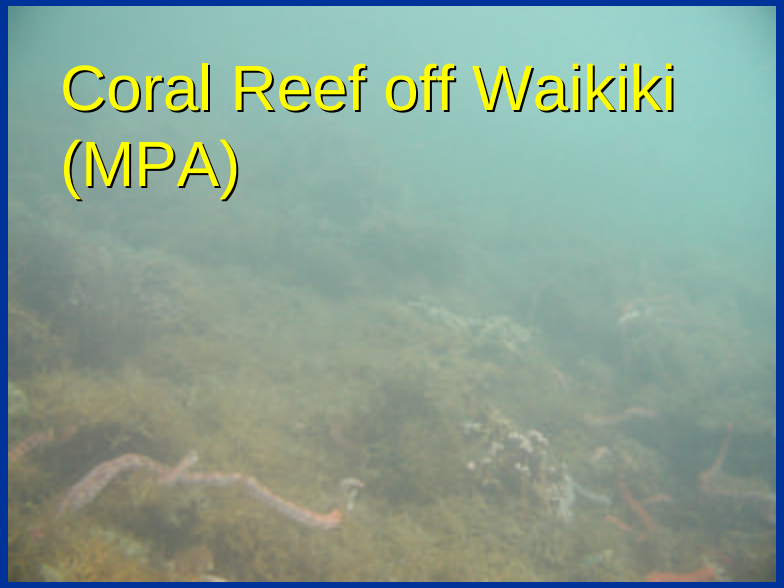
- Alteration of Complex Food Web
- Breakdown of Social Structure/Territories
- Removal of Keystone Species with Resulting Habitat Shift
- Loss of Symbionts/Hosts

Phase shifts on reefs change ecosystem features



Benthic cover changes: slow growing corals loose to fast growing macroalgae


J. E. Smith



Gracilaria salicornia

Over time, continuous large amounts of excess algal biomass wash ashore and decompose

Phase shifts can also change deep reef ecosystem features

Native Black Coral Forest

Alien Soft Coral
Carijoa resii

Benthic cover changes: slow growing black corals loose to faster growing alien.

PREVENTION AND CONTROL OF MARINE ALIEN SPECIES

Prevention is preferable because it is often the cheaper and less intrusive solution. Implementation of effective laws and regulations may preclude or reduce the establishment of aliens. When aliens become established, the means for controlling them can be extremely costly in terms of funding and negative impacts to the surrounding environment. Methods may include Physical, Chemical, or Biological controls.

- **Chinese Mitten Crab (Eriocher sinensis) in California**
  About 1 million dollars of federal funds spent for control and research in 2000-01

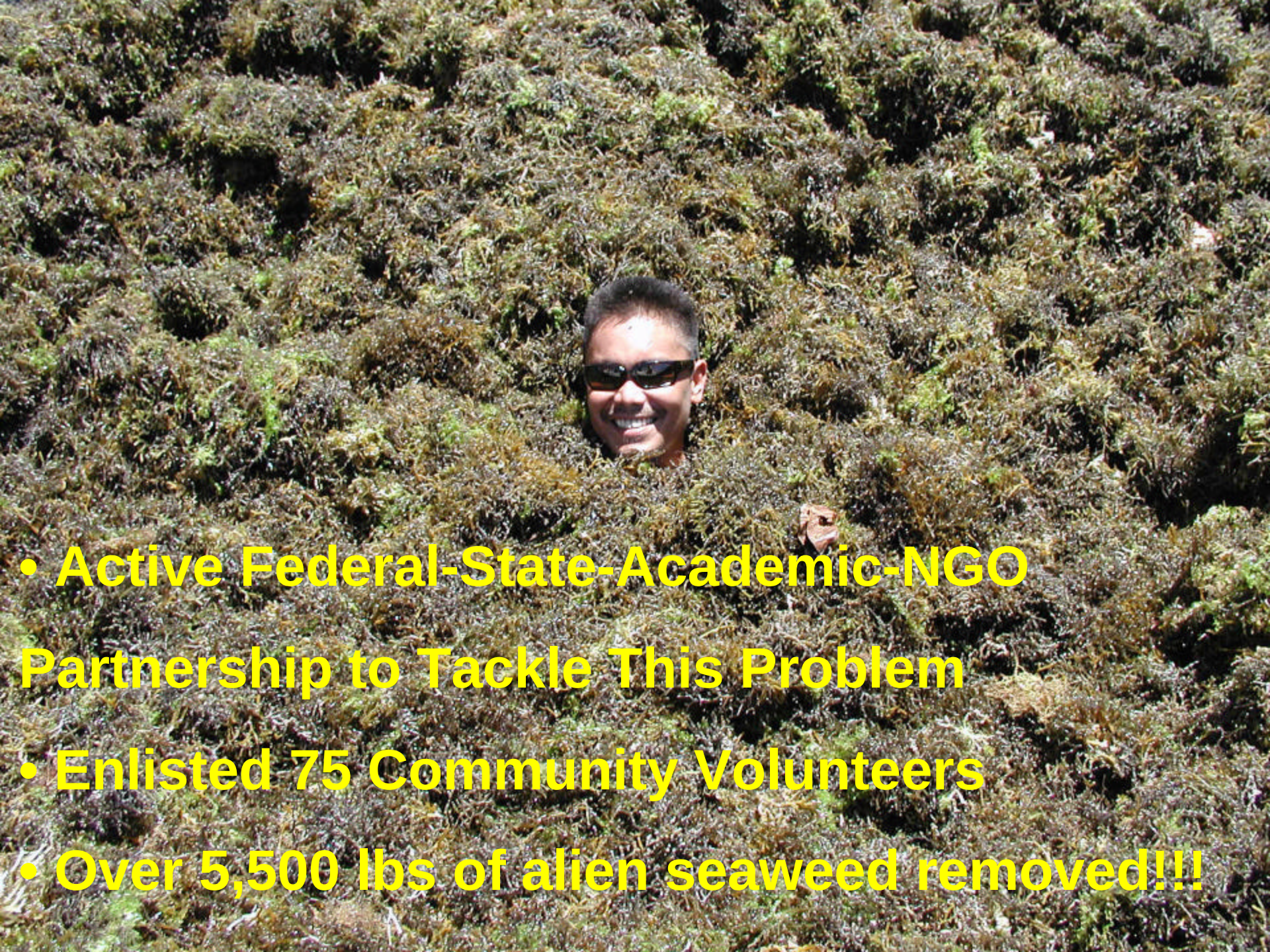
- **Asian Mussel (Mytilopsis sallei) Darwin, Australia**
  Chemical treatment liquid chlorine, sodium hypochlorite, copper sulfate

NOXIOUS SEAWEED FOUND IN SOUTHERN CALIFORNIA COASTAL WATERS

Over $1,600,000 has been spent in California over two years to physically and chemically control two small populations and was still not able to control the problem!

Chemical and Physical Methods Used to Control Aliens Elsewhere Are Difficult to Implement on Coral Reefs

- High Biodiversity
- Endemism
- Presence of Protected Species
- Living 3D Substrate
- High Levels of Symbiosis
- Complex Trophic Structures
- High Human Use
- High Economic Value



- Active Federal-State-Academic-NGO Partnership to Tackle This Problem
- Enlisted 75 Community Volunteers
- Over 5,500 lbs of alien seaweed removed!!!

What needs to be done???

- More state and federal participation
- Stronger guidelines for use of Federal funds as they may relate to inadvertent spread of alien species
- Public education, specifically marine user groups, volunteer monitoring and final ornamental consumers
- Stronger incorporation of ecosystem concerns into permitting and certification (MAC?)
- More interaction between marine ornamental industry and reef resource managers— focus on how both direct and indirect aquaculture and collection activities influence alien species impacts on coral reef ecosystems???
- Lacking strong effort on the above, immediate need for more regulation and direct oversight on aquarium trade, research activities and marine ornamental aquaculture.

Conclusions

This is what Hawaiian reefs should look like...

This is what many of them have become...

- **Hawaii's coral reefs may be more impacted by introduced species than any other tropical region in the world**
- **Multidisciplinary, comprehensive approaches are needed to develop effective management programs**

Acknowledgements

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