Artificial Reefs: Good for Fishing, Bad for Fish

Paul Arena, Ph.D.
Nova Southeastern University
Farquhar College of Arts and Sciences
Pollution
Invasive Species
Habitat Destruction
Climate Change
Overfishing
The Sixth Extinction
I WANT IT ALL,
I WANT IT ALL,
I WANT IT ALL,
AND I WANT IT NOW!
State of Global Fisheries

FAO (Food and Agriculture Organization of the United Nations) reports that 32% of the fish stocks they manage are overexploited and 55% are fully exploited (FAO, 2011).

~20% of US fish stocks are overfished, however ~47% of stocks are in an unknown status (NOAA, 2012).

Fish is the single most important source of protein for humans, providing 16% of the protein consumed (FAO, 2012).

Demand expected to increase by 43% by 2030 (Delgado et al. 2003).
Fishing Statistics

25 million registered recreational anglers in US

Florida has highest recreational landings in the country

~ 47 million fish harvested in 2012
~ 74 million caught and released in 2012
- 30-40% of those released die
Why are fisheries in trouble?

60% of world's population lives within 60 km of coast

- Florida has 8,400 miles (~13,500 km) of coastline

Florida is expected to surpass twenty million residents in 2016, and become the third largest state in the country.

30% of all residents live in Palm Beach, Broward, and Miami-Dade Counties

↑Population leads to:

↑Pollution

↑Habitat Destruction

Overfishing
Nowhere to Hide
Management Response

1. Fishing regulations
   - Bag limits, size limits, effort limits (commercial), seasonal closures
     - Based on MSY estimates
     - Considered to be ineffective since fisheries are still declining

2. Deployment of Artificial Reefs (ARs)

3. Establishment of Marine Protected Areas (MPAs)
What is an Artificial Reef?

AR Projects should provide biological, social and economic benefits

Definition of an AR –

“a structure which is constructed or placed for the purpose of enhancing resources for commercial and recreational fishing opportunities”

“constructed” = prefabricated  “placed” = materials of opportunity

(1985 National Artificial Reef Plan)
Prefabricated Artificial Reefs

- Specific Designs
- ↑ Construction Costs
- Japan Leader due to government support
# Materials of Opportunity

## TABLE 1

<table>
<thead>
<tr>
<th>Materials Used Worldwide for Artificial Reef Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft</td>
</tr>
<tr>
<td>Automobiles, buses, and trolleys</td>
</tr>
<tr>
<td>Bamboo and bamboo combined with tires</td>
</tr>
<tr>
<td>Baled garbage</td>
</tr>
<tr>
<td>Bridges</td>
</tr>
<tr>
<td>Concrete blocks</td>
</tr>
<tr>
<td>Construction rubble (concrete debris</td>
</tr>
<tr>
<td>such as culverts, pile cutoffs)</td>
</tr>
<tr>
<td>Engines, including internal-combustion</td>
</tr>
<tr>
<td>engines</td>
</tr>
<tr>
<td>Fiberglass and reinforced plastic</td>
</tr>
<tr>
<td>Freight trains (boxcars) and wheels</td>
</tr>
<tr>
<td>Metal (mainly steel, iron)</td>
</tr>
</tbody>
</table>

(Duedall and Champ 1991)
Historical Use of Artificial Reefs

1\textsuperscript{st} Historical Record of AR Deployment
- Boulders deployed off Japan in 1650

1\textsuperscript{st} AR deployed in U.S.
- Tree bundles off South Carolina in 1860
Florida’s Artificial Reefs

- 2,700 AR sites
- Broward County: 20 km coastline
- 112 ARs since ’82
- 70-100 ARs deployed annually off Fl.
AR Goals

Enhancement of Commercial and Recreational Fisheries

• Fishing sites closer to shore = save time and fuel
• Concentrate fish densities = reduced fishing effort
• Provide production of new biomass = enhanced fisheries

Additional Uses:

Artisinal fishing, Mariculture, Habitat Protection, Submarine Ecotours, and Recreational SCUBA diving
Why use ARs?

Many studies have demonstrated higher fish densities, biomass and diversity on ARs than natural habitats (Bohnsack et al. 1994; Clark and Edwards 1999; Rilov and Benayahu 2000; Perkol-Finkel and Benayahu 2004; Arena et al. 2007, Burt et al. 2009).
Why Do ARs Harbor an Abundance of Fish?

1. Increase availability of food resources
2. Increase feeding efficiency
3. Decreased competition in vacant habitat
4. Increase shelter from predation
5. Increase habitat for recruits
Are ARs effective management tools?

More fish leads to more catch, which has been documented on many ARs (Santos & Montiero 1998)

The addition of ARs in the Adriatic increased catch yields by 30-80 times initial landings (Relini et al. 2006)
Attraction/Production Debate

Are fishes on ARs the result of new fish production or simply attracted from nearby areas?
Production Hypothesis

Bohnsack (1989)

Production = artificial reef assemblages are result of production of new fish biomass

- Assumes fishes are habitat-limited

ARs increase productivity by:

1. ↑ food resources
2. ↑ feeding efficiency = faster growth
3. Creating vacant space
4. Increase juvenile recruitment, survival and growth (Polovina, 1991)
Few examples of AR production

Review of 30 years of Japanese research found only one AR Project demonstrating production (Polovina and Sakai 1989)

Red Snapper on oil rigs in habitat-limited Gulf of Mexico (Szedlmayer and Shipp 1994)

Juvenile blackfin snapper and snowy grouper only found on ARs (Arena et al. 2002)

Rockfish on oil rigs off California with faster growth rates (Love et al. 2007)
Attraction Hypothesis
Bohnsack (1989)

Many researchers suggest exploited fisheries are overfished and cannot be habitat-limited.
Many researchers suggest exploited fisheries are overfished and cannot be habitat-limited.

Artificial reefs attract fishes from natural reefs, but do not produce new biomass.
Attraction can have negative impact on fishery resources

- Fishes attracted to habitat with higher fishing pressure
- **Recruitment limited fish populations**
  - Reduced potential of replacement at natural reefs due to limited larval sources
Attraction

Newly deployed ARs are rapidly colonized by adult fish
-Spiegel Grove attracted 46 species in less than a month after deployment

Matthews (1985) revealed movement of tagged grouper from natural reefs to newly deployed ARs

Arena and coauthors (2007) found 20 of 25 economically important fish species on wrecks were only recorded as adults

In addition, a newly deployed vessel had 35 species recorded only as adults
The Impacts of Attraction:

ARs are considered by many researchers to be a fishing tool which can lead to overexploitation of an already depleted resource, rather than an enhancement device.
“The economic benefit of artificial reefs is very clear," says Michael Miglini, the captain of a 36-foot charter boat called *Orion*. "Creating habitat is akin to creating oases in the desert. An artificial reef is a way of boosting the ocean's capacity to create fish, to increase the life of the Gulf."
Artificial Reefs, They Produce Fish...and Catches

by Sam Hudson • May 28, 2012 • 1 comment

There's no denying the fish attraction of artificial reefs.

More than 180 scientists, county reef coordinators, state and federal officials, fishermen and shareholders came together at the January Artificial Reef Summit in Cocoa Beach to discuss the latest in Florida artificial reef development and deployment. University researchers and federal officials were on hand to explain the impacts of manmade wrecks on bottom-fish species—not all of them rosy—while county coordinators divulged their latest developments in reef material and placement.
Fishing Effects: Recreational Fisheries

Lindberg and coauthors (2006)

• In eight months abundance dropped by 40%
• All legal sized gag (*Mycteroperca microlepis*) were removed
• Total biomass on five fished reefs dropped by 77%
• 3,038 lbs. of fish harvested
Fishing Effects: Commercial Fisheries

Brock (1994)
- Submarine Ecotour to a shipwreck
- MSY for the AR = 34.8 kg/yr
- Commercial catch was averaging 31 kg/day
- Annual catch allotment in one day!

Branden and coauthors (1994)
- Historic shipwreck discovered in 1983 off Australia
- Commercial catch = 1 ton of snapper/day
- Government quickly restricted fishing
Marine Protected Areas (MPAs): Another option to enhance fisheries

Areas with special zoning and regulations, established to protect ecosystems and biodiversity, preserve cultural resources such as shipwrecks and archaeological sites, or sustain fisheries production.

- Provide fish with a safe haven from fishing pressure (no-take zone) or at least reduced fishing pressure or gear restrictions

- While these have been around for many years, the last decade has seen a rapid expansion
Do MPAs Enhance Fisheries?

Higher fish density, diversity and greater mean size within their boundaries (Babcock et al. 1999, Charbonnel & Serre 1999, Gerber et al. 2002)

• Higher reproductive output from larger individuals

• Once carrying capacity reached then a spillover effect should occur
Extent of MPAs

4435 MPAs worldwide
- cover 0.65% of the oceans
- only 0.08% of oceans are within fully no-take reserves

Many of these small MPAs are not managed effectively and lack enforcement (Kearney et al. 2012)
Florida Keys National Marine Sanctuary - established in 1990

State and Federal
Marine Managed Areas in the Florida Keys

- NATIONAL PARK
- EXISTING MANAGEMENT AREA*
- NATIONAL WILDLIFE REFUGE
- MARINE ZONES
- AREAS TO BE AVOIDED **
- STATE PARK
- AQUATIC PRESERVE

STATE WATERS (APPROXIMATE)

* NOAA managed areas created before the establishment of the Florida Keys National Marine Sanctuary (FKNMS). These areas contain rules and regulations above and beyond FKNMS regulations.

** Prohibited areas for tank vessels and other vessels greater than 50 meters in length.
Merritt Island National Wildlife Refuge

- Oldest no-take reserve in US - 1962
- Established for security of Kennedy Space Center
- Adjacent fishing grounds have 3-13x catch rate of targeted species
- Majority of world record trophy fish from this area
MPA Issues

• Most are too small to be effective = fish home range larger than MPA boundaries
  - Kramer and Chapman (1999) suggested MPAs have to be 12.5x larger than the home range of the species to be effective = only 14% of current MPAs

• Most lack proper enforcement – rely on self governance and honor code
MPA Issues

• 70% of MPAs are in areas of high human impacts
  - Populations susceptible to threats other than fishing and habitat loss
  - 53 MPAs were in proximity of the Deep Water Horizon Gulf Oil Spill
Artificial Reefs & MPAs

Common goals

- Reduce impacts on natural resources
- Enhance fisheries
  - Increase production
    - larger fishes = larger reproductive output
    - more fishes = spillover
AR within a MPA/Reserve

Debate
ARs should increase MPA efficiency

Caddy (2000) suggested MPA efficiency can be increased in area of high fishing pressure by

1. Increase surface area protected
2. Increase its holding capacity = ARs
How can we increase enforcement?

New technologies and advantageous locations

EarthNet Live Cams

*Our complete line of megapixel cameras document your projects and provide time-lapse videos*
Scutti – sunken tugboat

1 mile offshore

Questions?