Ecological and fishery dynamics of southern Florida
Larvae hatch from eggs and drift in currents for 35-50 days.

Fertilized eggs drift in currents.

Post-larvae settle in mangrove litter and roots.

Juveniles hide in mangrove microhabitats.

Older juveniles migrate to coral reefs, bays/rivers and beyond.

Adults live in reefs for 80+ years.

Adults migrate and spawn into water column.

Freshwater Inflows

Coastal Oceanography & Fate-Transport

Regional Forcing (Oceanography, Coastal Development, etc.)
New Data Paradigm Required

**Fish Community Assessment**
- Exploited and Non-Target Species
- Trophodynamic Levels (Predator-Prey)
- Full Size Spectrum (Recruits, Adults, Exploited)

**Spatial Dynamics**
- Inside-Outside MPAs
- Habitat Use Patterns/Movement Strategies

**Fishery-Dependent Data Largely Inadequate**

**Goal of Fishery-Independent Surveys:**
Estimate population & community metrics -- Accurate, precise, and cost-effective
Relationship between Reef-fish Visual Census and Data Needs of Stock Assessment

Average Population Size

\[ \bar{N} = \frac{N_0}{(M + F)}(1 - S) \]

Baranov Catch Equation

\[ C = Y_N = F\bar{N} = EN_0 = N_0 \left( \frac{F}{(M + F)} \right)(1 - e^{-(M+F)}) \]

Diver Sighting (Catch) Equation (with negligible selectivity in exploited phase)

\[ \frac{Y_N}{f} = q \left( \frac{N_0}{(M + F)} \right)(1 - e^{-(M+F)}) \]
"Observable" Assessment Indicator Variables

40.6”, 42.8 lbs
SPR = 100%

36.4”, 30.1 lbs
SPR = 35.1%

27.9”, 12.6 lbs
SPR = < 6%

Minimum Legal Size
(24 inches)
Limit-Control Rule Indicator

- Overfished & overfishing
- Overfishing, but stock not overfished
- Stock overfished, no overfishing (recovering)
- No overfishing, & stock not overfished

- $F_{msy} = MFMT$
- $F(OY)$
- $B_{msy}$

Indicators of Response & Impact
Multispecies survey design for assessing reef-fish stocks, spatially explicit management performance, and ecosystem condition

Steven G. Smith\textsuperscript{a,\ast}, Jerald S. Ault\textsuperscript{a}, James A. Bohnsack\textsuperscript{b}, Douglas E. Harper\textsuperscript{b}, Jiangang Luo\textsuperscript{a}, David B. McClellan\textsuperscript{b}

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\textsuperscript{b} NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149, USA
A Cooperative Multi-agency
Reef Fish Monitoring Protocol for
the Florida Keys Coral Reef Ecosystem

Natural Resource Report NPS/SFCN/NRR—2009/150
Gulf of Mexico
Visual Survey Sampling Area
Florida Straits
The Managed Florida Keys-Dry Tortugas Coral Reef Ecosystem
Visual Survey Sampling Area
Biscayne National Park
Dry Tortugas National Park
Everglades National Park
Florida Keys National Marine Sanctuary
SEFCRI Region

- Martin
- North Palm Beach
- South Palm Beach
- Deerfield
- North Miami-Dade & Broward
- Miami-Dade
- Palm Beach
- Broward
Precise, Cost-Effective Survey Designs

Stratification Scheme
Partitions survey domain into subregions of low, moderate, and high variance

Allocation Scheme
Allocation based on stratum size and variance
More samples in larger strata
More samples in higher variance strata
Yellowtail Snapper, Juveniles and Adults

Habitat Class

Density

Inshore Patch Reefs
Mid-Channel Patch Reefs
Offshore Patch Reefs
Fore Reef 0-6 m
Fore Reef 6-18 m
Gray Snapper

Frequency vs. Length (cm)

Bay
Inshore Reefs
Offshore Reefs

Newborn 3 6 9
Juveniles 12 15 18 21 24 27 30
Adults 33 36 39 42 45 60
Dry Tortugas Region Reef Habitats

- Reef Terrace
- Pinnacle Reef
- Patchy Hardbottom in Sand
- Patch Reefs
- Low-Relief Hardbottom
- Rocky Outcrops
- Medium Profile Reef
- Low-Relief Spur & Groove
- High-Relief Spur & Groove

Florida
Dry Tortugas
Miami
Florida Keys
Sampling Design Efficiency 1979-2010

Neyman Optimal Sampling Allocation

Pre-Survey Analyses
Habitat Characterization & Mapping
Species Lifestage-Habitat Associations

Pre-Survey Sampling Design
Stratification & Spatial Allocation of Sampling Effort
Randomized Selection of Sampling Locations

Conduct Survey

Data Assimilation

Design-based Estimates

“Adaptive” Precision

Multispecies Stock Assessments

Modeling of Spatial Management Alternatives

Community Analyses
Data Applications
## Fishery-Dependent & Fishery Independent Data Sources

### Primary

<table>
<thead>
<tr>
<th>Source</th>
<th>Database</th>
<th>Metrics</th>
<th>Spatial Resolution</th>
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</thead>
<tbody>
<tr>
<td>Commercial Fleet</td>
<td>Florida Trip-Ticket</td>
<td>Catch-per-unit-effort and size structured abundance</td>
<td>Florida-wide, but particularly focused on southwest and southern Florida</td>
</tr>
<tr>
<td></td>
<td>Trip Interview Program</td>
<td>Catch length composition</td>
<td>Florida-wide, but particularly focused on southwest and southern Florida</td>
</tr>
<tr>
<td>Recreational Fleet</td>
<td>MRFSS/MRIP</td>
<td>Catch-per-unit-effort, and size structured abundance</td>
<td>Florida-wide, but particularly focused on southwest and southern Florida</td>
</tr>
<tr>
<td>Fishery-Independent</td>
<td>Reef Fish Visual Census (&lt;35 m)</td>
<td>Size-structured abundance</td>
<td>Southern Florida, Florida Keys &amp; Dry Tortugas</td>
</tr>
<tr>
<td></td>
<td>NMFS Bottom Longline</td>
<td>Size-structured abundance</td>
<td>Florida-wide, but particularly focused on southwest and southern Florida</td>
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<tr>
<td></td>
<td>Reef Fish ROV and Drop Camera Surveys (&gt;35m)</td>
<td>Size-structured abundance</td>
<td>Pulley Ridge, Madison-Swanson reserve, W. FL Shelf</td>
</tr>
</tbody>
</table>

### Secondary

<table>
<thead>
<tr>
<th>Source</th>
<th>Database</th>
<th>Data Types</th>
<th>Spatial Resolution</th>
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</thead>
<tbody>
<tr>
<td>Recreational Fleet</td>
<td>Headboat Survey</td>
<td>Length compositions</td>
<td>Florida-wide, but particularly focused on southwest and southern Florida</td>
</tr>
<tr>
<td></td>
<td>NPS Creel Survey</td>
<td>Catch-per-unit-effort, and size structured abundance</td>
<td>Biscayne National Park</td>
</tr>
<tr>
<td></td>
<td>NPS Creel Survey</td>
<td>Catch-per-unit-effort, and size structured abundance</td>
<td>Dry Tortugas National Park</td>
</tr>
</tbody>
</table>
Indicators for assessing the ecological dynamics and sustainability of southern Florida’s coral reef and coastal fisheries


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National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, HI 96822, USA
Standardization of Size-Structured Abundance Among Fleets

(A) Empirical length frequencies

(B) Model-predicted length frequency at estimate F=0.38.
Evaluation of average length as an estimator of exploitation status for the Florida coral-reef fish community

Jerald S. Ault, Steven G. Smith, and James A. Bohnsack


A retrospective (1979–1996) multispecies assessment of coral reef fish stocks in the Florida Keys

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Manuscript accepted 16 December 1997.

Length-based assessment of sustainability benchmarks for coral reef fishes in Puerto Rico

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Date submitted: 17 December 2007; Date accepted: 3 September 2008
Dry Tortugas Region--2010

Florida Keys Region--2010
Designing Marine Reserves for Fishery Management

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Optimal Design of Marine Reserves

OBJECTIVE FUNCTION

\[ \text{Min} \left\{ \mu_d^+ q^+ + \sum_{s \in S} \left( \mu_s^+ p_s^+ + \mu_s^- p_s^- \right) + \left( \mu_f^+ f^+ + \mu_f^- f^- \right) + \left( \mu_c^+ c^+ + \mu_c^- c^- \right) + \left( \mu_a^+ a^+ + \mu_a^- a^- \right) + \sum_{r \in R} \left( \mu_a^+ a_r^+ + \mu_a^- a_r^- \right) \right\} \]

Reserve shape SPR over all species fishing effort Reef area Total Reserve area Regional Reserve area

CONSTRAINTS -- SUBJECT TO:

(C1) Reserves non-overlapping
(C2) Pre-specified number of reserves
(C3) Fixed proportion of SPR protected
(C4) Maximum number of fishing vessels displaced by reserves
(C5) Target area of coral reef area protected
(C6) Target total area protected
(C7) Distribution of reserves among regions of ecosystem
(C8) Each reserve contiguous, compact, and desirably shaped

Assessing coral reef fish population and community changes in response to marine reserves in the Dry Tortugas, Florida, USA

Jerald S. Ault\textsuperscript{a,\ast}, Steven G. Smith\textsuperscript{a}, James A. Bohnsack\textsuperscript{b}, Jiangang Luo\textsuperscript{a}, Natalia Zurcher\textsuperscript{a}, David B. McClellan\textsuperscript{b}, Tracy A. Ziegler\textsuperscript{g}, David E. Hallac\textsuperscript{d}, Matt Patterson\textsuperscript{e}, Michael W. Feeley\textsuperscript{e}, Benjamin I. Ruttenberg\textsuperscript{b}, John Hunt\textsuperscript{f}, Dan Kimball\textsuperscript{c}, Billy Causey\textsuperscript{g}

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\textsuperscript{c} National Park Service, Everglades/Dry Tortugas National Park, 40001 State Road 9336, Homestead, FL 33034-6733, United States
\textsuperscript{d} Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190, United States
\textsuperscript{e} National Park Service, South Florida-Caribbean Network, 18001 Old Cutler Road Suite 419, Palmetto Bay, FL 33157, United States
\textsuperscript{f} Florida Fish and Wildlife Conservation Commission, 2796 Overseas Highway, Suite 119, Marathon, FL 33050, United States
\textsuperscript{g} Florida Keys National Marine Sanctuary, 33 East Quay Road, Key West, FL 33040, United States
Bank ER
Density = 0.04
Occupancy = 5.3%

Bank Open
Density = 0.19
Occupancy = 21.9%

Park
Density = 0.10
Occupancy = 10.7%

Spatial Impact of Reserve Implementation

mutton exdens 2000
Dexp
- 0.000
- 0.001 - 0.250
- 0.251 - 0.750
- 0.751 - 1.250
- 1.251 - 1.750

2000
Dry Tortugas National Park: 22% of Survey Frame

Contains 33 - 50% of adult spawner abundance for black and red grouper; yellowtail & mutton snapper.

These species are 55.5% of commercial reef fish catch in the State of Florida!!
Investigating Design Performance in Hawaii

Projected Sample Size Requirements, 2-stage StRS

2000-2005 Baseline Design Analysis

Caranx ignobilis, SPC
Bodianus bilunulatus, BLG
Stegastes fasciolatus, BSM

Survey Precision

2007 Naso unicornis

Sample Size (i.e., Costs)
We Thank You!