US Caribbean Fisheries Independent Survey Workshop
Sept. 2014

Predicting stock status of a heavily fished Caribbean gastropod

R.L. Hill, J.C. Doerr, K.J. McCarthy, and R.S. Appeldoorn

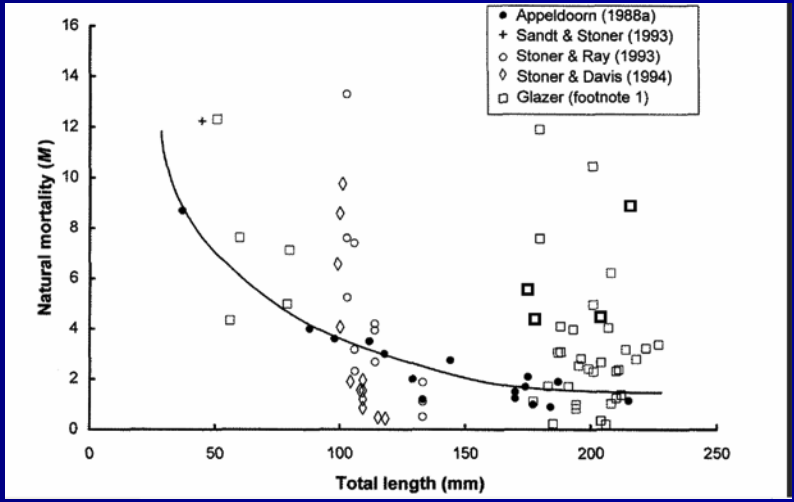
Queen Conch (*Strombus gigas*)

- Marine gastropod
- US SE
  - US Caribbean
    - E & W PR
    - STX vs STT/J
  - Florida Keys

- Wider Caribbean
- CITES Appendix II
- ESA?

Queen Conch

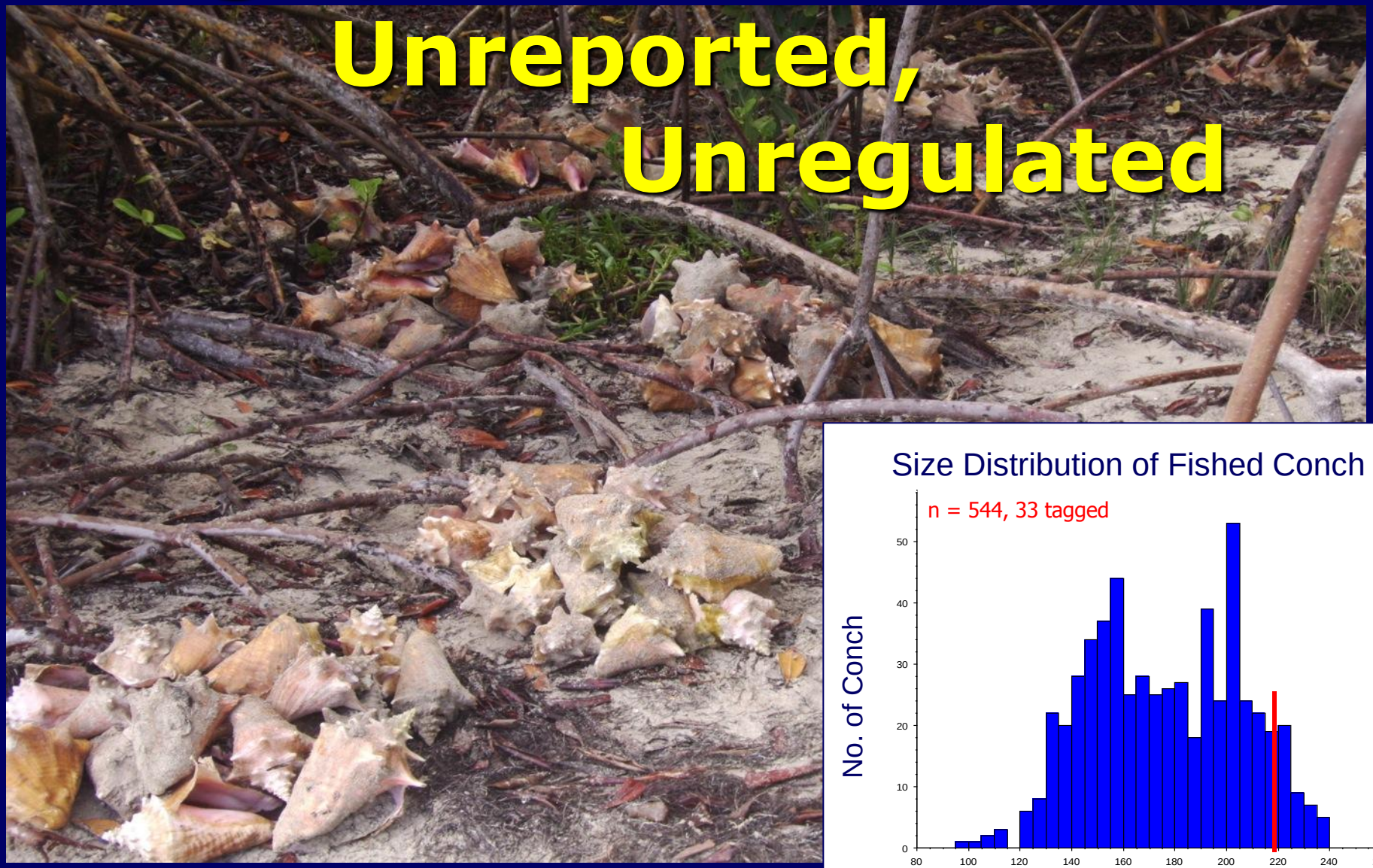
- Biology
  - Not possible to age
  - Growth pattern varies during life history
  - Natural mortality varies dramatically with age
  - Shared stocks
  - Growth plasticity

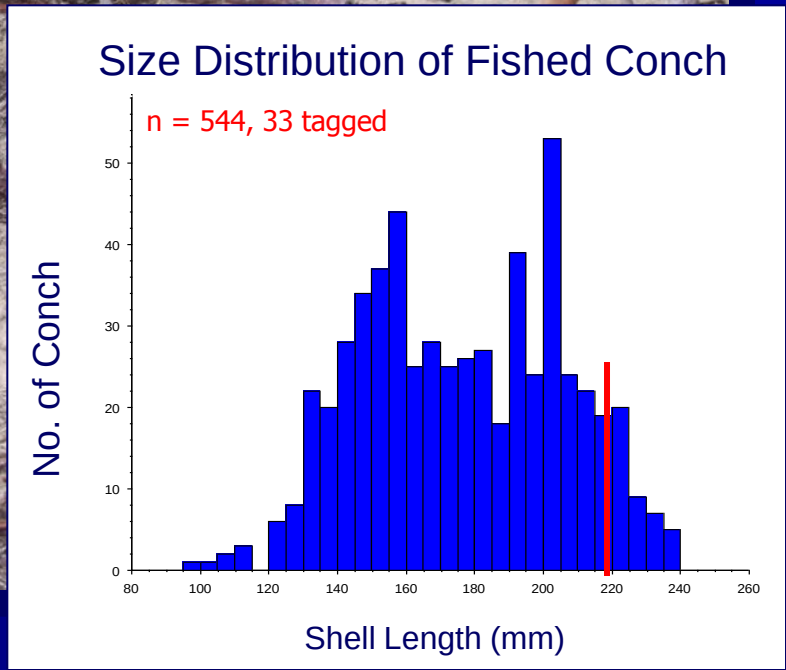


Queen Conch & its Fisheries

- Data Poor
  - Commercial Fisheries
    - Multigear, Multispecies
  - Subsistence/Recreational Fisheries
    - Unreported
    - Est. 35% rec. catch
- Virtually no market sector for validation of landings

Illegal, Unreported, Unregulated





USVI Fishing Regulations

Queen Conch
Strombus gigas

All Queen Conch

Must be landed in the shell.
Empty shells cannot be
disposed of in the water.

Season Open

November 1 to May 31

(until ACL reached)

Quota-bag limit
Max Catch Per Day
200 per boat (commercial)
6 per person to a
max. 24 per boat (personal)
Conch meats:
2/lb uncleaned or 3/lb cleaned

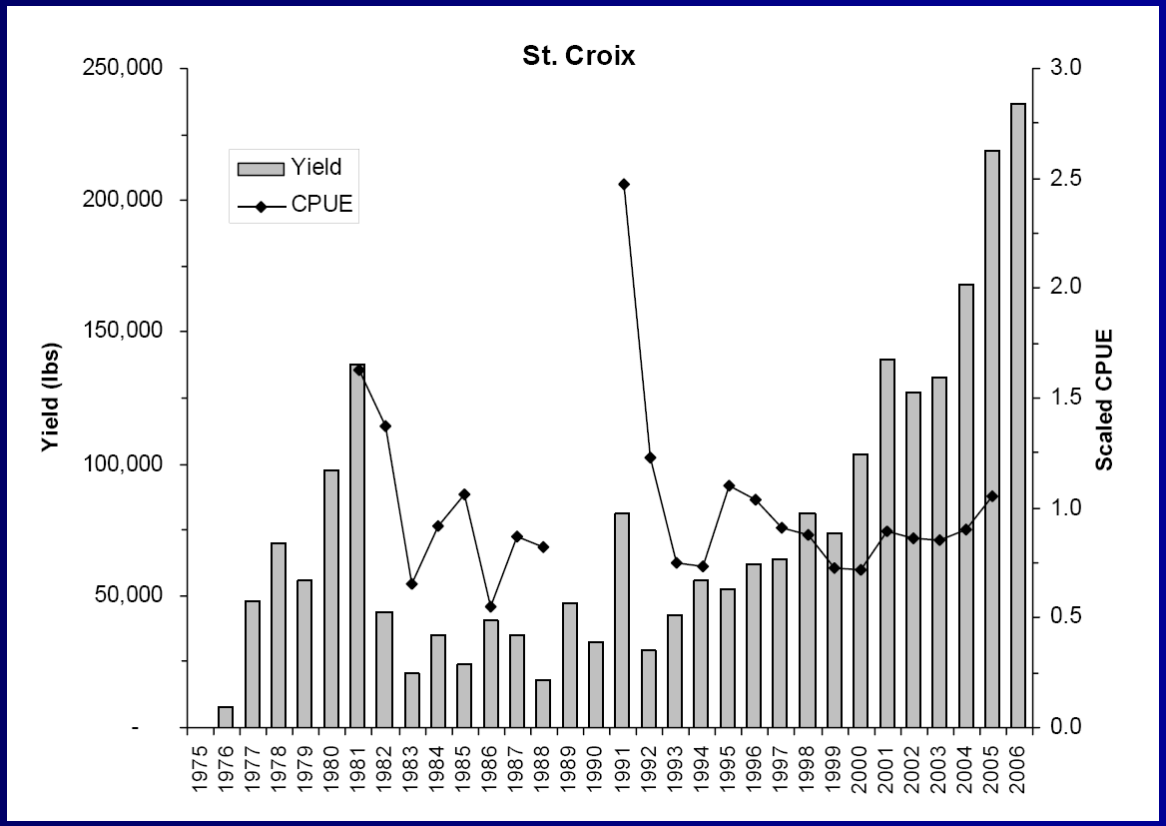
Size Limits

Conch shell **MUST** be at least 9" long
or
have a lip thickness of 3/8"

SEDAR 14 Approaches

- Proposed using surplus production model
  - Requires yield series and index of abundance
- Standardized catch per unit effort series from commercial fishery was only available stock abundance measure
- CPUE from self-reported commercial diver data did not vary even with 8-fold increase in landings
- **CPUE series did not meet assumption that change in catch is reflected in effort change**
- Landings data also had uncertainty due to non-reporting and use of expansion factors
- No information on recreational harvest

SEDAR 14 Approaches



Diaz, 2007

Habitat Based Surveys
(MARFIN)

- Size distribution by habitat
  - Current status of populations
  - Effectiveness of MPA-Buck Island Natl. Monument
  - Comparison to recent SEAMAP surveys (traditional)
- Compare to landings
  - Account for unreported fishing mortality
- Direct future surveys
  - Trends, Condense habitat to survey

Relationship of US Caribbean status to other Carib. Countries: Standing Stock and Fishing Rates

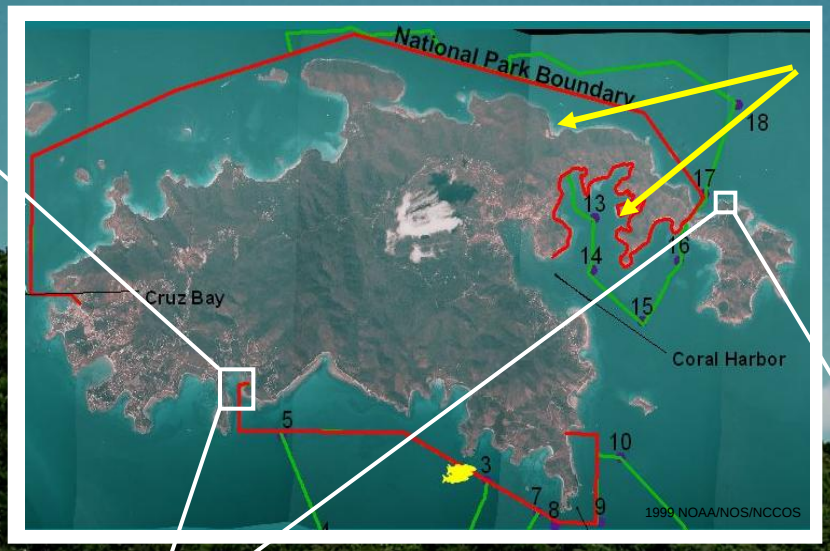
Methods

- Mark-and-recapture
  - capture and tagging
  - environmental parameters
  - benthic composition
  - temperature loggers

- Vemco VR2 receivers
  - detection zones, attachment
  - V7 acoustic tags
  - data downloads

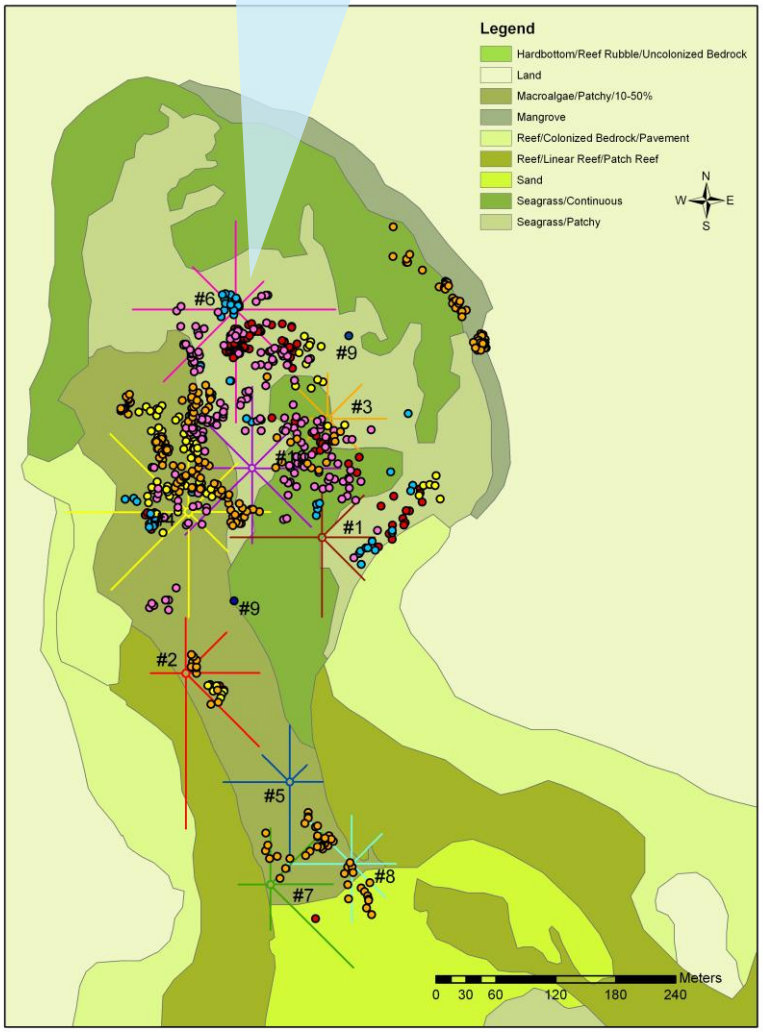
Study Areas

Fish Bay
©2007 Google Earth


National Park Boundary
FY-08+
Cruz Bay
Coral Harbor
3
5
7
8
9
10
13
14
15
16
17
18
1999 NOAA/NOS/NCCOS

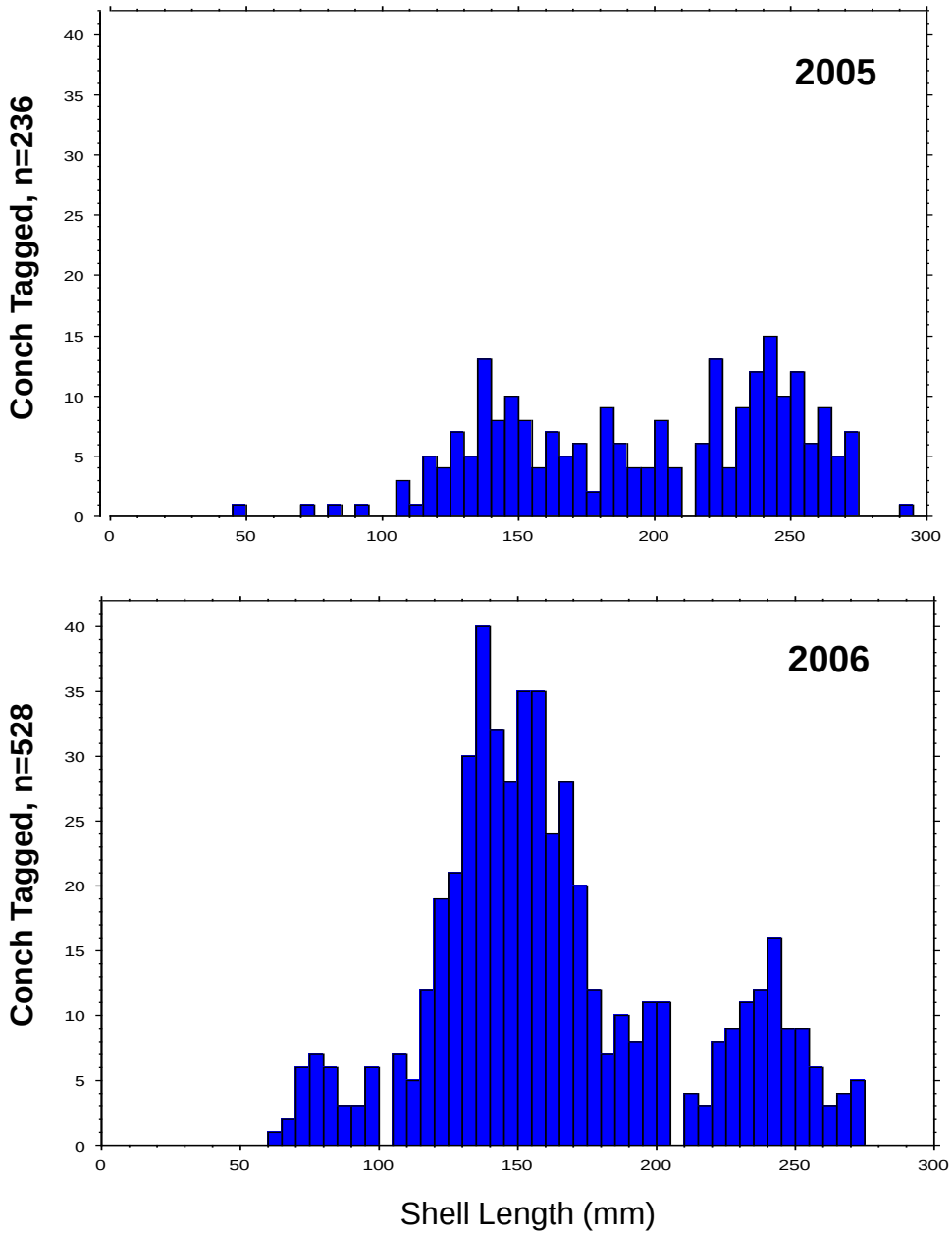
No Name Bay
©2007 Google Earth

VR-2 Hydrophone Receiver and detection zone



FISH BAY, ST. JOHN
Initial Tagging Locations (N=758) and Sonic tracking array (10 hydrophones)

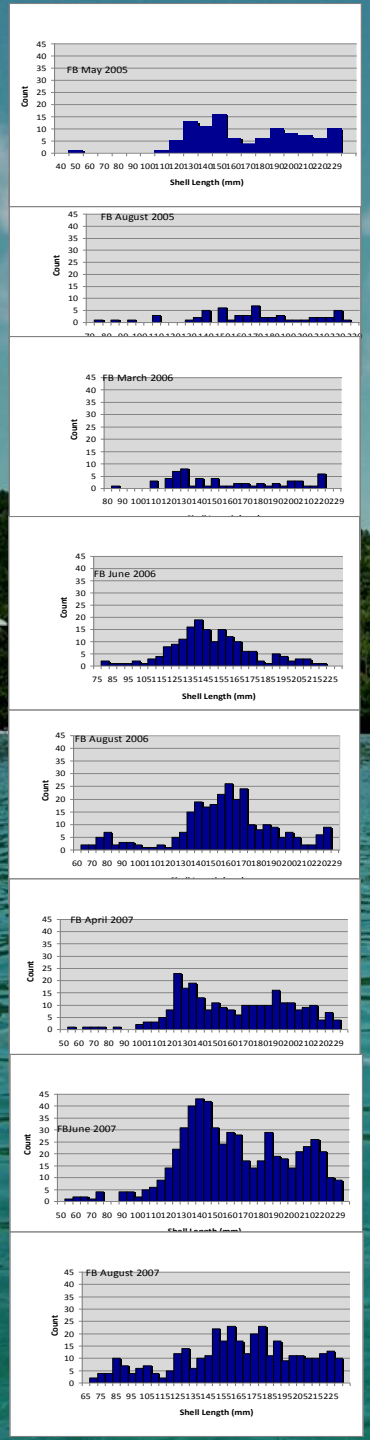
Length Frequency Distribution for Conch Tagged in Fish Bay

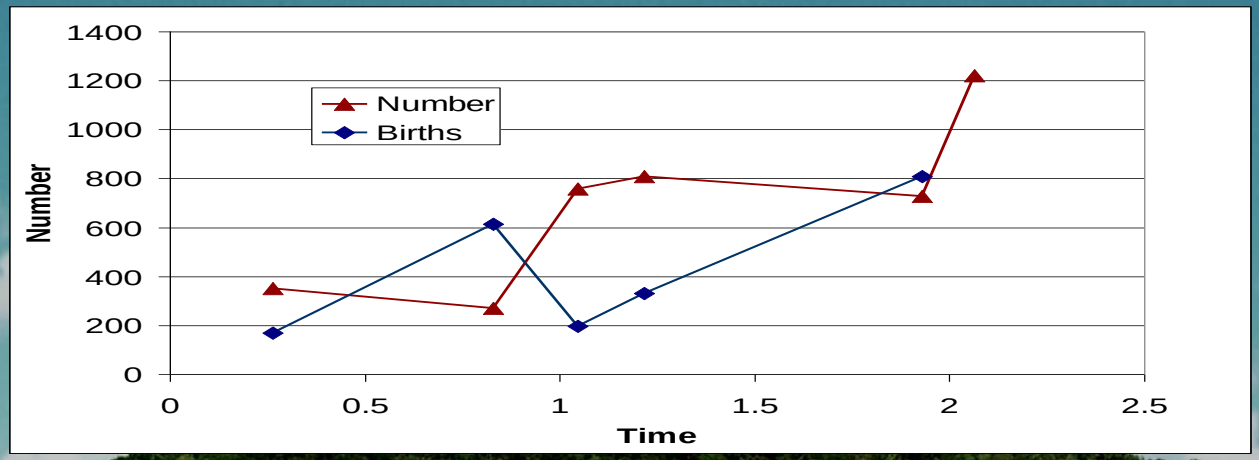


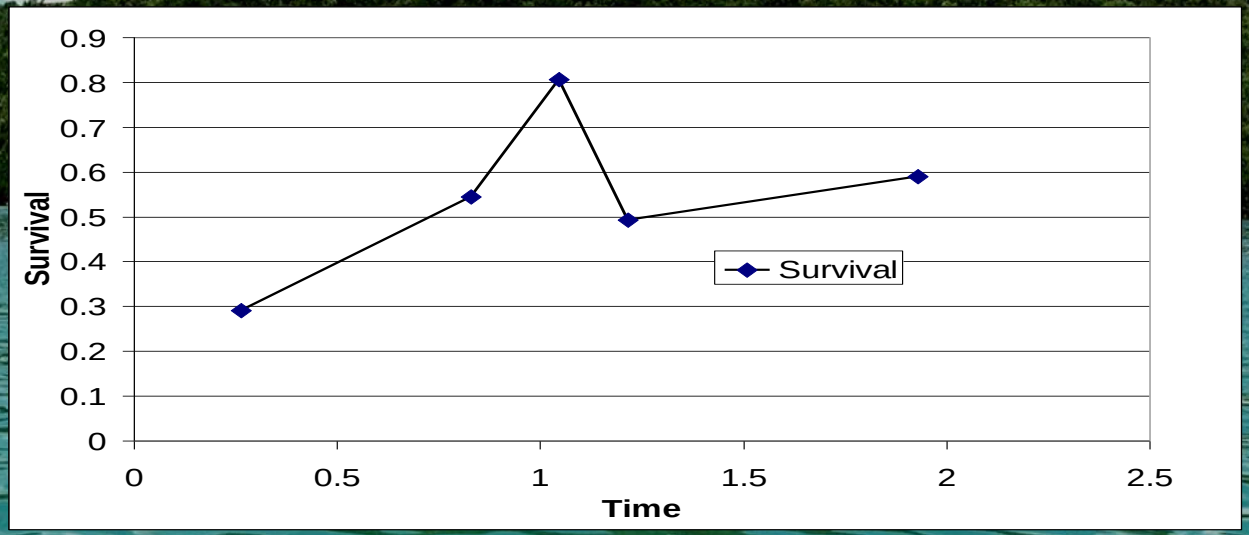
Habitat Use

- Juveniles
  - 30% patchy macroalgae
  - 70% seagrass (45% patchy, 25% cont.) {*Thalassia, Syringodium, Halodule*}
  - 1-3 meters depth

- Adults
  - 69% patchy macroalgae {*Halimeda, Penicillus, Avrainvillea*}
  - 2-9 meters depth







Jolly-Seber Outputs: Population Estimates, Births, Rate of Survival (May 2005-August 2007)

Habitat Based Surveys

- SEAMAP-Caribbean
  - Repeated transect surveys
  - Towed divers
- SEFSC-Galveston
  - Tag-and-recapture
- NCCOS Biogeography Team
  - Randomly stratified fish surveys
  - Large spatial distribution

Relationship of US Caribbean status to other Carib. Countries: Standing Stock and Fishing Rates

Habitat Based Surveys

Surveys Stratified by habitat

& size Adult/Juveniles by habitat

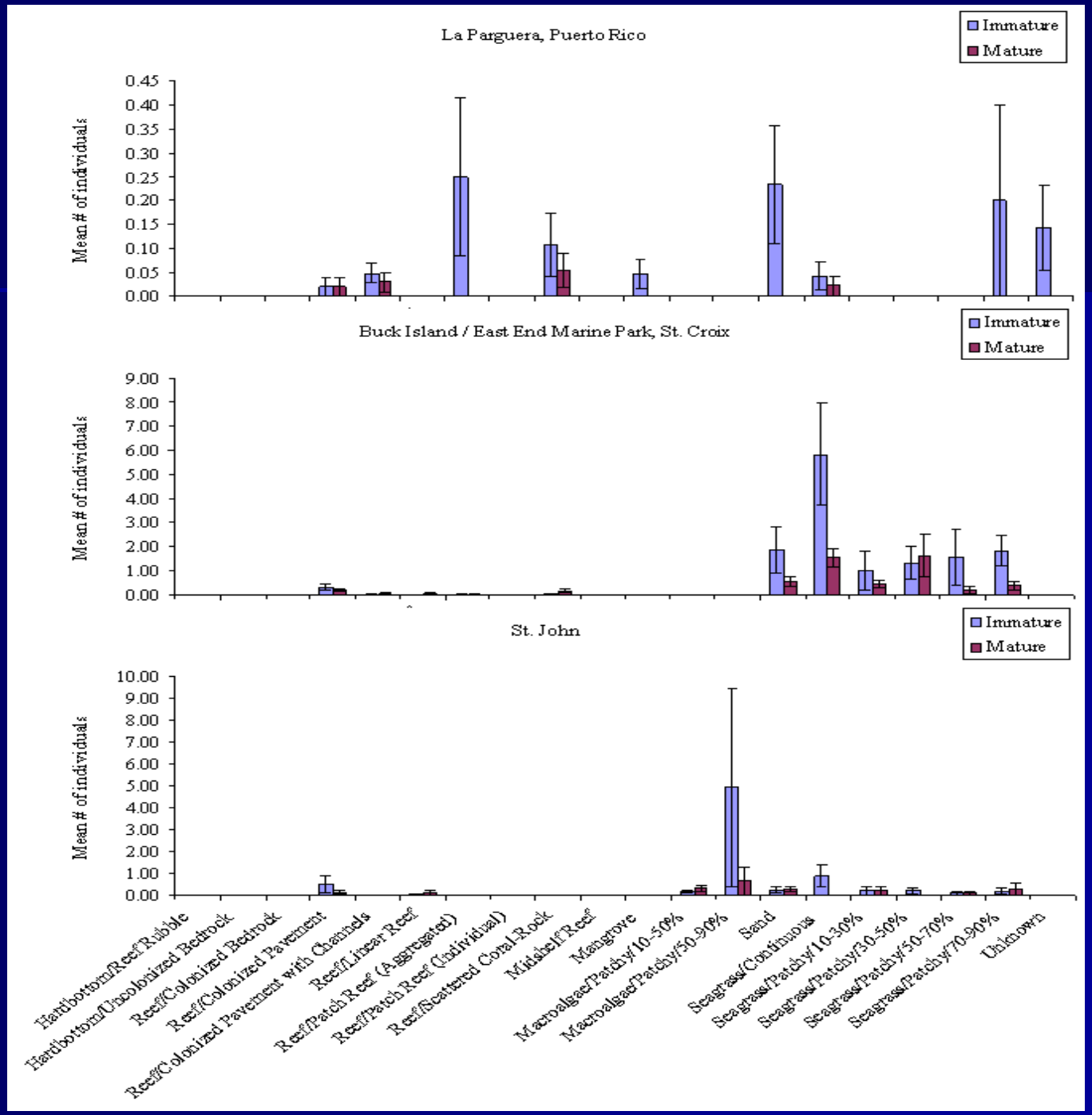
Areal extent of habitats

Density and Abundance Adults/Juvenile

Shell Length to Meat Weight Conversions

Estimate of Standing Stock vs Reported Landings

Population Extrapolations



Population Extrapolations

SEAMAP-C Surveys

Habitat	Hectares	Est. # conch
Sand	587.656019	27651.1
Coral rubble	22.2692	16.7
Algal plain	1024.704869	101433.5
Seagrass	609.882943	29760.8
		158862.2

NOS Surveys/NMFS Tagging

Habitat	Hectares	**Est. # conch**
Mangrove (m2)	26.037331	**640.1**
Sand	587.597219	**10088.7**
Reef/linear reef	449.629268	**12345.5**
Macroalgae patchy, 10-50%	859.472273	**45964.4**
Seagrass, continuous	202.892359	**4187.2**
Seagrass patchy, 10-30%	94.089909	**16491.8**
Seagrass patchy, 50-70%	120.019724	**4271.6**
		93989.3

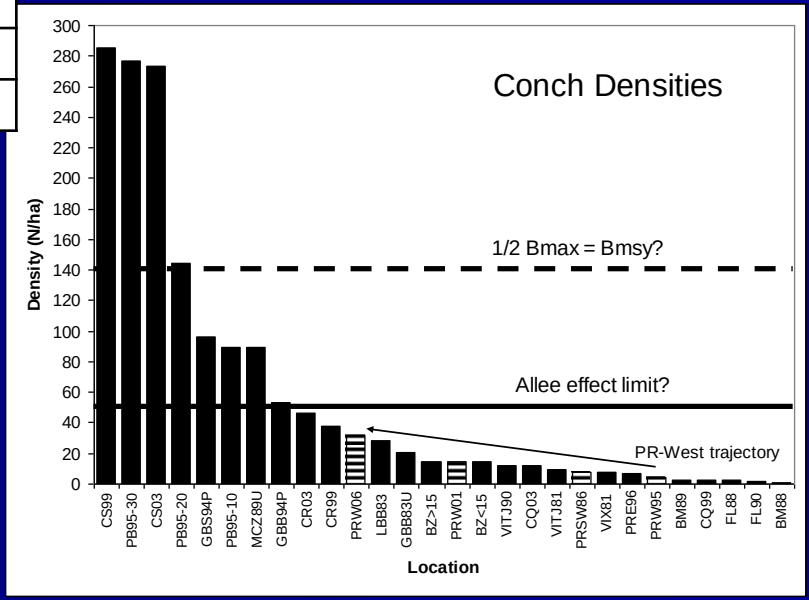
St. John, Biomass (meat)

St John (Area: 4699 ha)						
YEAR	DENSITIES		POPULATION			BIOMASS (Adult/Juv)
	ADULT	JUVE.	ADULT	JUVE.	TOTAL	(UNCLEANED LBS)
1981	52.4	na	246,296	na	246,296	197,965/na
1985	31.3	na	147,045	na	147,045	118,190/na
1990	8.08	0.7	37,971	3,102	41,073	30,520/289
1996	4.8	5.2	22,557	24,296	46,853	18,130/2193
2001	1.5	4.2	7,002	19,597	26,599	5,628/1769
2004/6[1]	9.7	35.4	72,832	169,838	242,670	58,540/15,331
2005/7[2]	5.3	24.5	24,907	115,136	140,042	20,019/10,393
Sources: 1. NOS surveys, 2. SEFSC conch tagging						

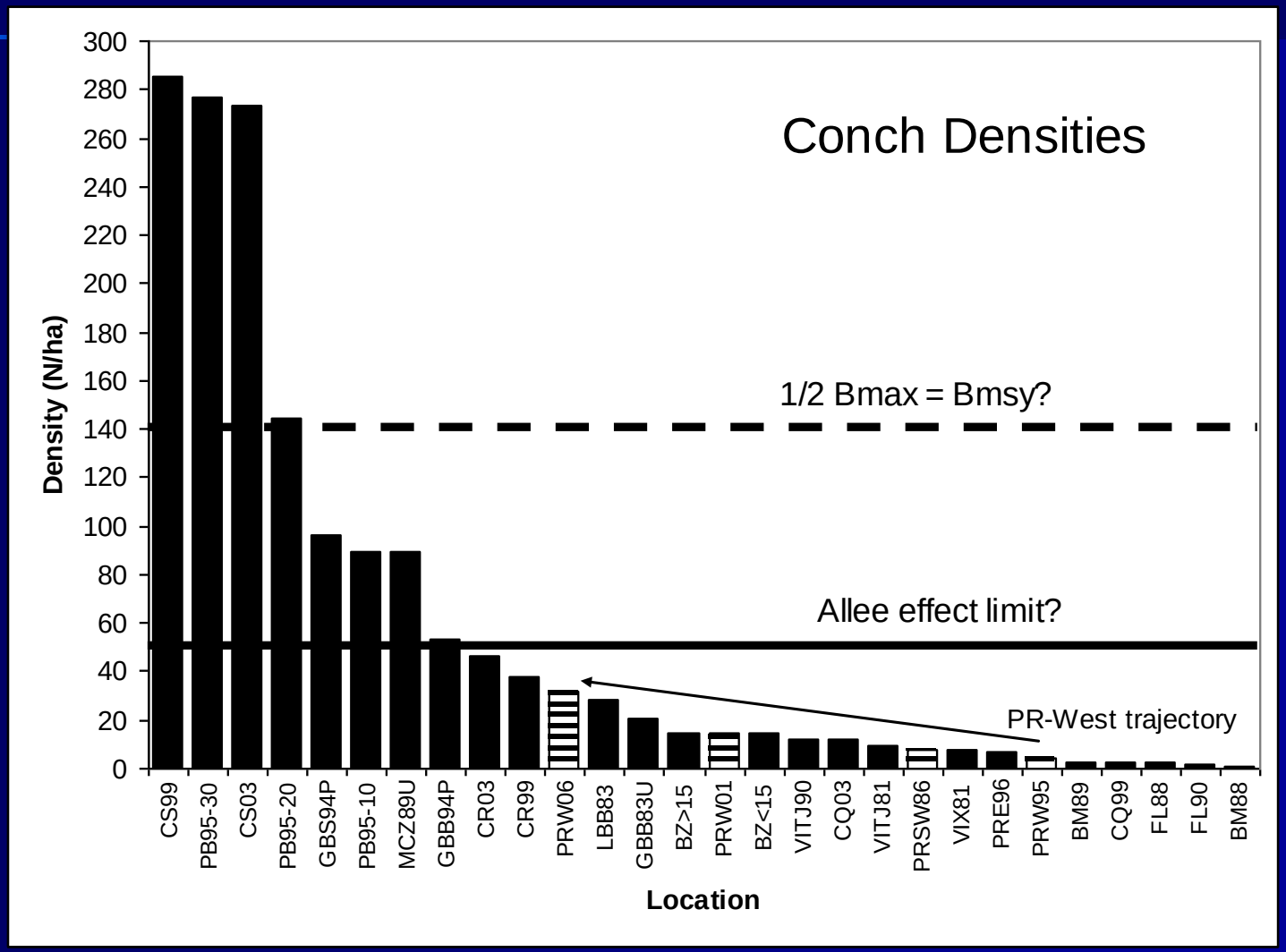
Using Density to Assess Stock Status

	Density-based Total Stock Biomass (Adults Only-lbs.)	Yield (lbs)
Puerto Rico	1,897,000	
St. Croix	668,000	
TOTAL	2,565,000	723,719
Conch FMP		
MSST	1,404,000	
MSY	452,000	+60% high

- Compare actual density to known fished and unfished areas
- Assume unfished densities ~ Virgin Stock Biomass



Using Density to Assess Stock Status



Catch Rates

Turks and Caicos MSY

Commercial Catch	+	Local Consumption	=	MSY
87 kg/km2	+	51 kg/km2	=	3.04 lbs/ha
(Ninnes 1994)		(Olsen 1985)		

Puerto Rico - 3.10 lbs/ha – similar
St. Croix - 7.39 lbs/ha – double

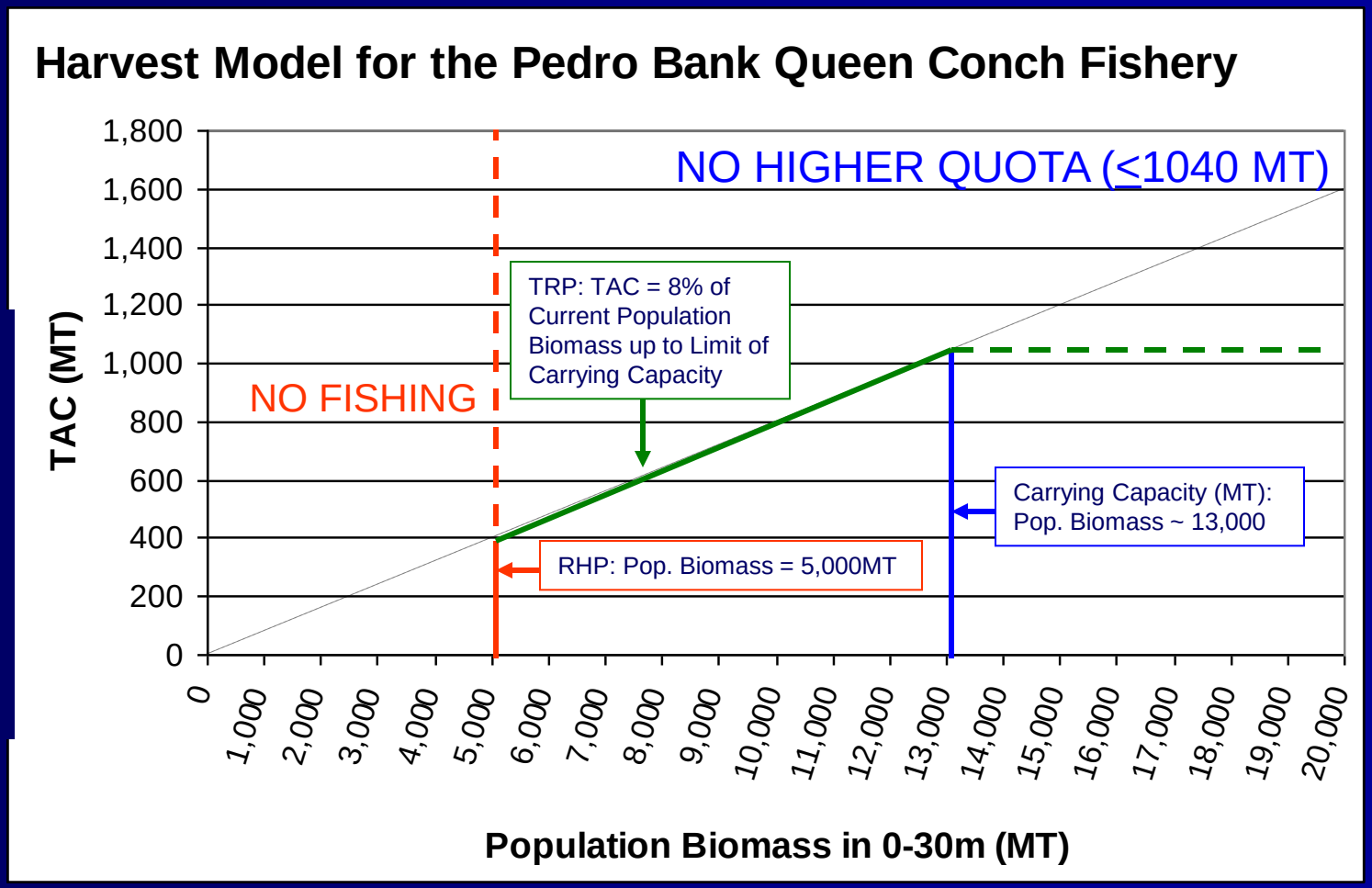
Assessing the Assessment

- *"and (c) expansion of habitat-specific survey densities to domain-wide abundance estimates were based on low survey coverage and small sample sizes of conch."*

- *"The RP considers that future SEDAR assessments for queen conch will only be appropriate once significant progress has been made on improving both fishery statistics and fishery independent indices."*
  SEDAR review panel

Proposed Harvest Model for Pedro Bank, Jamaica (Smikle 2010)

- Based on stratified random surveys at 4-5 year intervals
- Carrying Capacity set by density in unfished area > 30 m
- TAC below CC set at 8% of exploitable stock(<Medley 2008=10%)
- Lower limit set at 1.5 x Density of potential Allee effect (Stoner & Ray 2000)



Safety Factors built in:

- Marine reserve(s)
- Repeated surveys
- Maximum quota
- LF distributions
- C/E (in progress)
- Poaching included

Using Fishery-Independent Surveys to Estimate Densities of Queen Conch, *Strombus gigas*, Populations in St. Croix, U. S. Virgin Islands

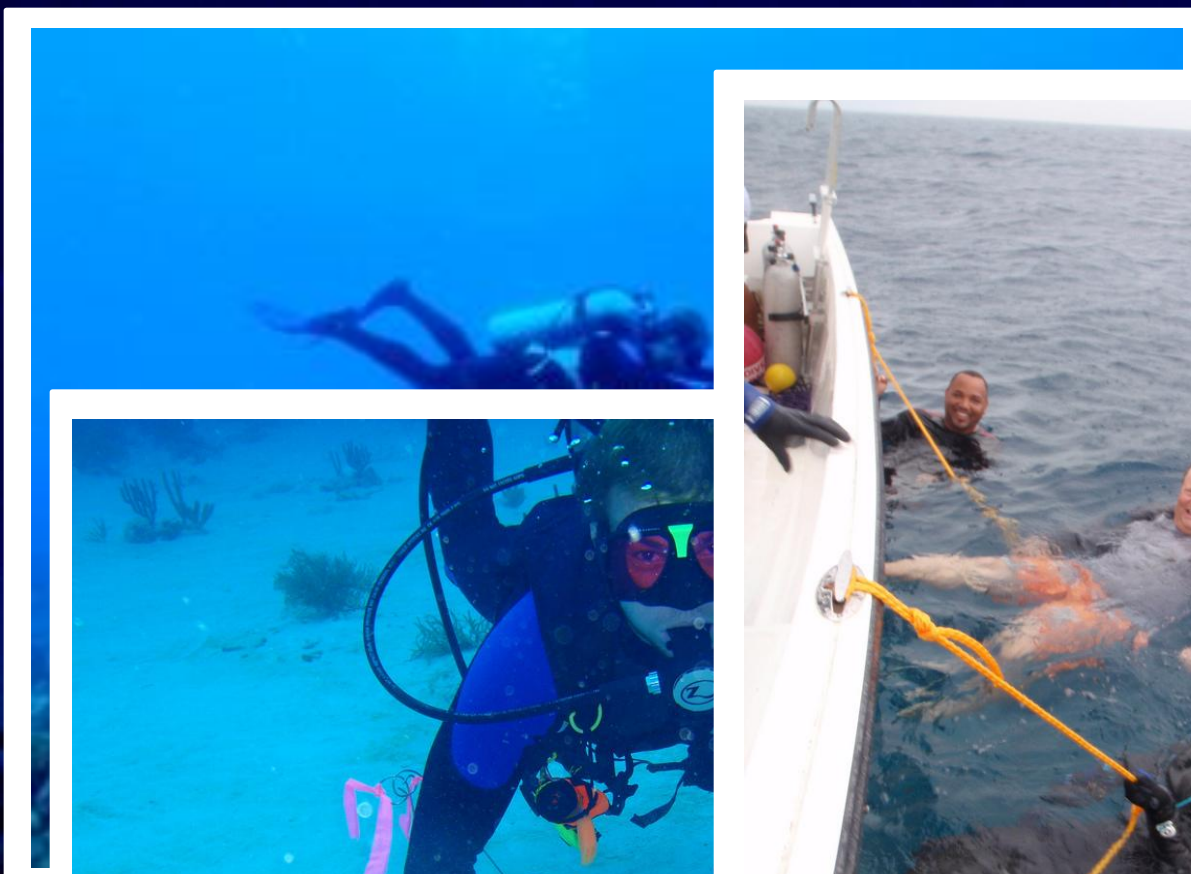
Ron Hill and Jennifer Doerr
NOAA Fisheries Service
Galveston, Texas

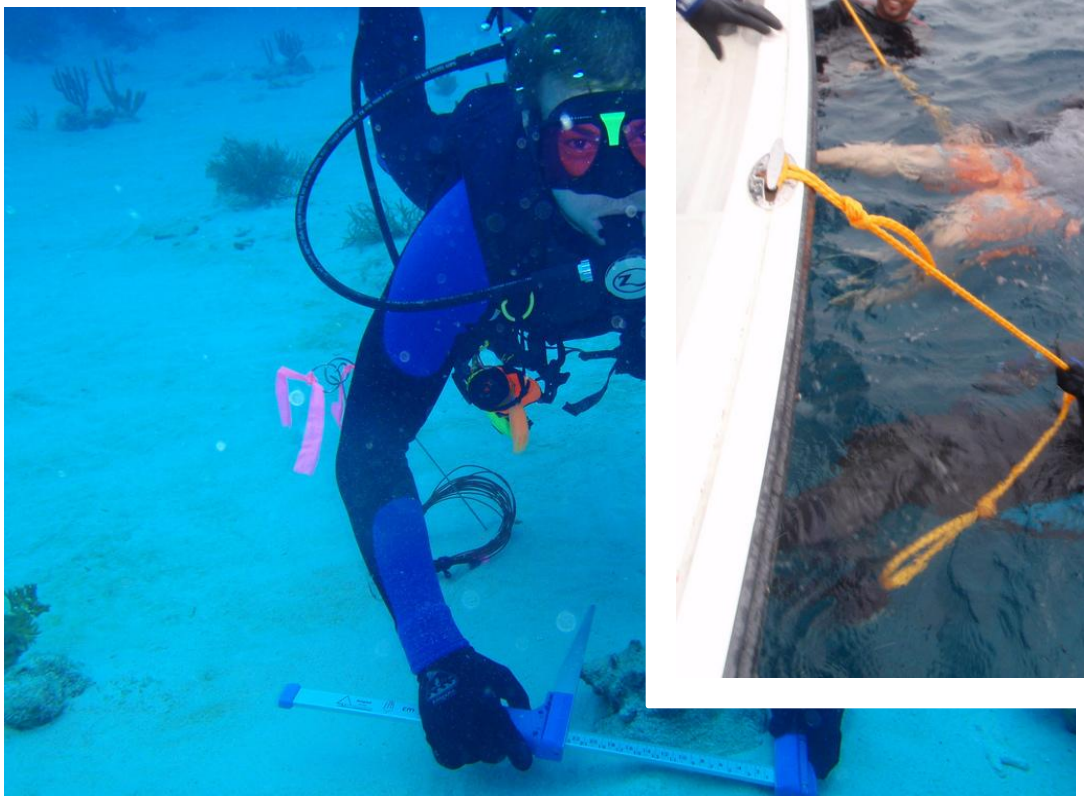
NOAA Fisheries
National Marine Fisheries Service

What We Set Out To Do…

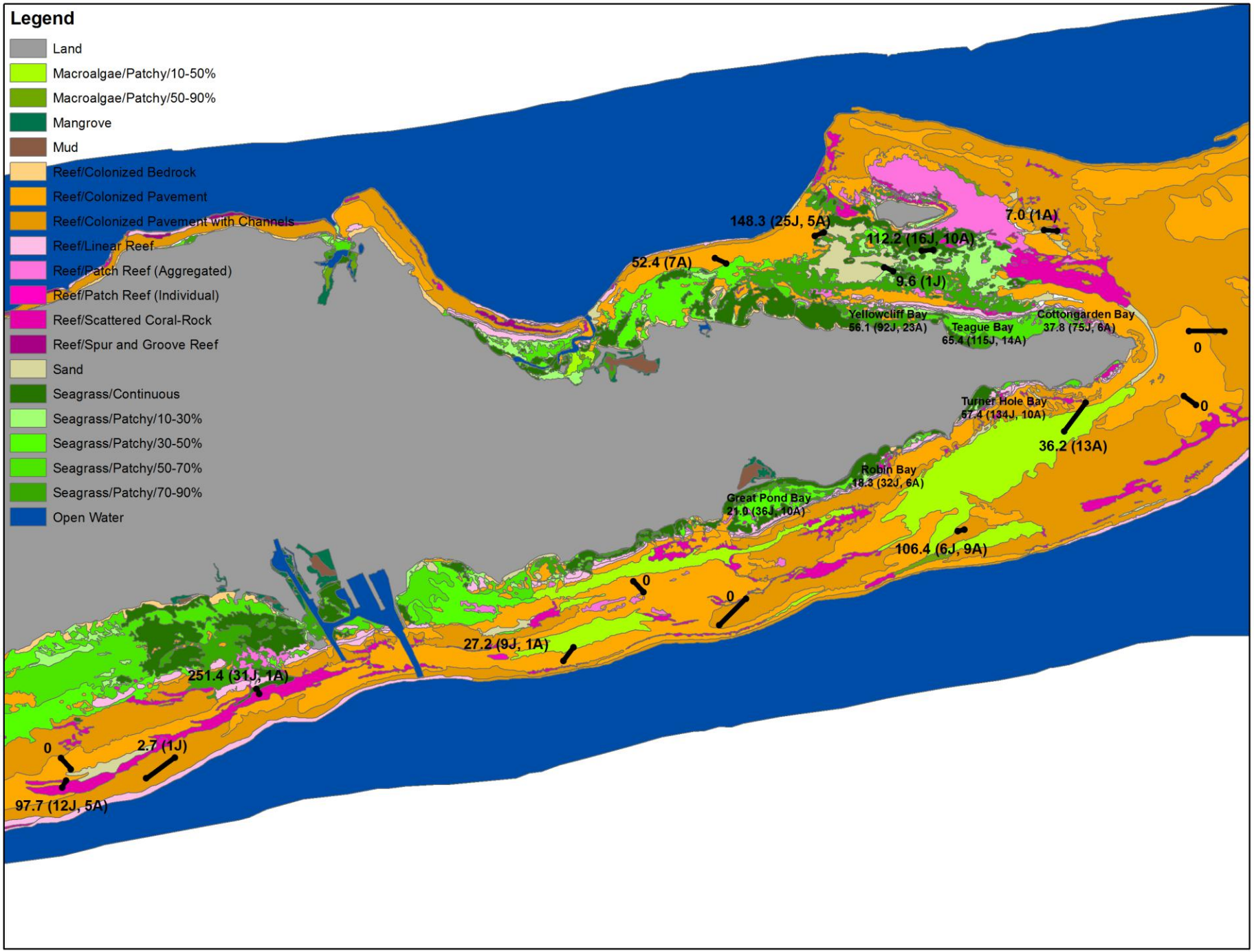
- Conduct fishery-independent surveys on the northern shelf of St. Croix
  - BIRNM
  - Open fishing grounds
- Generate size-structured population estimates suitable for stock assessments
- Analyze spatial data to describe differences in conch densities and distribution by habitat type, management regime, and depth

…And How We Did It

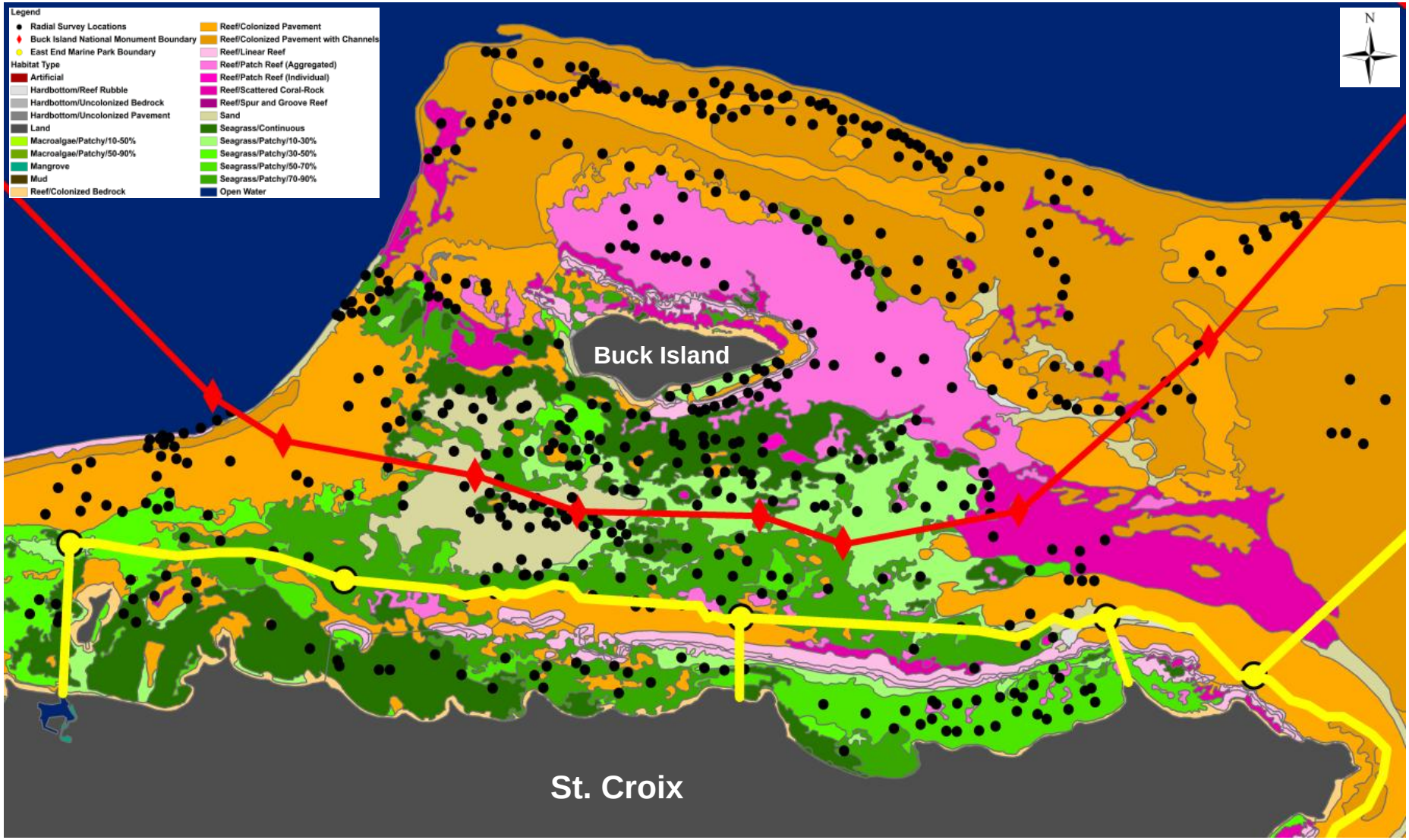




All Photos: Katy Brown


Legend
Land
Macroalgae/Patchy/10-50%
Macroalgae/Patchy/50-90%
Mangrove
Mud
Reef/Colonized Bedrock
Reef/Colonized Pavement
Reef/Colonized Pavement with Channels
Reef/Linear Reef
Reef/Patch Reef (Aggregated)
Reef/Patch Reef (Individual)
Reef/Scattered Coral-Rock
Reef/Spur and Groove Reef
Sand
Seagrass/Continuous
Seagrass/Patchy/10-30%
Seagrass/Patchy/30-50%
Seagrass/Patchy/50-70%
Seagrass/Patchy/70-90%
Open Water
148.3 (25J, 5A)
7.0 (1A)
112.2 (16J, 10A)
52.4 (7A)
9.6 (1J)
Yellowcliff Bay
56.1 (92J, 23A)
Teague Bay
65.4 (115J, 14A)
Cottongarden Bay
37.8 (75J, 6A)
0
Turner Hole Bay
57.4 (134J, 10A)
0
36.2 (13A)
Robin Bay
18.3 (32J, 6A)
Great Pond Bay
21.0 (36J, 10A)
106.4 (6J, 9A)
0
0
27.2 (9J, 1A)
251.4 (31J, 1A)
0
2.7 (1J)
97.7 (12J, 5A)

Results


Legend
Radial Survey Locations
Buck Island National Monument Boundary
East End Marine Park Boundary
Habitat Type
Artificial
Hardbottom/Reef Rubble
Hardbottom/Uncolonized Bedrock
Hardbottom/Uncolonized Pavement
Land
Macroalgae/Patchy/10-50%
Macroalgae/Patchy/50-90%
Mangrove
Mud
Reef/Colonized Bedrock
Reef/Colonized Pavement
Reef/Colonized Pavement with Channels
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Reef/Patch Reef (Individual)
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Reef/Spur and Groove Reef
Sand
Seagrass/Continuous
Seagrass/Patchy/10-30%
Seagrass/Patchy/30-50%
Seagrass/Patchy/50-70%
Seagrass/Patchy/70-90%
Open Water
N
Buck Island
St. Croix

USVI Fishing Regulations

Queen Conch
Strombus gigas

All Queen Conch

Must be landed in the shell.
Empty shells cannot be
disposed of in the water.

Season Open

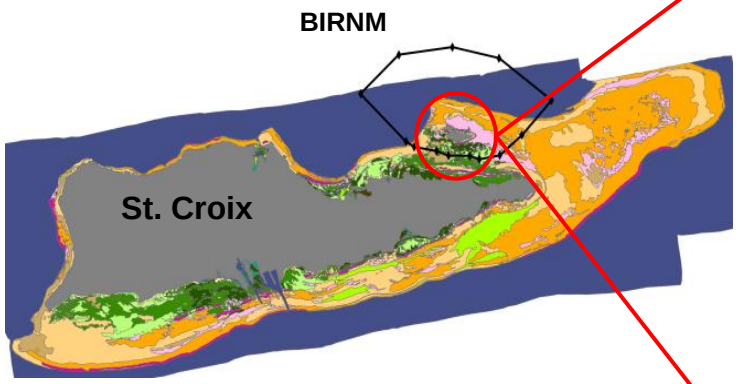
November 1 to May 31

(until ACL reached)

Quota-bag limit
Max Catch Per Day
200 per boat (commercial)
6 per person to a
max. 24 per boat (personal)
Conch meats:
2/lb uncleaned or 3/lb cleaned

Size Limits

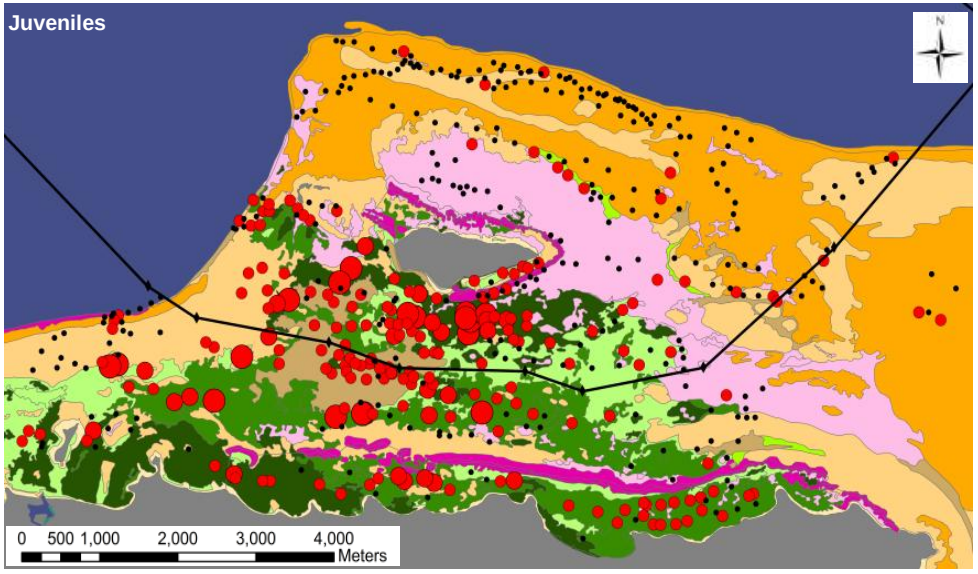
Conch shell **MUST** be at least 9" long
or
have a lip thickness of 3/8"

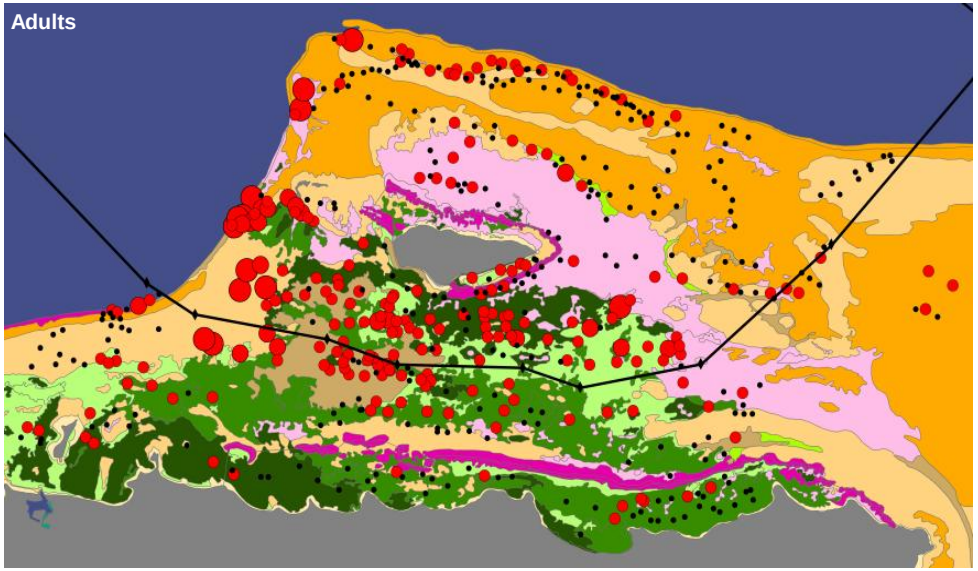


BIRNM Boundary
Land
Patchy Macroalgae/Rubble
Colonized Pavement
Colonized Pavement with Channels
Linear Reef
Patch Reef/Coral-Rock
Sand
Continuous Seagrass
Patchy Seagrass 10-50%
Patchy Seagrass 50-90%
Open Water

Mean Juvenile Density
- 0 per ha
- 1 - 637 per ha
- 638 - 1751 per ha
- 1752 - 9581 per ha

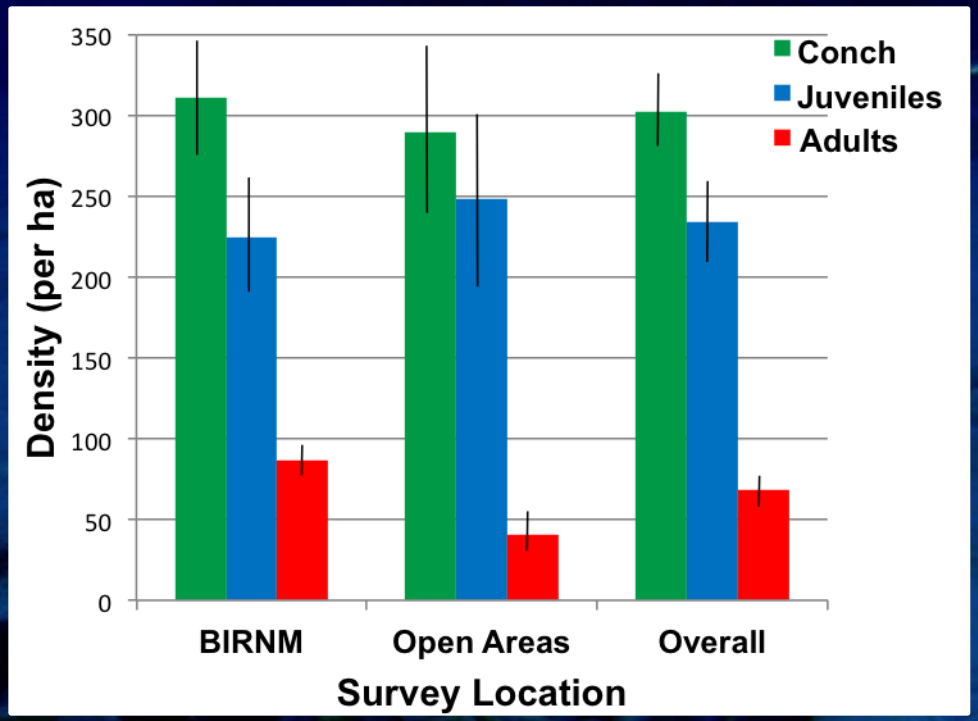
Mean Adult Density
- 0 per ha
- 1 - 255 per ha
- 256 - 605 per ha
- 606 - 1050 per ha

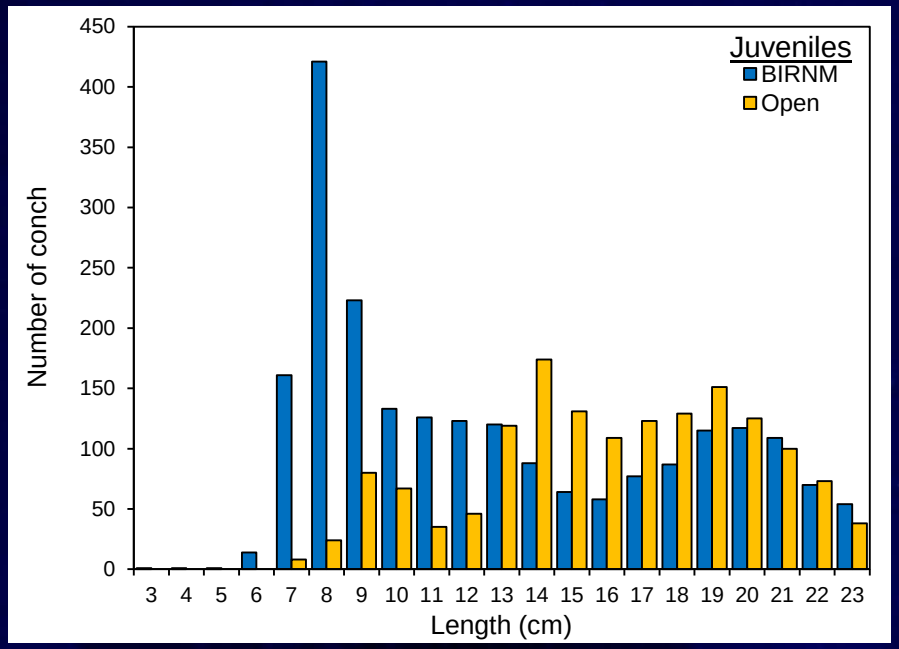


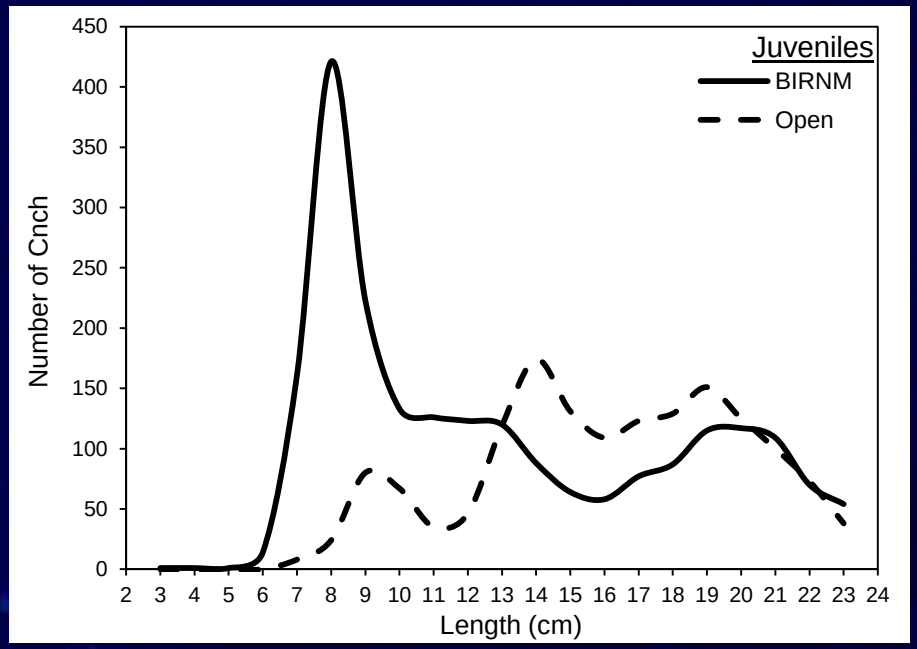


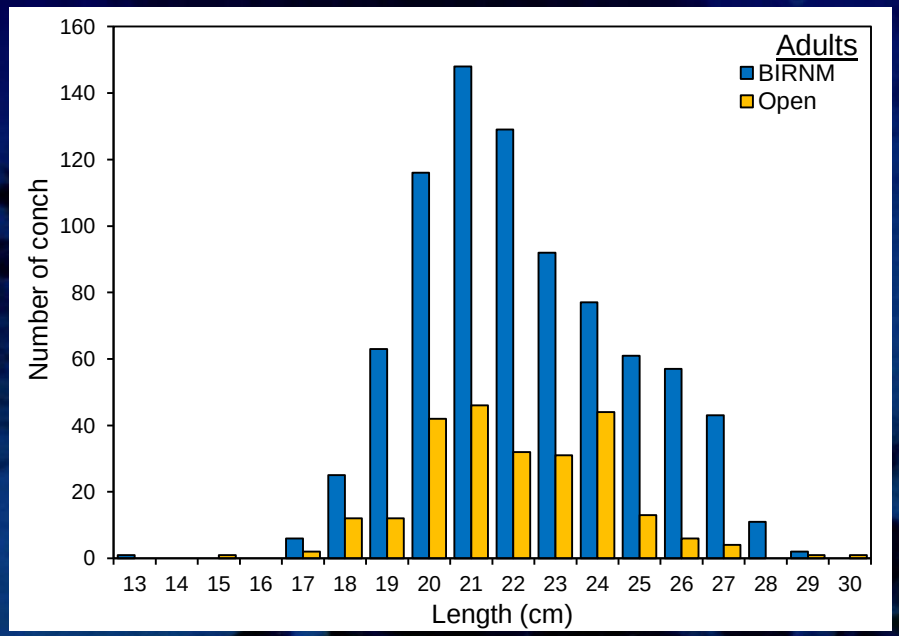
Overall Conch Densities

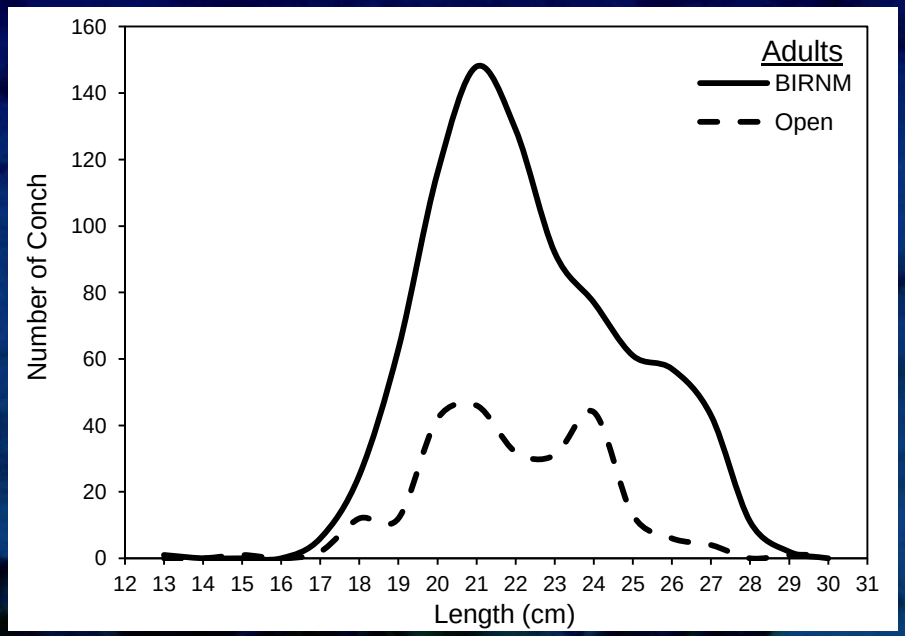
- Located and measured 4773 conch, representing a density of 302 conch/ha
  - 3690 juveniles = 234/ha
  - 1083 adults = 69/ha
- BIRNM = 311/ha
  - Juveniles = 224/ha
  - Adults = 86/ha
- Open areas = 289/ha
  - Juveniles = 248/ha
  - Adults = 41/ha



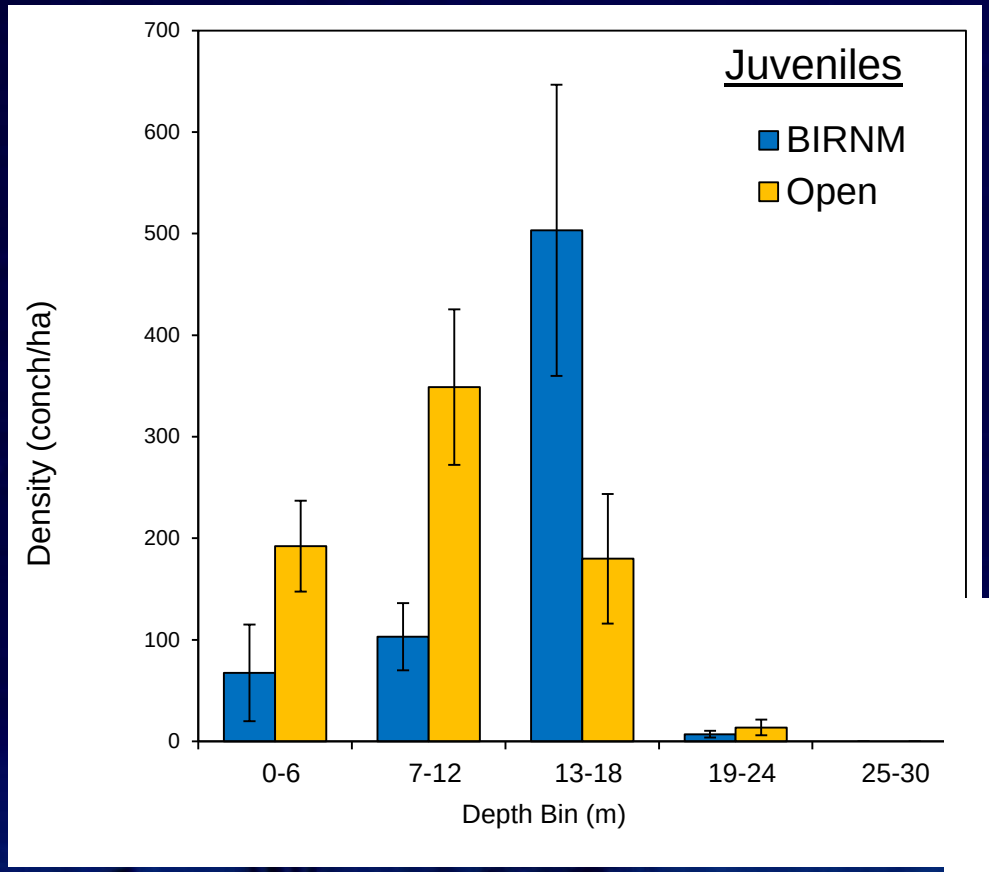

Juveniles
BIRNM
Open
Number of conch
Length (cm)

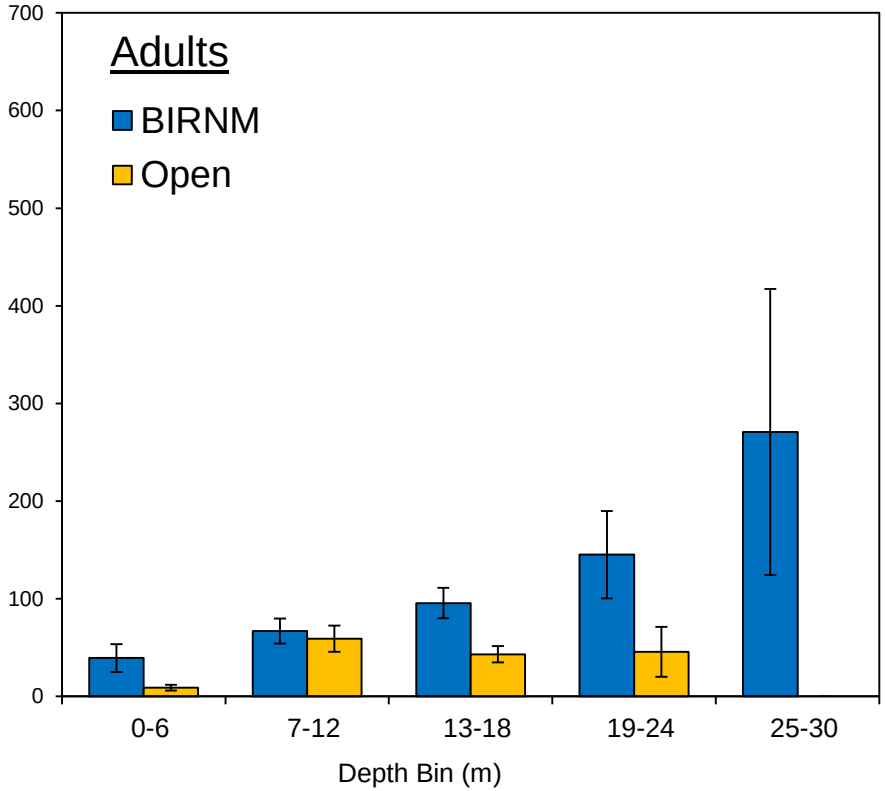

Juveniles
BIRNM
Open
Number of Cnch
Length (cm)


Adults
BIRNM
Open
Number of conch
Length (cm)

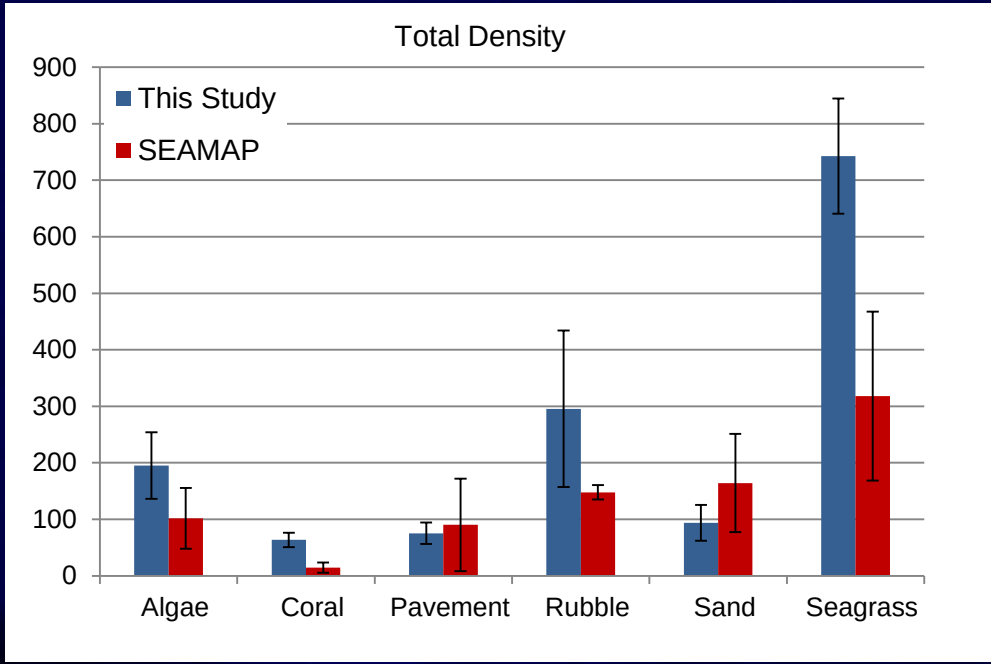

Adults
BIRNM
Open
Number of Conch
Length (cm)

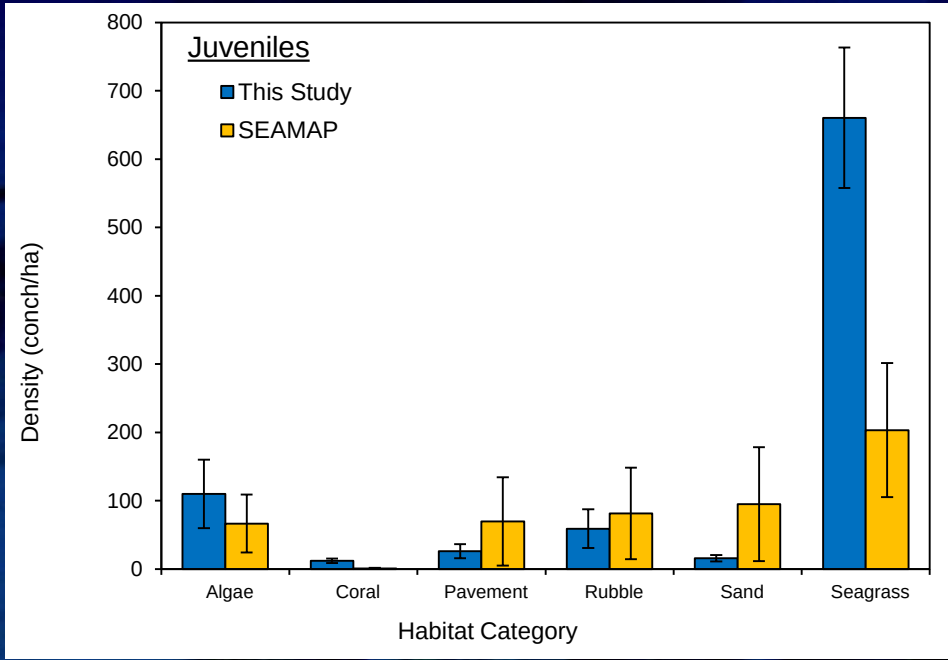
Reserve Performance

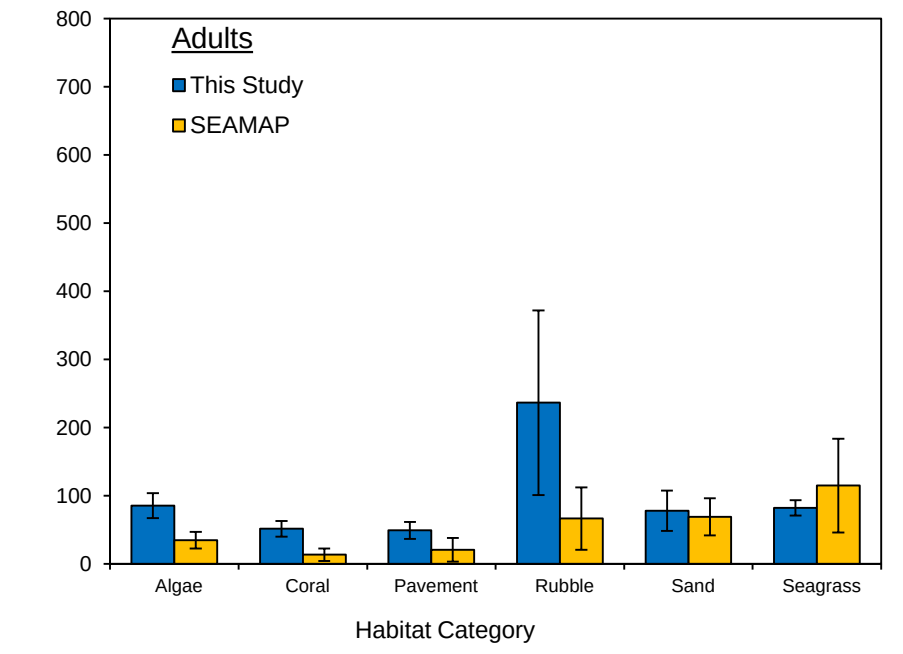




Habitat


Total Density
This Study
SEAMAP
900
800
700
600
500
400
300
200
100
0
Algae
Coral
Pavement
Rubble
Sand
Seagrass


Juveniles
This Study
SEAMAP
Density (conch/ha)
800
700
600
500
400
300
200
100
0
Algae
Coral
Pavement
Rubble
Sand
Seagrass
Habitat Category


Adults
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SEAMAP
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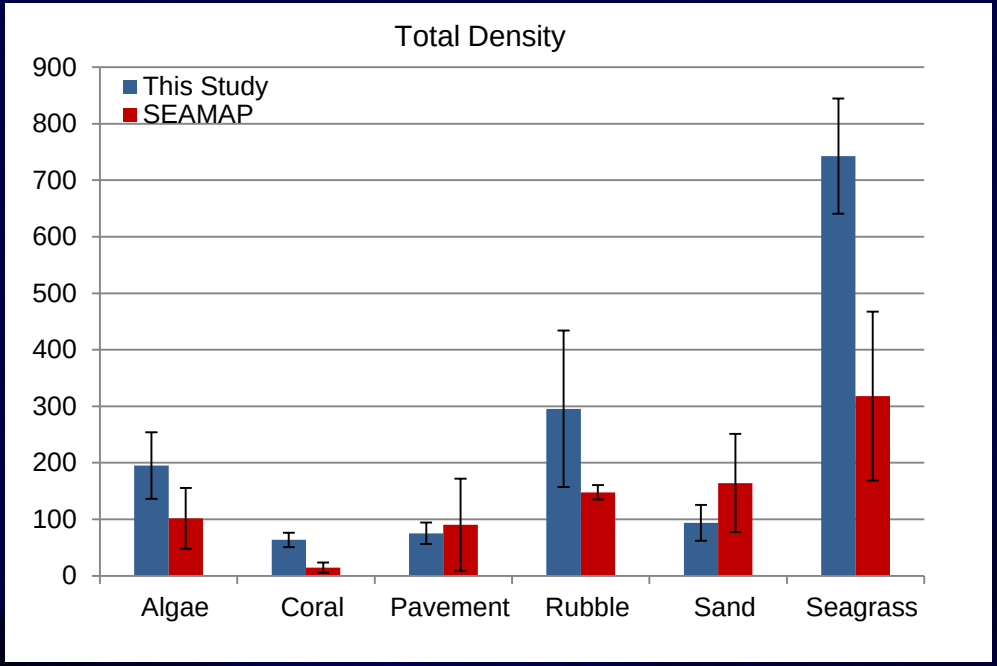
Habitat Category

Habitat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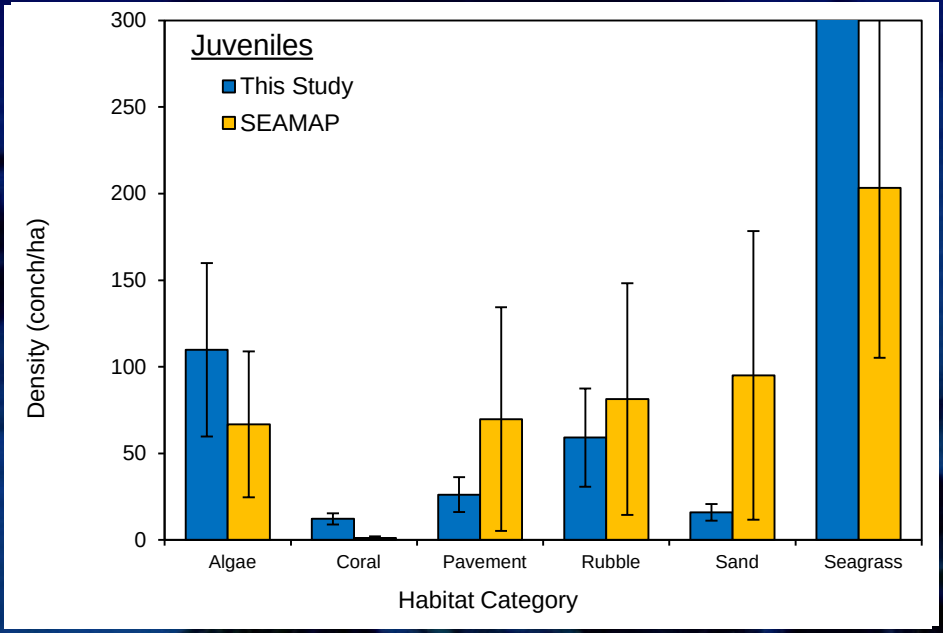
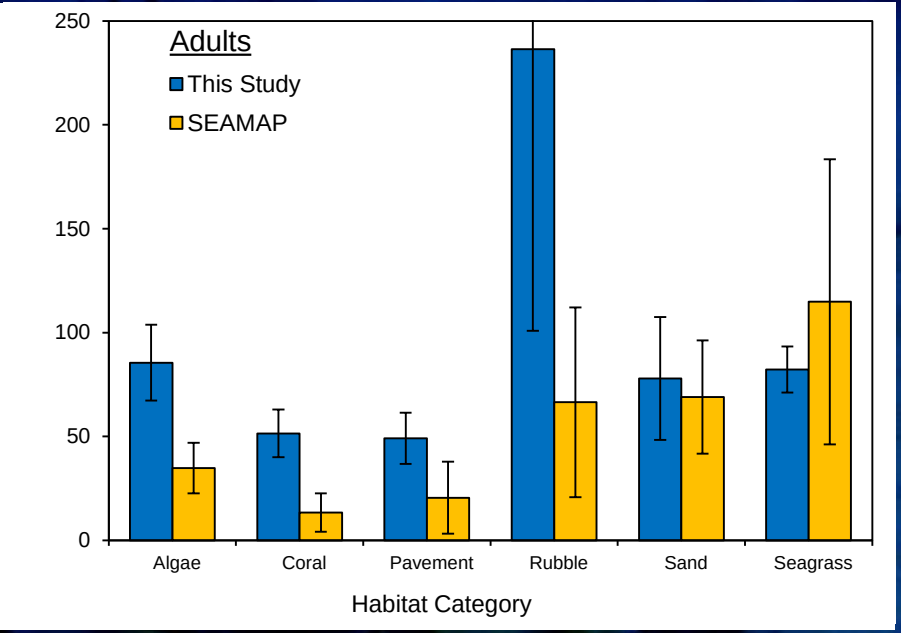
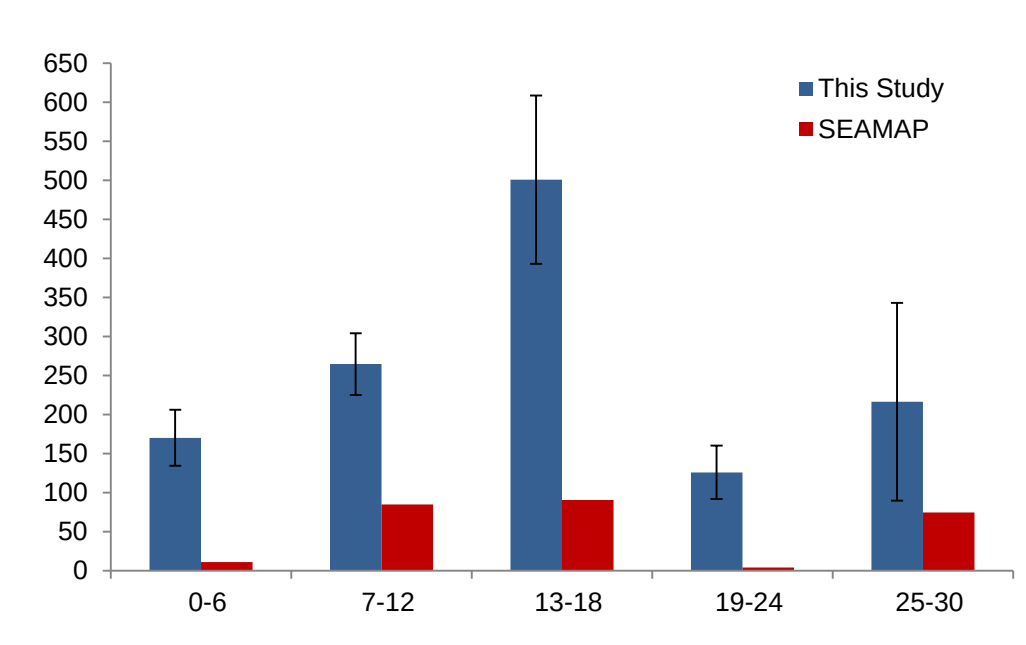
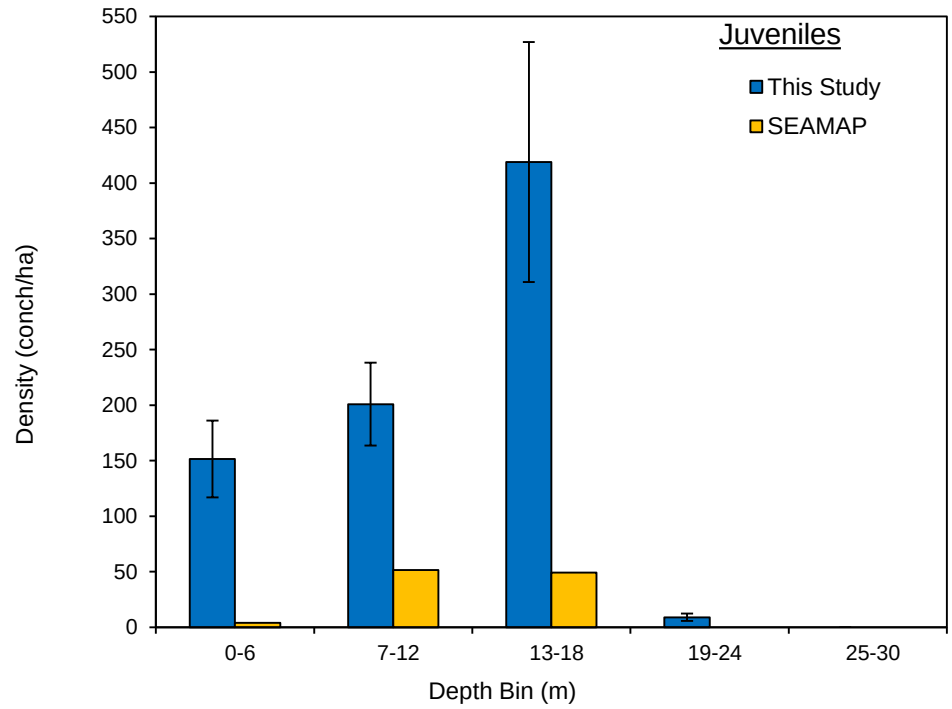
Pavement
Rubble
Sand
Seagrass

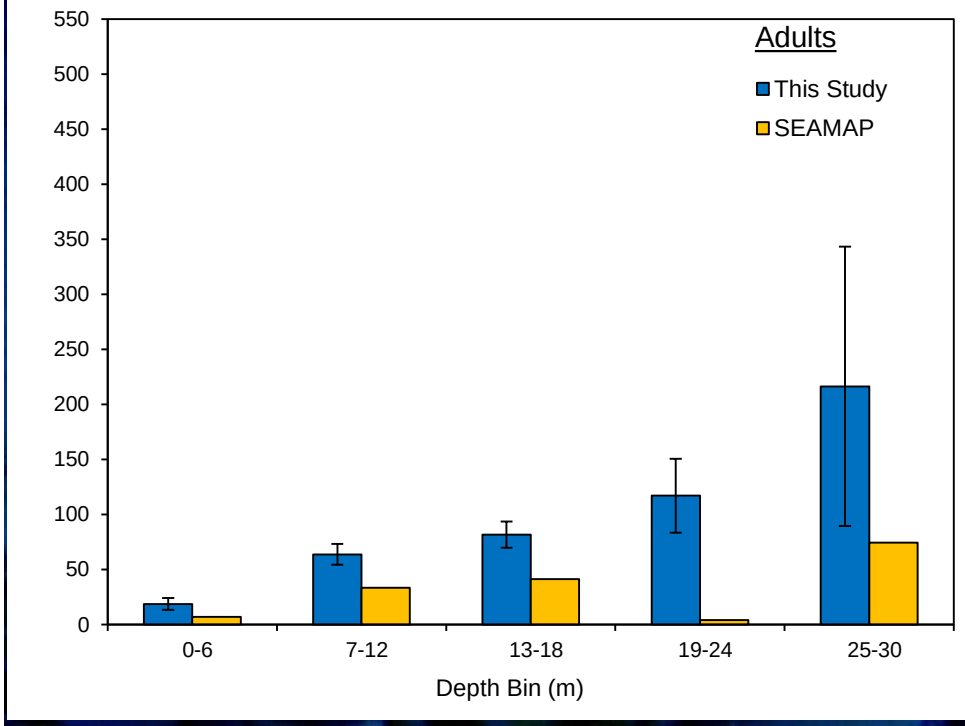

Juveniles
This Study
SEAMAP
Density (conch/ha)
300
250
200
150
100
50
0
Algae
Coral
Pavement
Rubble
Sand
Seagrass
Habitat Category


Adults
This Study
SEAMAP
250
200
150
100
50
0
Algae
Coral
Pavement
Rubble
Sand
Seagrass
Habitat Category

Depth


650
600
550
500
450
400
350
300
250
200
150
100
50
0
This Study
SEAMAP
0-6
7-12
13-18
19-24
25-30


Juveniles
This Study
SEAMAP
Density (conch/ha)
550
500
450
400
350
300
250
200
150
100
50
0
0-6
7-12
13-18
19-24
25-30
Depth Bin (m)


Adults
This Study
SEAMAP
550
500
450
400
350
300
250
200
150
100
50
0
0-6
7-12
13-18
19-24
25-30
Depth Bin (m)

Uncolonized Habitat Types:

mud	fine sediment
sand	coarse sediment

Colonized/Reef Habitat Types:

colonized bedrock	bedrock covered by macroalgae or sessile invertebrates
colonized pavement	flat solid rock covered by macroalgae or sessile invertebrates
colonized pavement with channels	alternate sand and colonized pavement, low vertical relief
linear reef	linear coral formations parallel to shore
patch reef, aggregate	clustered patch reefs
patch reef, individual	distinctive single patch reefs
scattered coral-rock	sand or seagrass bottom with scattered rocks or very small isolated coral heads
spur and groove reef	alternating sand and coral formations, high vertical relief

Other Hardbottom Habitat Types:

reef rubble	dead rubble, may be colonized with macroalgae
uncolonized bedrock	exposed bedrock
uncolonized pavement	flat solid rock, may be covered with thin sand veneer
uncolonized pavement with channels	alternating sand and uncolonized pavement formations, low vertical relief

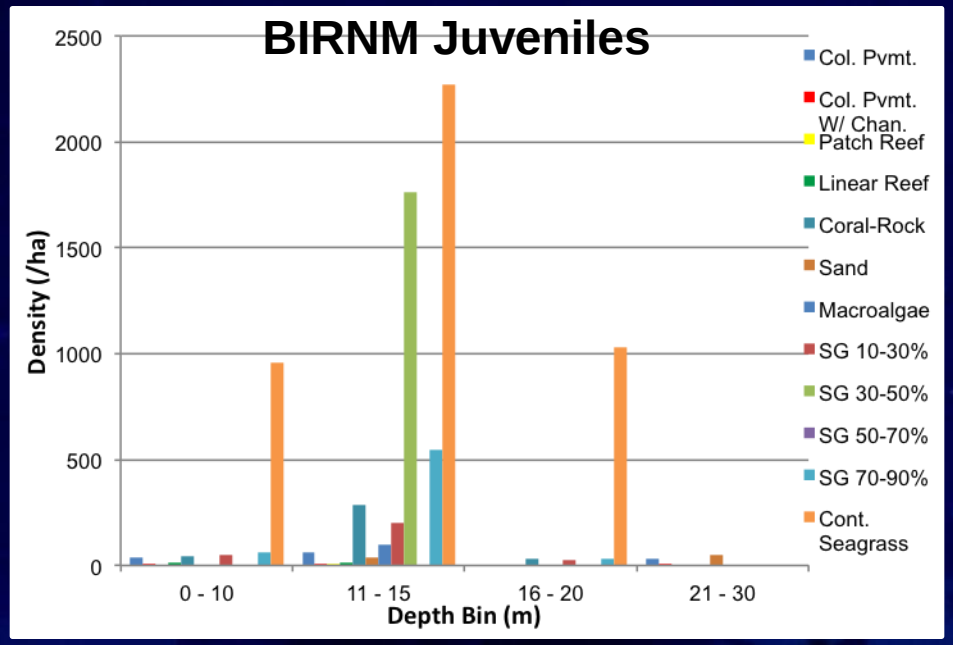
Vegetated/Macroalgae Types:

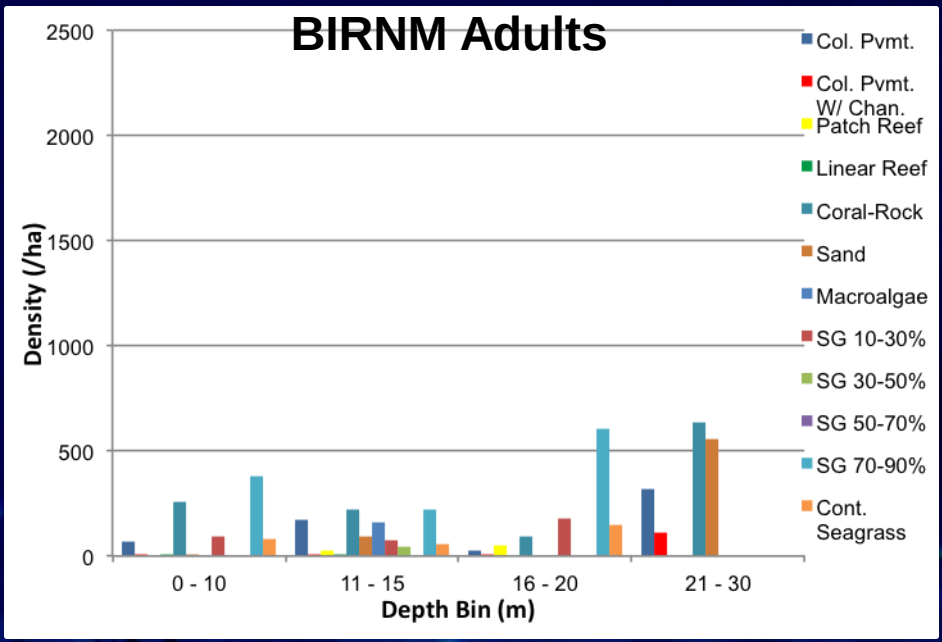
continuous macroalgae	more than 90% macroalgae
patchy macroalgae, 10-50%	discontinuous, sparse isolated patches of macroalgae
patchy macroalgae, 50-90%	discontinuous, isolated patches of macroalgae

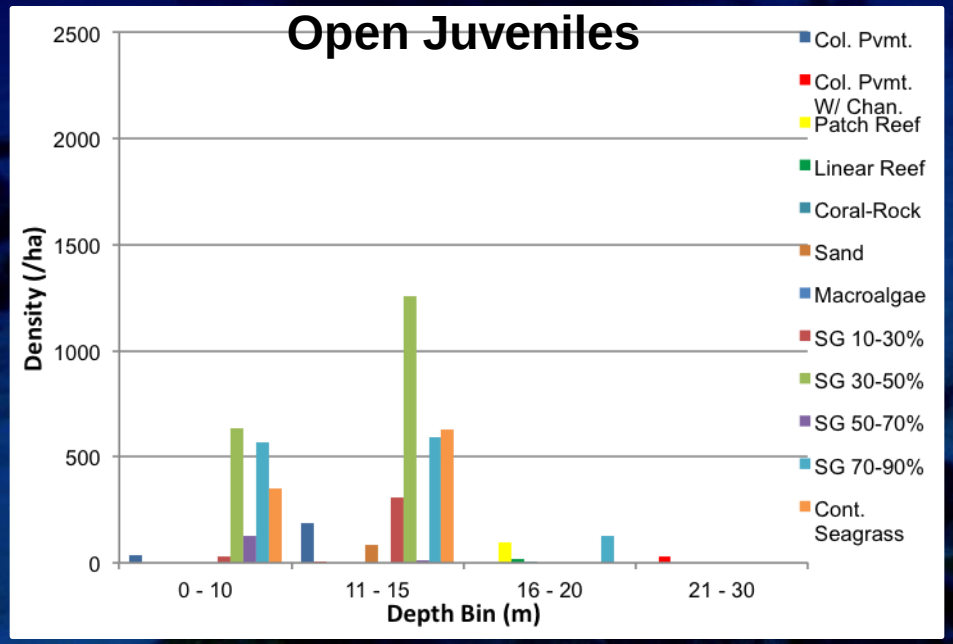
Vegetated/Seagrass Types:

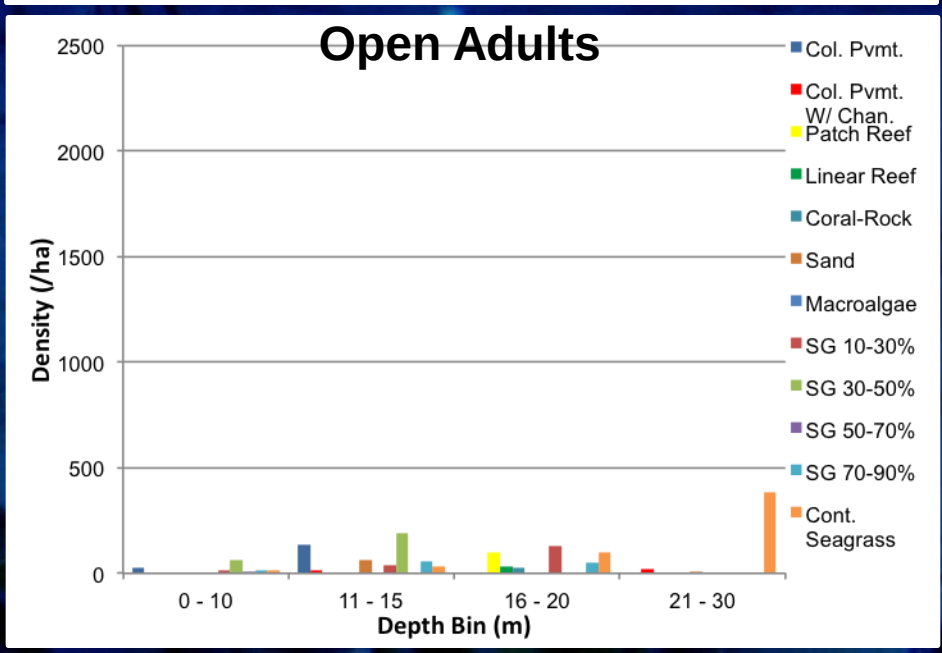
continuous seagrass	more than 90% seagrass
patchy seagrass, 10-30%	discontinuous, sparse isolated patches of seagrass
patchy seagrass, 30-50%	discontinuous, sparse isolated patches of seagrass
patchy seagrass, 50-70%	discontinuous, isolated patches of seagrass
patchy seagrass, 70-90%	discontinuous, isolated patches of seagrass

Densities By Habitat/Depth…???

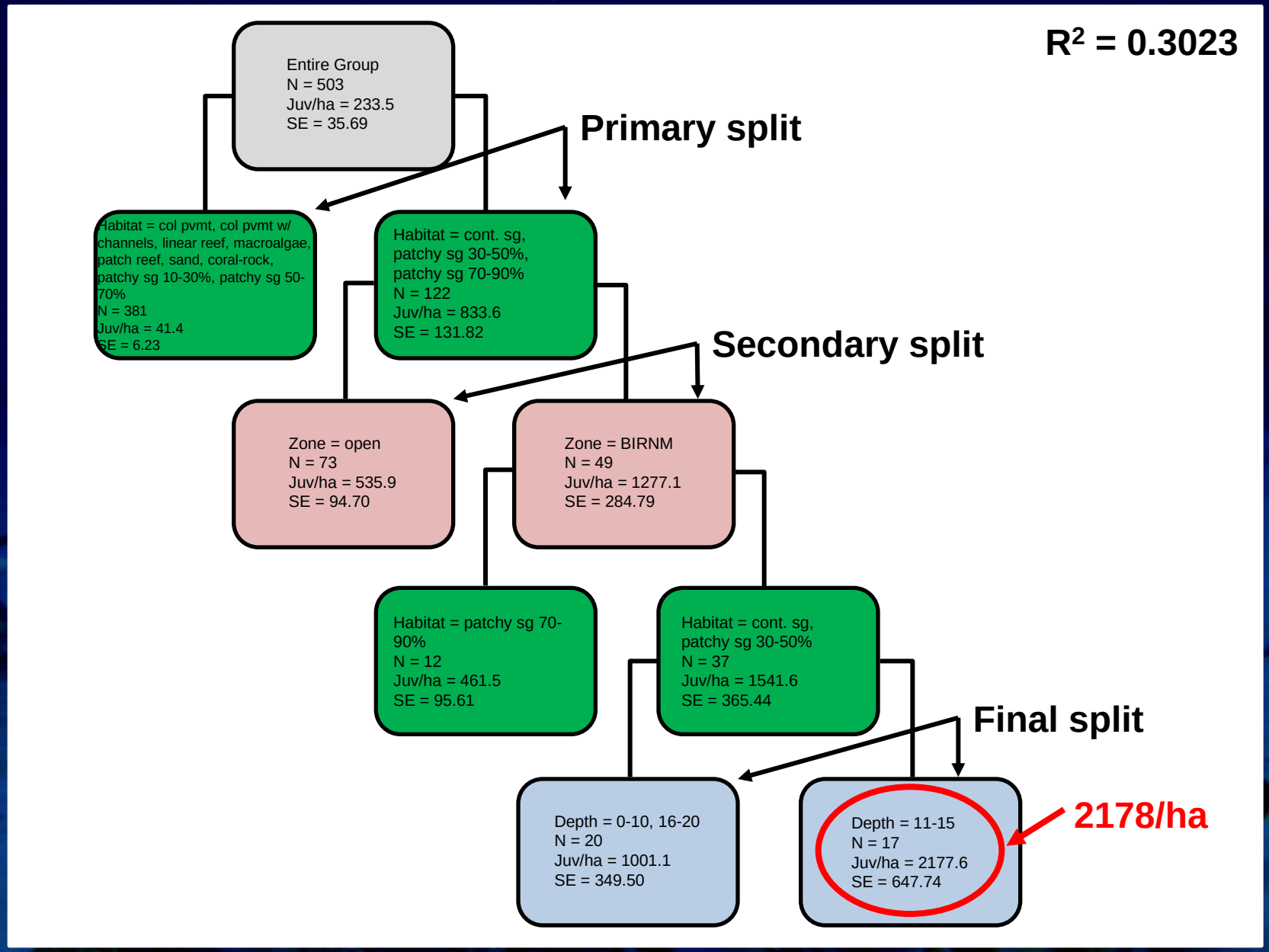


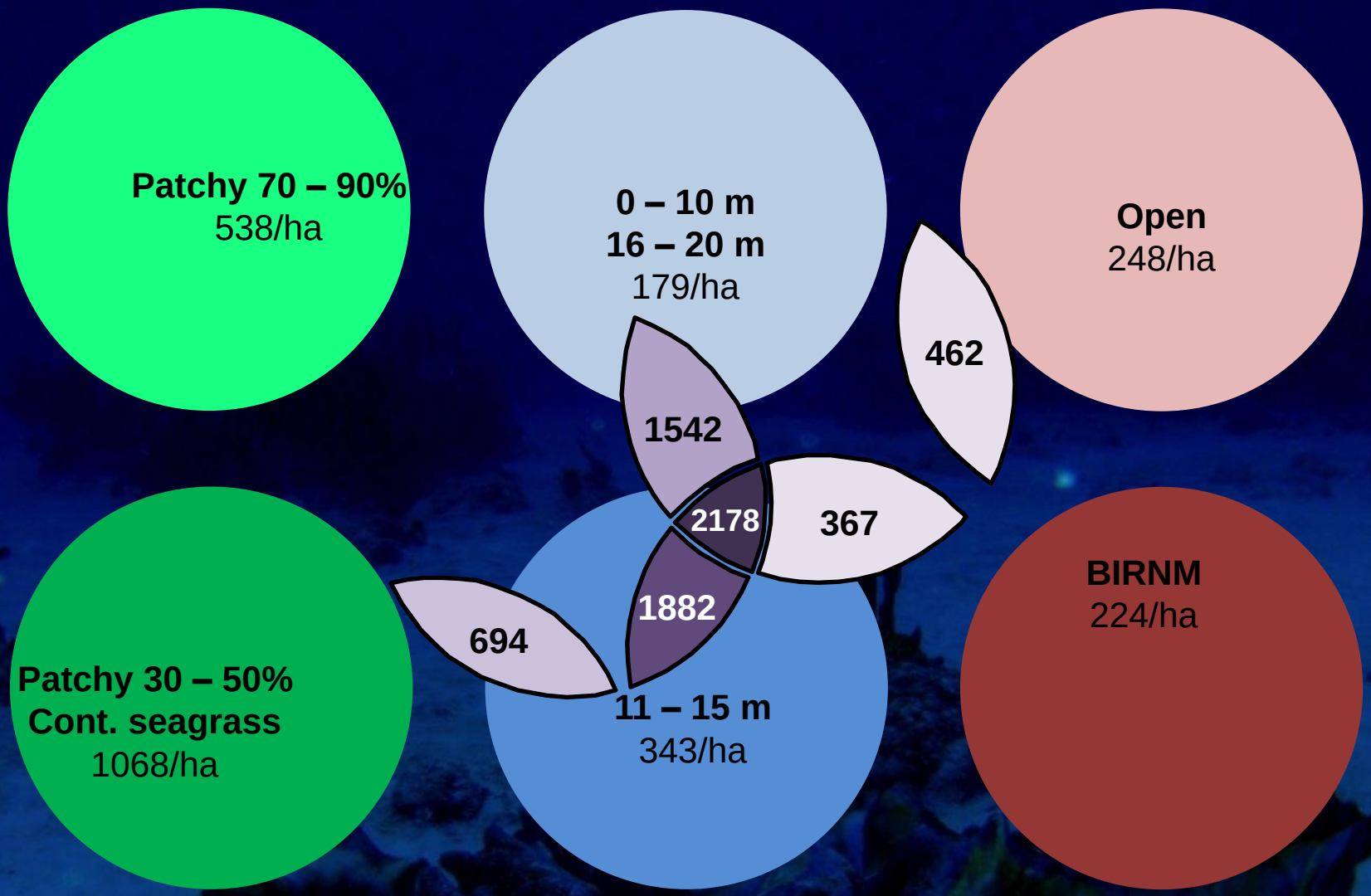




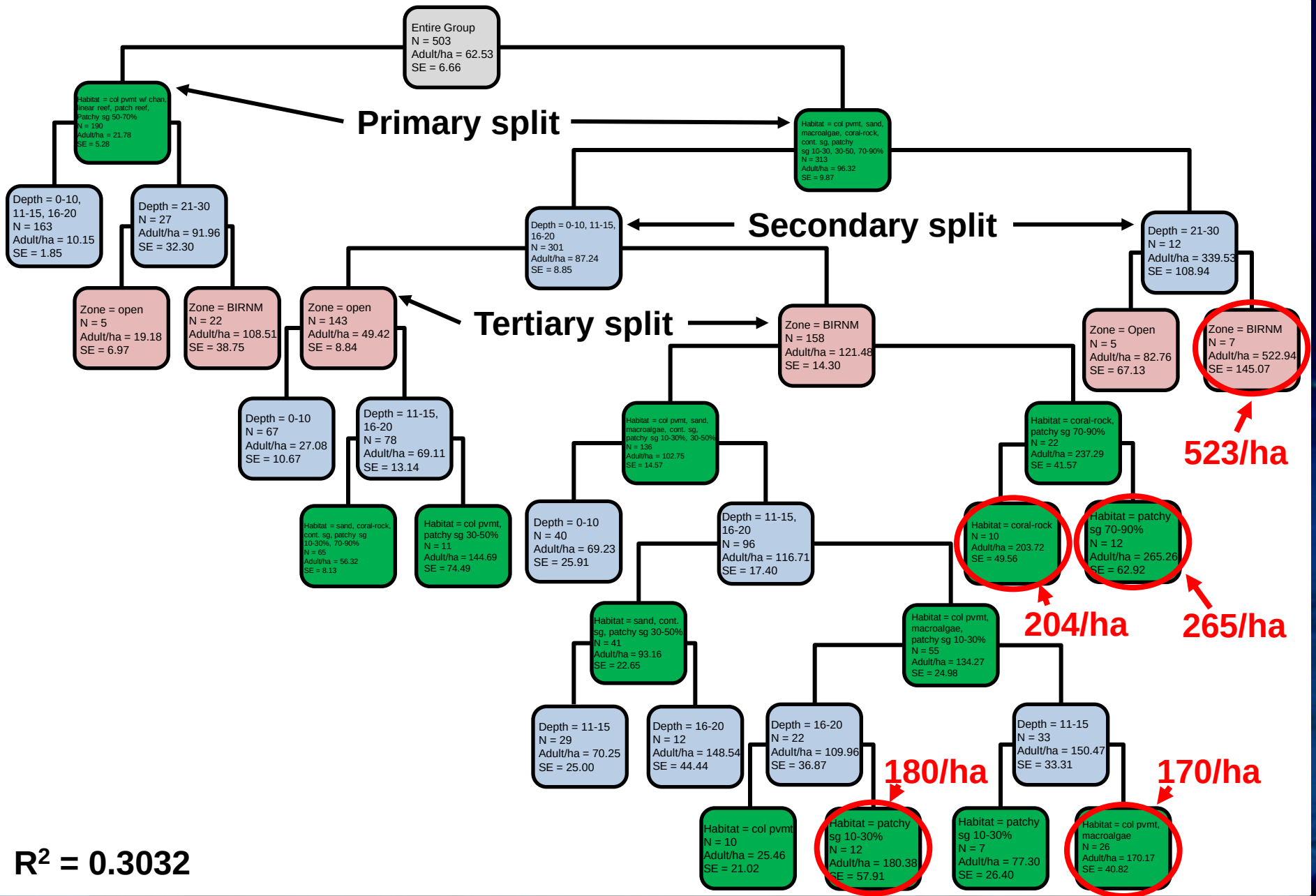


Juvenile Regression Tree




Patchy 70 – 90%
538/ha
0 – 10 m
16 – 20 m
179/ha
Open
248/ha
462
1542
2178
367
1882
694
Patchy 30 – 50%
Cont. seagrass
1068/ha
11 – 15 m
343/ha
BIRNM
224/ha

Adult Regression Tree



$R^2 = 0.3032$

Final Words

- Predictors differed in order of importance between juveniles and adults
- Mating and egg masses observed for 2.5% of adults
- Fill critical gaps in management needs:
  - SEDAR
  - NPS
  - CFMC
  - SEAMAP

Acknowledgements

- **Logistical support:**
  - **Paige Rothenberger and Jose Sanchez, Jr., East End Marine Park**
  - **Ian Lundgren and Zandy Hillis-Starr, U.S. National Park Service**

- **And many, many divers: Jennifer Atchison, Cody Bliss, James Brown, Katy Brown, Nick Corby, Dave Grenda, Harmony Hancock, Kevin Iglesias, Sara Jarossy, Chris LaPointe, Jenna Lueg, Lisa McManus, Jenna Soulliere, and Paige Switzer**

Prevalence and impact of coral disease in remote locations (PIs: A. Bruckner, R. Hill) and Recovery of reef fish assemblages at the Fortuna Reefer grounding site at Mona Island, Puerto Rico (PIs: R. Hill, A. Bruckner)

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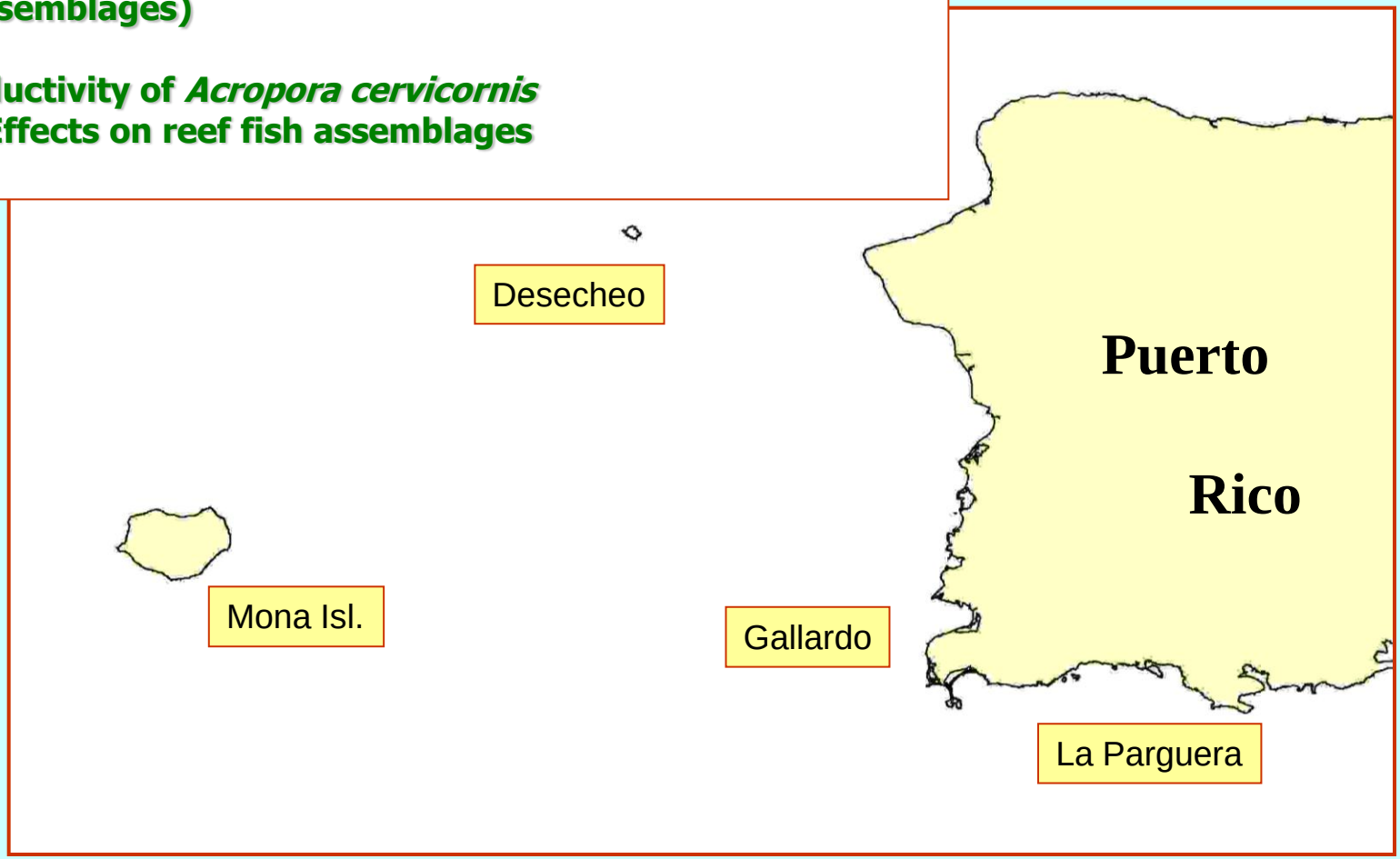
Coral Reef Conservation Program
Ecosystem Assessment Div.
Office of Habitat Conservation
NOAA Fisheries Silver Spring, MD

Ronald L. Hill, PhD
Coral Reef Conservation Program
Fishery Ecology Branch
Southeast Fisheries Science Center
NOAA Fisheries Galveston, TX

1. **Prevalence and impact of coral disease in remote locations**
   - **Effects on reef fish assemblages**

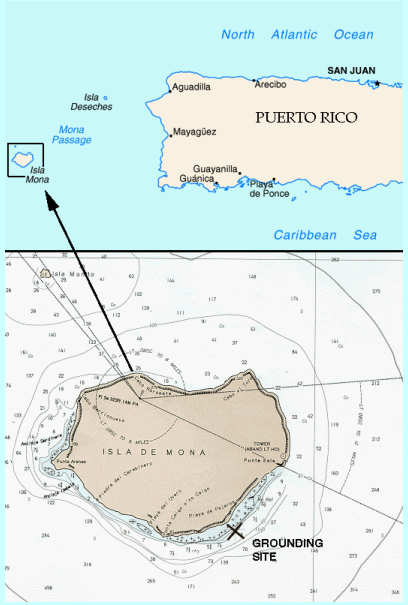
2. **Restoration Effectiveness – Fortuna Reefer**
   (Recovery of *Acropora palmata* community and reef fish assemblages)

3. **Productivity of *Acropora cervicornis***
   - **Effects on reef fish assemblages**



Long-term Monitoring Sites

M/V Fortuna Reefer Grounding



24 July 1997

326 foot freighter

Aground 8 days (*Acropora palmata* zone)

1° & 2° damage = 2.75 ha.

Loss of 3-D structure

Shattered massive coral head. (Coastal Planning & Engineering, Inc., Sept. 1997)

Elkhorn coral fragments. (Coastal Planning & Engineering, Inc., Sept. 1997)

Benthic Monitoring Approaches

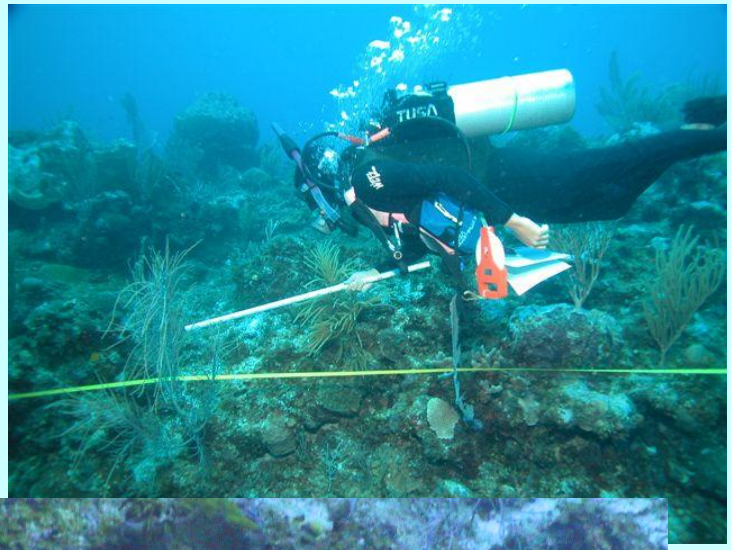
Fragment Survival and Growth

- Original mapped position
  - Survival, growth, fused, protobranches
  - Disease, predators, competitors

Belt Transect

- Line Intercept
- Point Intercept

Fish Monitoring Approaches

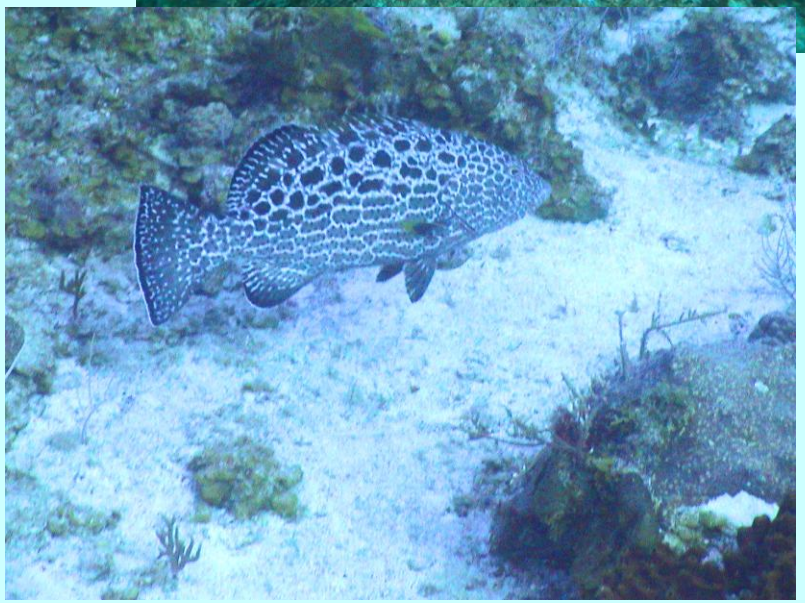


Belt Transects 30 x 2 m

- Modified AGRRA protocol
  - Fishery spp
  - Ecologically important spp
- Paired

Point Counts

- Bohnsack & Bannerot (Bortone mod.)
- Diurnal, non-cryptic species



Roving Diver Surveys

- 5 min. between other surveys
- Elusive species

Coral Demographics

Typical Project Results

Fig. 2. The fates of *A. palmata fragments* over 6 years. The white bars refer to the percent of the fragments that are still living, the black bars are those that died, and the shaded bars are fragments that were detached and removed.

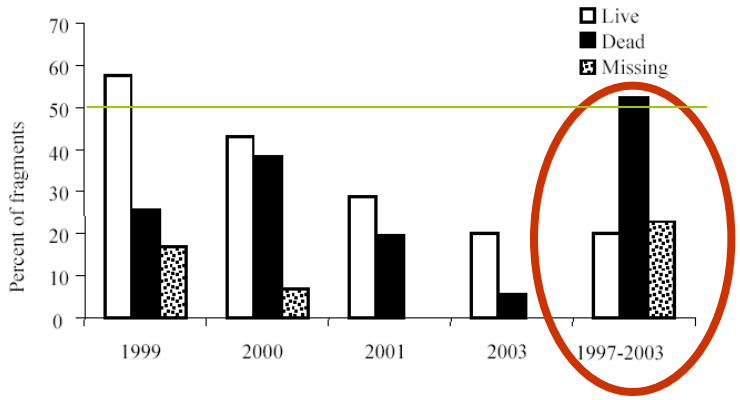
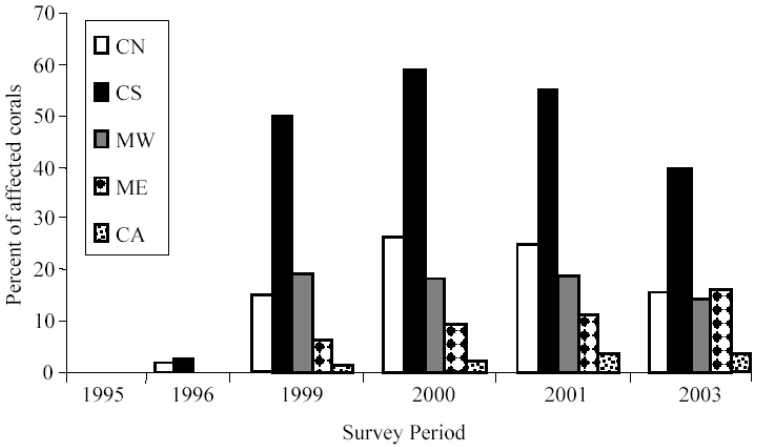
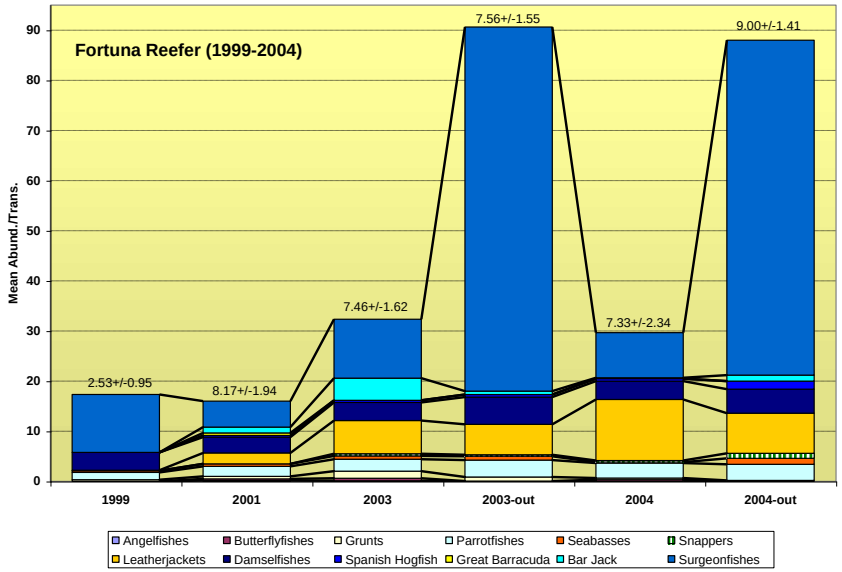
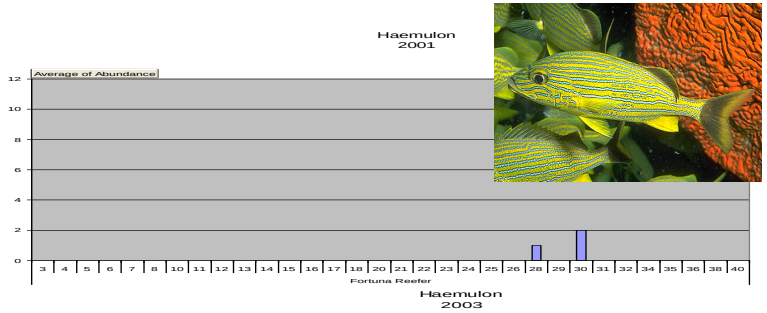
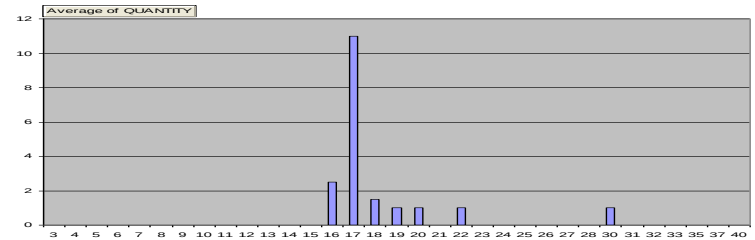


Fig 3 . Prevalence of YBD on five reefs off Mona Island Puerto Rico between 1995-2003. The percent of affected colonies refers only to *M. annularis* species complex.

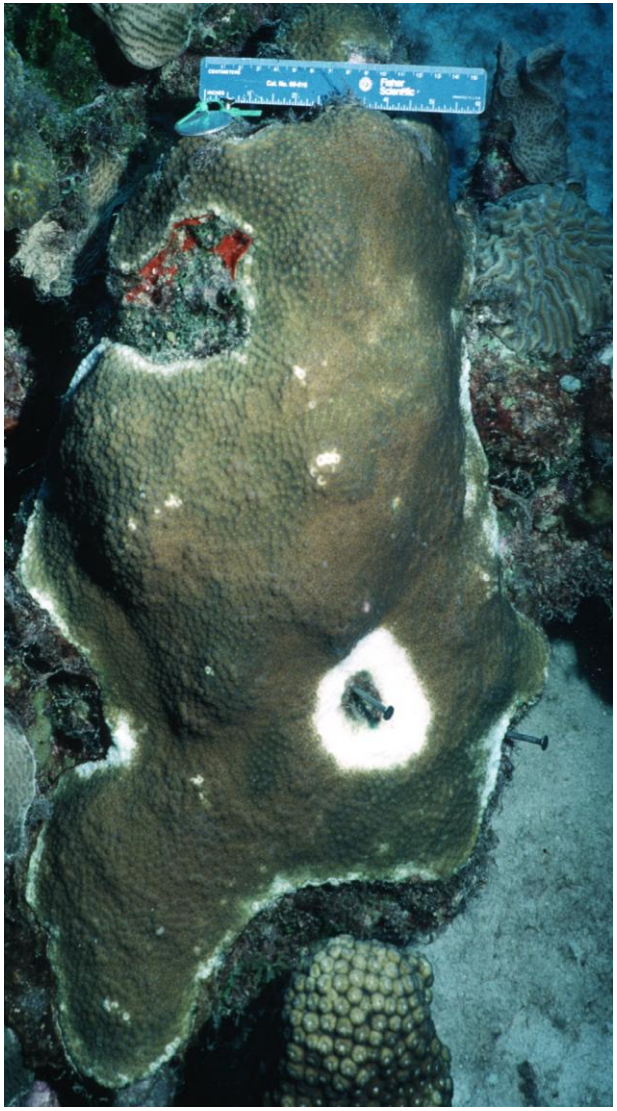




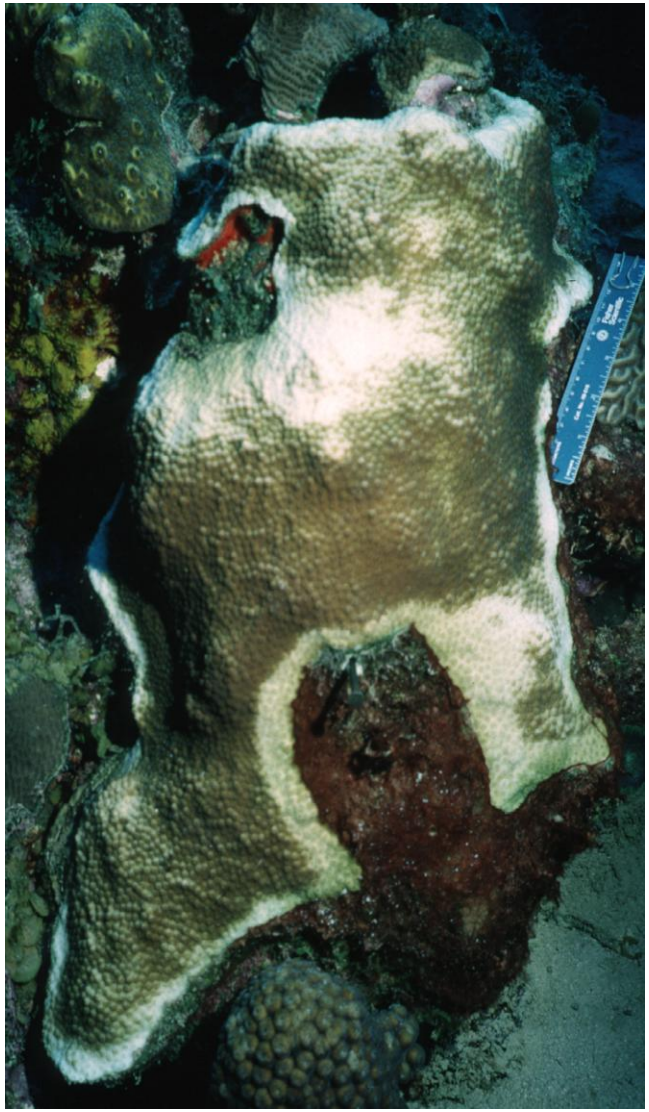




Impacts of disease (Ind. colonies)



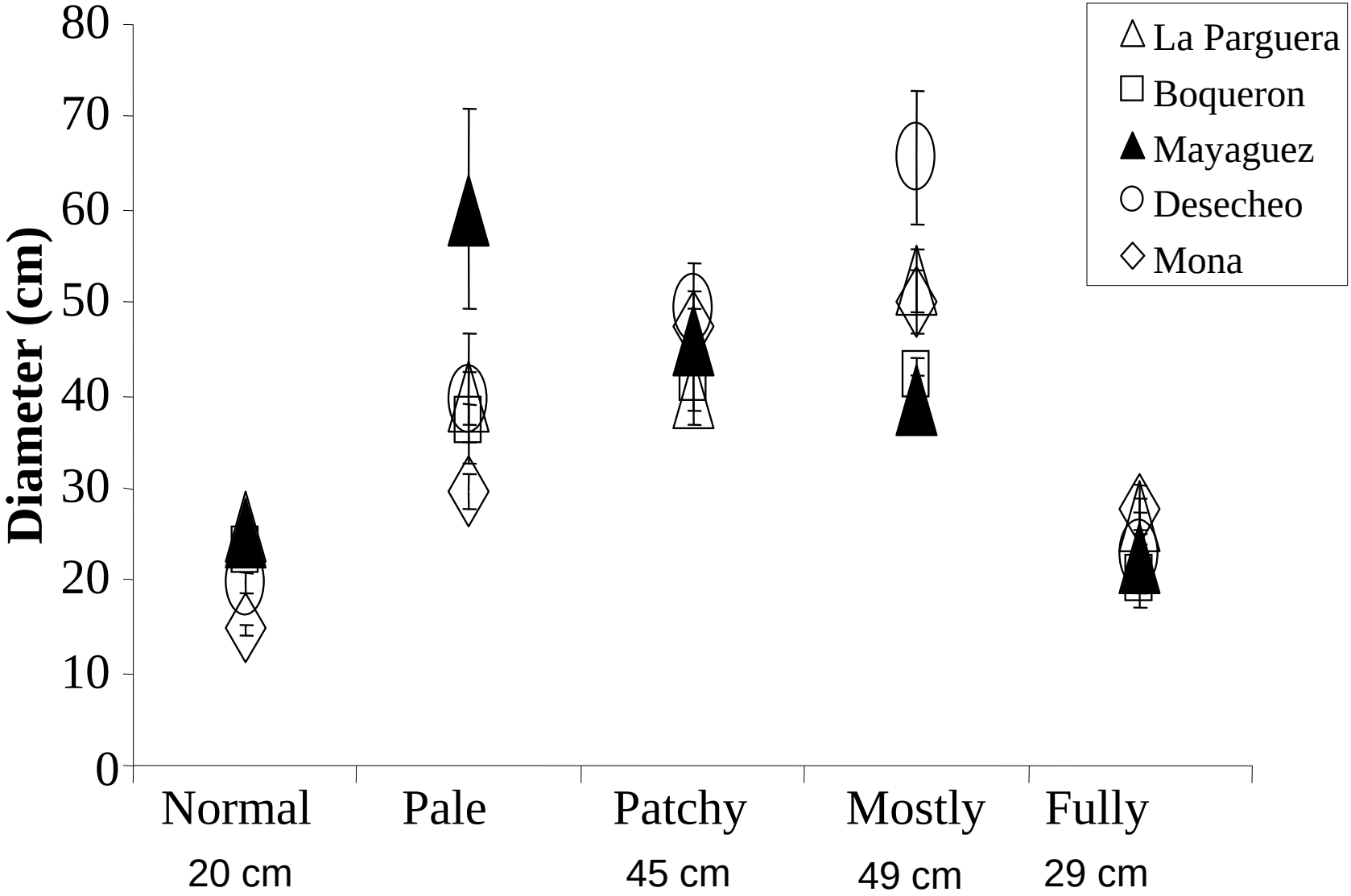
10/97



12/98

1/00

Mean colony size and severity of bleaching



Characterization of Bycatch from St. Thomas (USVI) Fisheries

Supported By NOAA Grant Numbers:

NA05NMF4540042 (to MRAGAmericas),
NA06NMF4330052,
NA10NMF4540101

MARFIN Study

Summary of Effort and Landings

Capture Method	# Trips	Total Gear units	Average (# units/ trip)	Lobster Landings	Fish Landings	Average (lbs/trip)
Fish Traps	767	63,524[a]	82.8	10,098	136,911	213.0
Lobster Traps	364	41,181[a]	113.1	47,299	7,288	133.6
Hand Line	410	827[b]	2.0	0	40,026	48.0
Seine Net	247	248[c]	1.0	0	60,314	244.2
Diving	8	16[b]	2.0	312	166	25.1
Rod & Reel	56	130[b]	2.3	0	3,480	26.8
Spear-fish	2	5[b]	2.5	20	0	10.0
Total	1854			57,749	248,917	

Effort Units

[a] Trap hauls; [b] Fisherman days; [c] Trips

Most Common Bycatch Species –
Fish Traps (73 Species)

TAXA	NUMBER	%
OSTRACIIDAE (Boxfishes)	39,512	37.7%
Acanthurus coeruleus (blue tang)	16,597	15.8%
Lutjanus apodus (schoolmaster)	10,847	10.4%
Acanthurus chirurgus/bahianus (doctor/surgeonfish)	8,178	7.8%
Panulirus argus (spiny lobster)	4,675	4.5%
Diodon holacanthus (balloonfish)	4,079	3.9%
Balistes vetula (queen triggerfish)	3,689	3.5%
Chaetodon striatus (striped butterflyfish)	3,567	3.4%
Calamus pennatula (porgy)	3,061	2.9%
Scorpaena plumieri (spotted scorpionfish)	2,328	2.2%
Caranx ruber (bar jack)	1,686	1.6%

Improving trap designs to reduce bycatch mortality of reef herbivores

NOAA Coral Reef Conservation Program

Project ID: 20607 - 2010

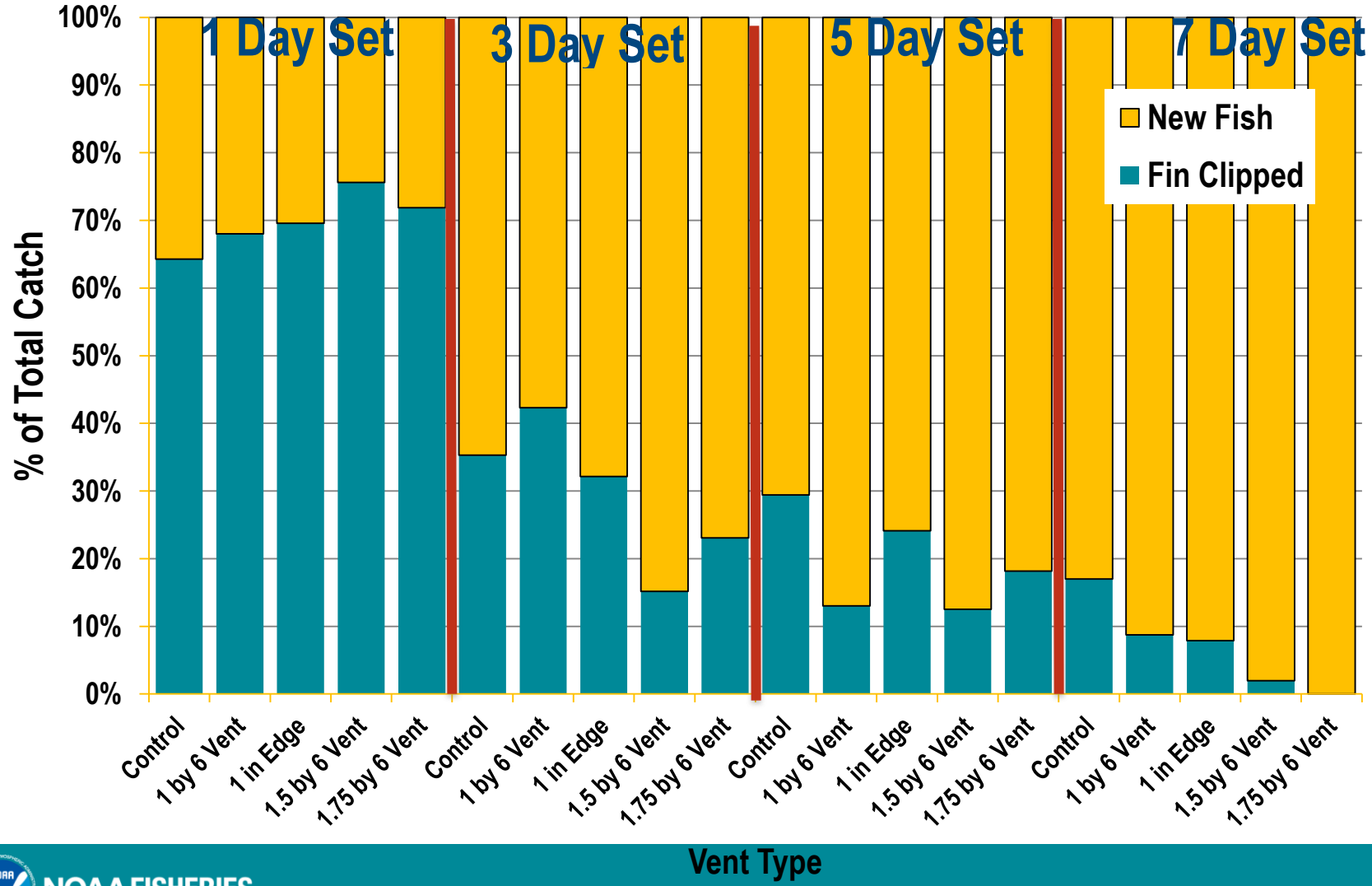
in collaboration with

Engineering Bycatch Reduction in West Indian Fish Traps: STFA CRP Trap Vent Study

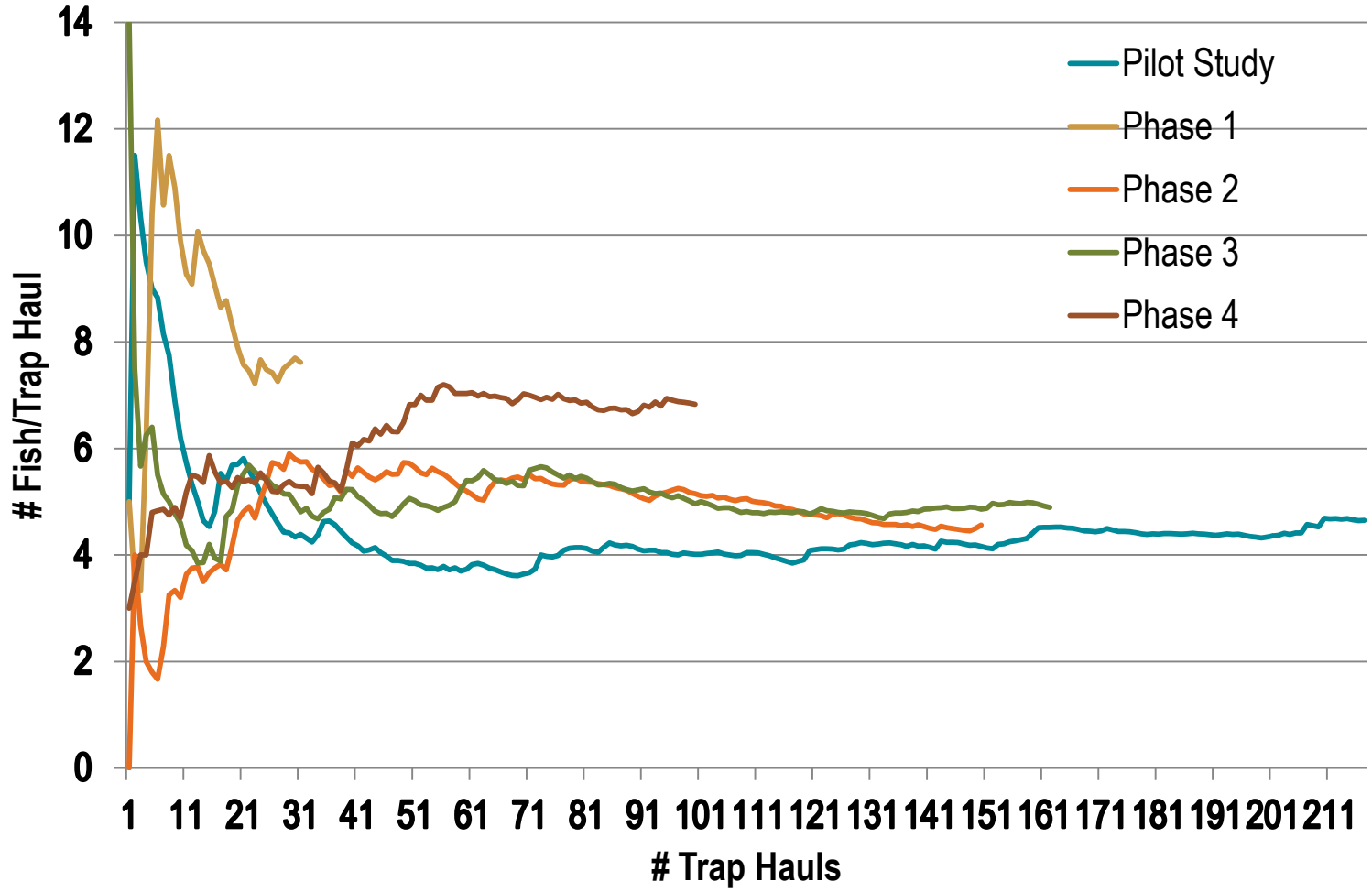
Cooperative Research Program

Project No. NMF4540101

Retention of Fin Clipped Fish in Trap Hauls



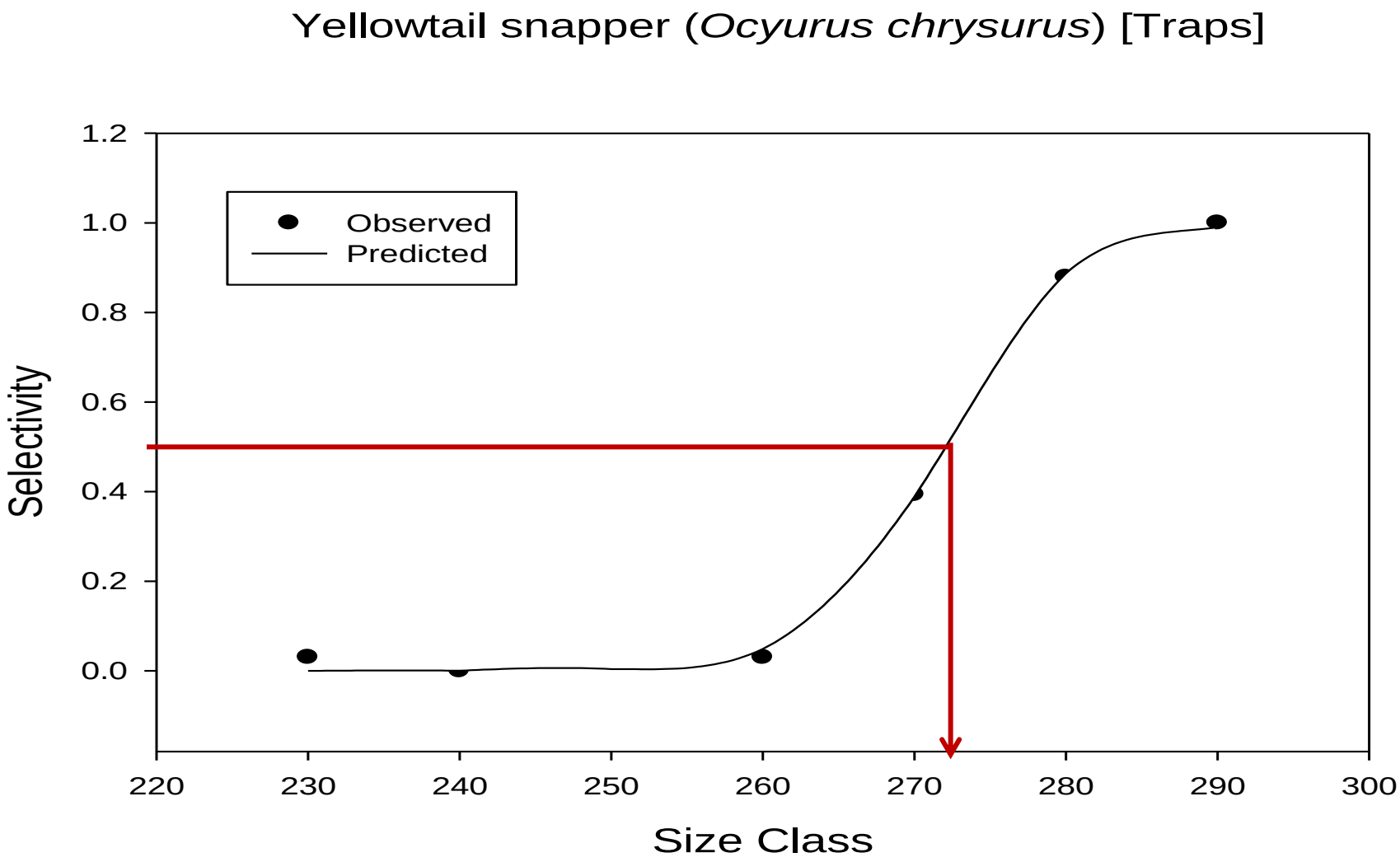
Cumulative Average # Fish/Trap Haul (Control Traps)



Field Testing Summary Results: General

- Average Catch/Trap Haul does not stabilize until > 40 trap hauls.
- No difference between rectangular and arrowhead traps
- Catch/trap haul not correlated with set length or temperature.
- Lunar effects (catches greater and fewer empty traps around full moon).
- Seasonal peaks for most species.
- Lionfish from 0 to 19th most common species at end of study.

Selectivity Analysis: Fish Traps



Life History: Reproduction Effects

Sample Size	Species	Measure-ment	L first reproduction Female	L first reproduction Male (mm)	Min Catch (mm)	MidPoint Overlap Min Catch and Max Bycatch (mm)	% Above L first repro-duction	Average Size Retained as Catch	Size at 50% Recruitment to Fishing Gear	Size at Full Recruit-ment
57	Pomacanthus paru	TL	226	268	192	202	37%	271.2	164.5	250-280
417	Pomacanthus arcuatus	TL	220	240	184	193	62%	256.5	159.4	200
135	Holacanthus ciliaris	TL			170	242		266.6	209.4	260
2120	Acanthurus coeruleus	FL	130	110	173	221	100%	244.1	159.5	200
262	Chaetodon striatus	TL			133		100%		120.4	130
168	Epinephelus fulvus	TL	160		220			281.4	265.6	280
674	Lactophrys poligonius	TL			165	223		267.0	185.3	220
1356	Lactophrys quadricornus	TL	170	160	162	211	100%	258.0	184.0	210
843	Acanthurus chirurgus	FL	170	140	210	213	100%	244.6	208.6	240
535	Haemulon sciurus	FL	170-200	140	210		100%	280.9	250.7	290
27	Haemulon carbonarium	FL			224			264.9		
28	Haemulon flavolineatum	FL	160		204		100%	267.4		
1020	Haemulon plumieri	FL	130-150	153	216		100%	274.5	244.9.5	270

Life History Reproduction Effects (cont)

Sample Size	Species	Measure-ment	L first reproduction Female	L first reproduction Male (mm)	Min Catch (mm)	MidPoint Overlap Min Catch and Max By catch (mm)	% Above L first repro-duction	Average Size Retained as Catch	Size at 50% Recruitment to Fishing Gear	Size at Full Recruitment
1078	Epinephelus guttatus	TL	250		214	221	94%	321.4	279.4	300
110	Pterois volitans	TL							256.1	310
296	Sparisoma chrysopterum	FL			240			303.5	278.2	310
414	Sparisoma viride	FL	180	160-200	222		100%	312.9	259.9	320
564	Calamus calamus	FL			200			266.7	217.3	250
513	Lutjanus apodus	FL	250		225				272.6	290
25	Lutjanus buccanella	FL	230-260	250-270	252	56	28%	284.6	276.5	
204	Lutjanus synagris	FL	180-235	150-214	248		100%	290.4	278.1	270
54	Lutjanus analis	FL	410	380	300		58%	411.5	259.3	
	Ocyurus chrysurus	FL	224	188						
1337	Panulirus argus	CL			89				81.7	100
885	Holocentrus rufus	FL	135		208		100%	281.0	273	230
1610	Balistes vetula	TL	235	265	223	236	96%	384.3	218.5	280
953	Lactrophry triqueter	TL			258				131.6	180
264	Lactrophrys bicaudalis	TL			200	219		275.6	150.9	200

Species Mortality Values

Species	#	L_{max} TL (in mm)	Information from FISHBASE				Current Analysis
			L_∞	k	t_0	Location	Total Z
Epinephelus cruentatus	168	388	340	0.23	-5.3	USVI	**1.025**
Lutjanus synagris	204	385	450	0.23		Puerto Rico	**0.956**
Sparisoma chrysopterum	296	385	418	0.78		BVI	**1.988**
Sparisoma viridae	420	402	290	0.96		USVI	**0.567**
Lutjanus apodus	563	605	349	0.35		USVI	**0.351**
Haemulon sciurus	315	337	371	0.3		Puerto Rico	**0.543**
Acanthurus chirurgus	843	318	332	0.13		USVI	**0.517**
Haemulon plumieri	879	388	420	0.26		Puerto Rico	**2.727**
Epinephelus guttatus	1,356	485	568	0.12		St. John	**1.037**
Balistes vetula	1,483	649	600	0.23		USVI	**0.966**
Acanthurus coerulus	2,116	414	369	0.11		USVI	**0.374**
Ocyurus chrusurus (Handline)	1,874	630	502	0.139	-0.96	Puerto Rico	**0.120**
Ocyurus chrusurus (Traps)	230	630	502	0.139	-0.96	Puerto Rico	**0.093**
Panulirus argus	1,337	180	152	0.432	-0.11	St. John	**0.472**

Impact of Selected Vents

	Control		1 ⅜ Vents		Comparison				
Species	Count	Avg. TL	Count	Avg. TL	Control CPUE	Vent CPUE	Reduction	% Reduction Control CPUE	% Control TL
Acanthurus coeruleus	311	192.77	75	200.09	0.755	0.182	0.573	81%	103.8%
Acanthurus chirurgus	135	232.47	92	239.15	0.328	0.223	0.104	45%	102.9%
Balistes vetula	295	368.42	258	380.39	0.716	0.626	0.090	30%	103.3%
Calamus calamus	62	266.82	25	279.08	0.150	0.061	0.090	68%	104.6%
Pomacanthus arcuatus	43	225.26	33	262.91	0.104	0.080	0.024	38%	116.7%
Holacanthus ciliaris	15	234.27	2	205.00	0.036	0.005	0.032	89%	87.5%
Holacanthus tricolor	22	185.50	8	186.29	0.053	0.019	0.034	71%	100.4%
Chaetodon striatus	27	124.33	9	125.78	0.066	0.022	0.044	73%	101.2%
Sparisoma chrysopterum	55	304.36	32	307.63	0.133	0.078	0.056	53%	101.1%
Sparisoma viride	55	308.89	55	324.64	0.133	0.133	0.000	20%	105.1%
Lutjanus apodus	59	319.00	39	321.64	0.143	0.095	0.049	47%	100.8%
Holocentrus rufus	135	283.16	135	285.23	0.328	0.328	0.000	20%	100.7%
Lutjanus synagris	19	285.95	17	287.53	0.046	0.041	0.005	28%	100.6%
Lutjanus buccanella	17	283.71	3	311.33	0.041	0.007	0.034	86%	109.7%
Ocyurus chrysurus	13	347.69	28	364.39	0.032	0.068	-0.036	-73%	104.8%
Haemulon plumieri	109	278.40	106	280.00	0.265	0.257	0.007	22%	100.6%
Haemulon sciurus	55	285.18	69	284.10	0.133	0.167	-0.034	-1%	99.6%
Epinephelus fulvus	25	284.56	32	278.25	0.061	0.078	-0.017	-3%	97.8%
Epinephelus guttatus	148	321.09	169	324.96	0.359	0.410	-0.051	8%	101.2%
Pterois volitans	22	267.82	25	282.36	0.053	0.061	-0.007	9%	105.4%
Haemulon melanurum	17	271.00	4	259.25	0.041	0.010	0.032	81%	95.7%
Lactophrys quadricornis	197	224.89	273	217.19	0.478	0.663	-0.184	-12%	96.6%
Lactophrys triqueter	126	168.40	184	168.82	0.306	0.447	-0.141	-18%	100.3%
Lactophrys bicaudalis	24	212.79	31	207.39	0.058	0.075	-0.017	-4%	97.5%
Lactophrys poligonius	74	237.45	127	232.70	0.180	0.308	-0.129	-38%	98.0%

Impacts of 1 ⅜ Vents on Selected Species

Species	L first reproduction Female	L first reproduction Male	Size at 50% Recruitment to Gear	L Min Catch	% Above L first reproduction	% Reduction from Control CPUE	% Increase in TL
Acanthurus coeruleus	130	110	159.5	173	100%	81%	4%
Acanthurus chirurgus	170	140	208.6	210	100%	45%	3%
Sparisoma chrysopterum			278.2	240		53%	1%
Sparisoma viride	180	160-200	259.9	222	100%	20%	5%
Pomacanthus arcuatus	220	240	159.4	184	62%	38%	17%
Holacanthus ciliaris			209.4	170		89%	1%
Chaetodon striatus			120.4	133		73%	1%
Calamus calamus			217.3	200		68%	5%
Balistes vetula	235	265	218.5.4	223	96%	30%	3%