Evaluating the Efficiency of a Marine Protected Area Network in Hawai`i: Ecological, Economic and Social Dimensions



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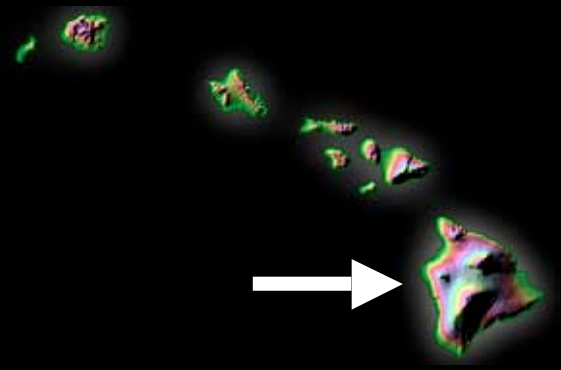
MPA Efficiency

- Multiple dimensions
- Ecological:
  - Replenish species; restore biodiversity
- Economic:
  - Promote sustainable resources
- Social & Political:
  - Reduce stakeholder conflicts

MPA Network in Hawai`i

- Conflict over shared resources
- Ecological:
  - Replenish depleted aquarium fish
- Economic:
  - Sustain local fishery & dive industry
- Social & Political:
  - Community-based management



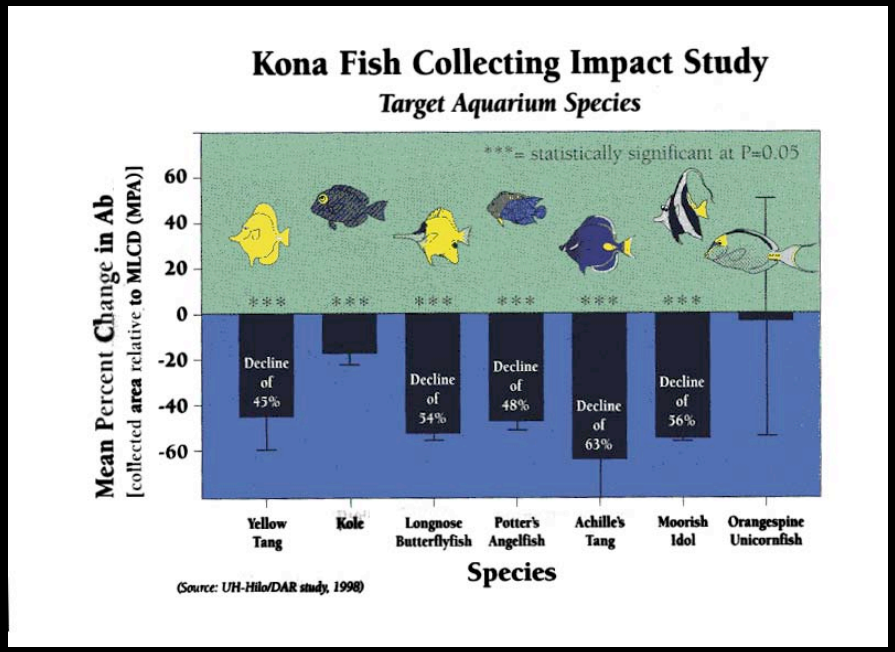
Aquarium Fish Collecting in Hawai`i

- Small, lucrative industry
- Rapidly growing
- Largely unregulated
- Long, contentious conflict:
  - Tour boat operators
  - Conservationists
  - Native Hawaiians

Barrier Net Collecting in West Hawai'i

Aquarium Fishery Research

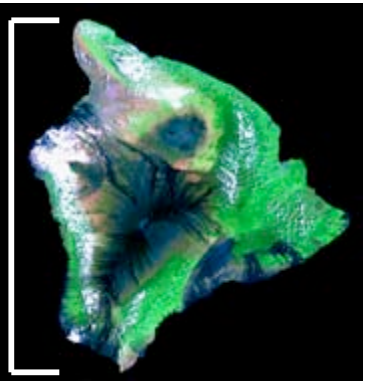
- Study on effects
- Results to the public & Legislature



Tissot & Hallacher, 2003, Conservation Biology, 17(6): 1759-1768

Act 306 (1998)

West Hawai'i Regional Fisheries Management Area



1. Designate ≥ 30% of coastal waters as Fish Replenishment Areas (FRAs) where aquarium fish collecting is prohibited
2. Substantive involvement of the community in resource management decisions
3. Evaluate effectiveness after 5 years

West Hawai'i Fisheries Council

Composition:

- Sport divers
- Fisherman
- Aquarium collectors
- Regional representation
- Native Hawaiians

Major goals:

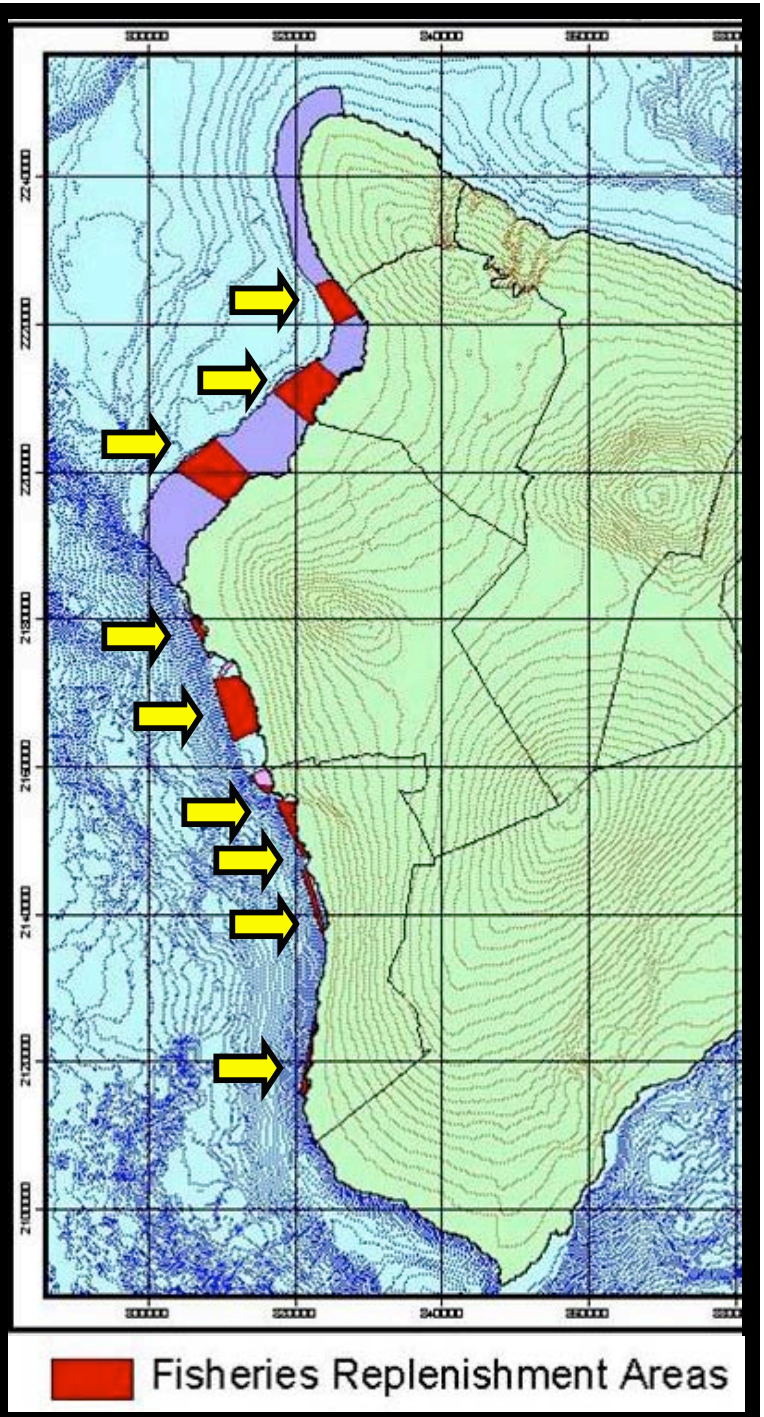
1) Establish MPAs
2) Separate conflicts

Fishery Replenishment Areas (FRAs)

Prohibit aquarium fish collecting_
Closed Dec. 31, 1999

1. North Kohala (20 km^2)
2. Puako (51)
3. Ka`upulehu (45)
4. Honokohau (3.8)
5. Kailua-Kona (41)
6. Red Hill (2.5)
7. Honaunau (15)
8. Ho`okena (5.8)
9. Miloli`i (3.9)

35% of West Hawai'i coast (0-200 m)



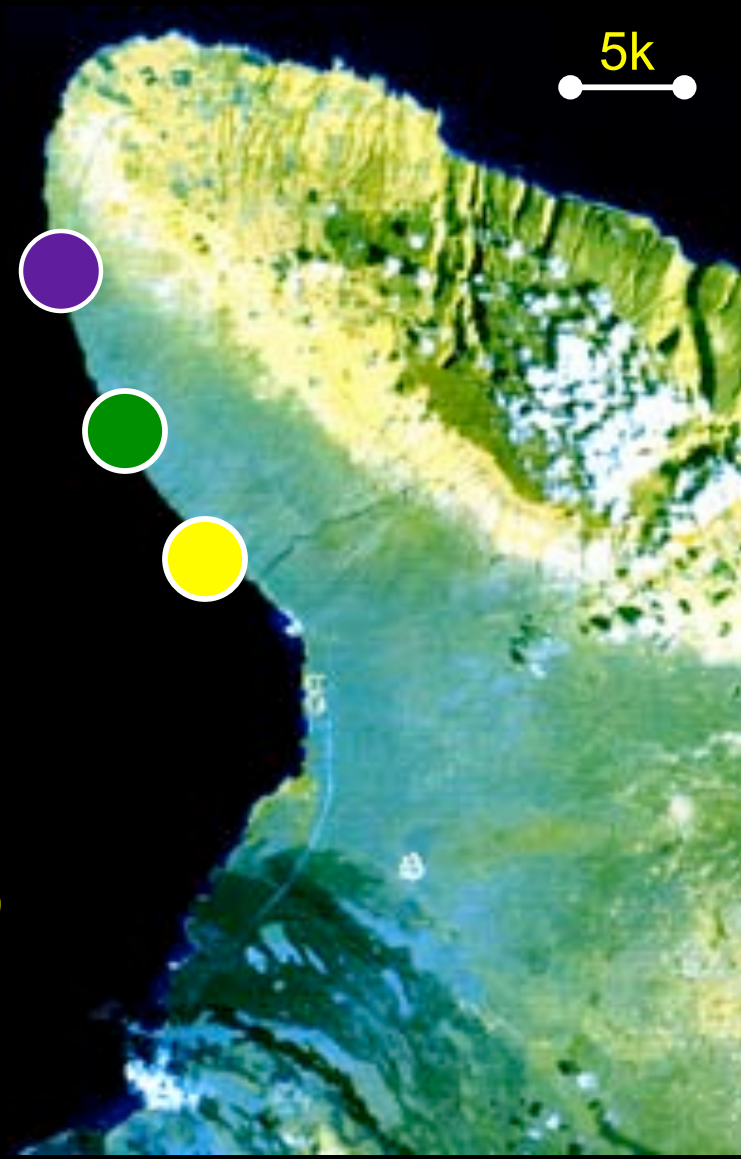
Overview of Monitoring Program

1. Six years: 1 year baseline, 5-years closure
2. Funded by NOAA–NOS through *Hawai`i Coral Reef Initiative Research Program*
3. Mandate through Act 306
4. Cooperative research program

Design of Monitoring Program

Observational design block

- Control - collecting
- Open + collecting
- FRA + collecting - collecting



Repeated measure BACI design:

- Among treatments (C-FRA, C-O)
- Before vs. After
- Among locations

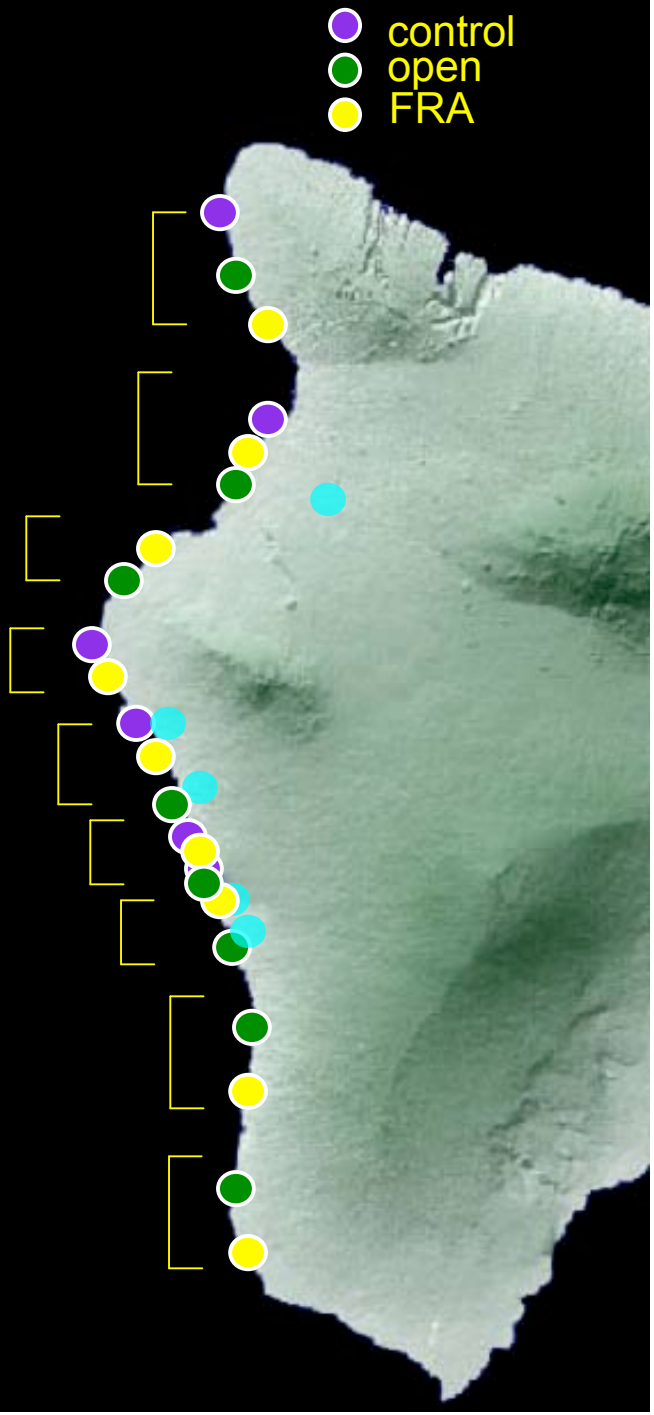
Monitoring Program

23 study sites - established pre-FRA (1999)

- Bimonthly surveys for fish
- Every 5 years for corals & habitat

Fish categorized into life stages:

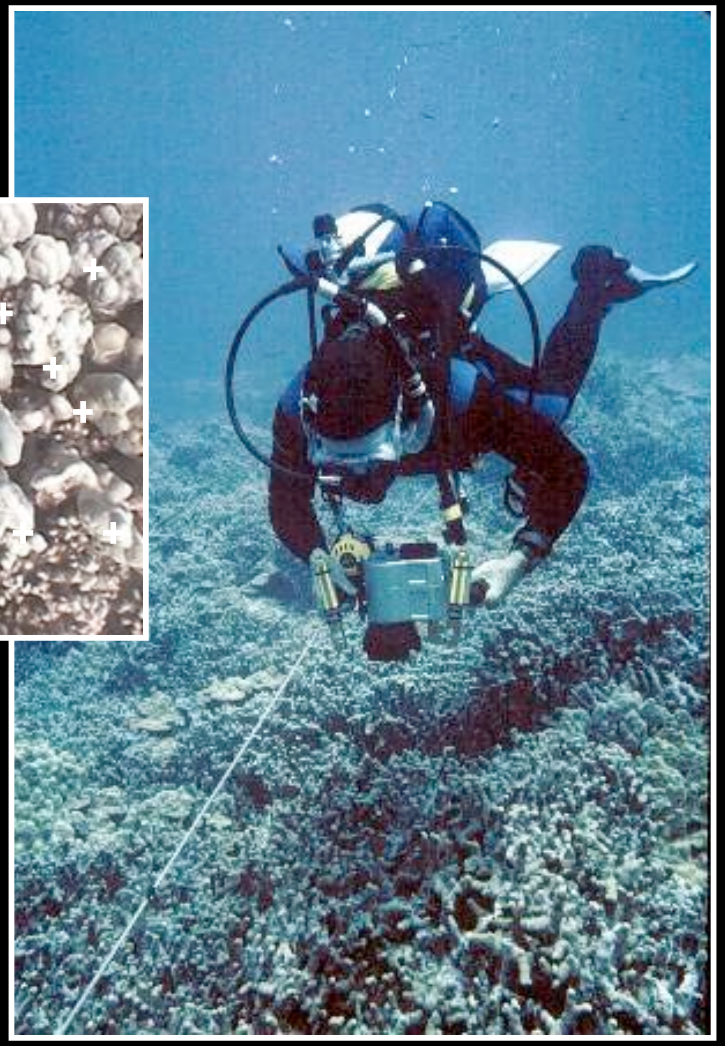
Adult Juvenile Recruit



Fish monitoring

- Four 25m transects
- Visual transect search
- Separated by life stages
- Control, FRA, Open block
  - Same day
  - Same divers

Coral-habitat monitoring

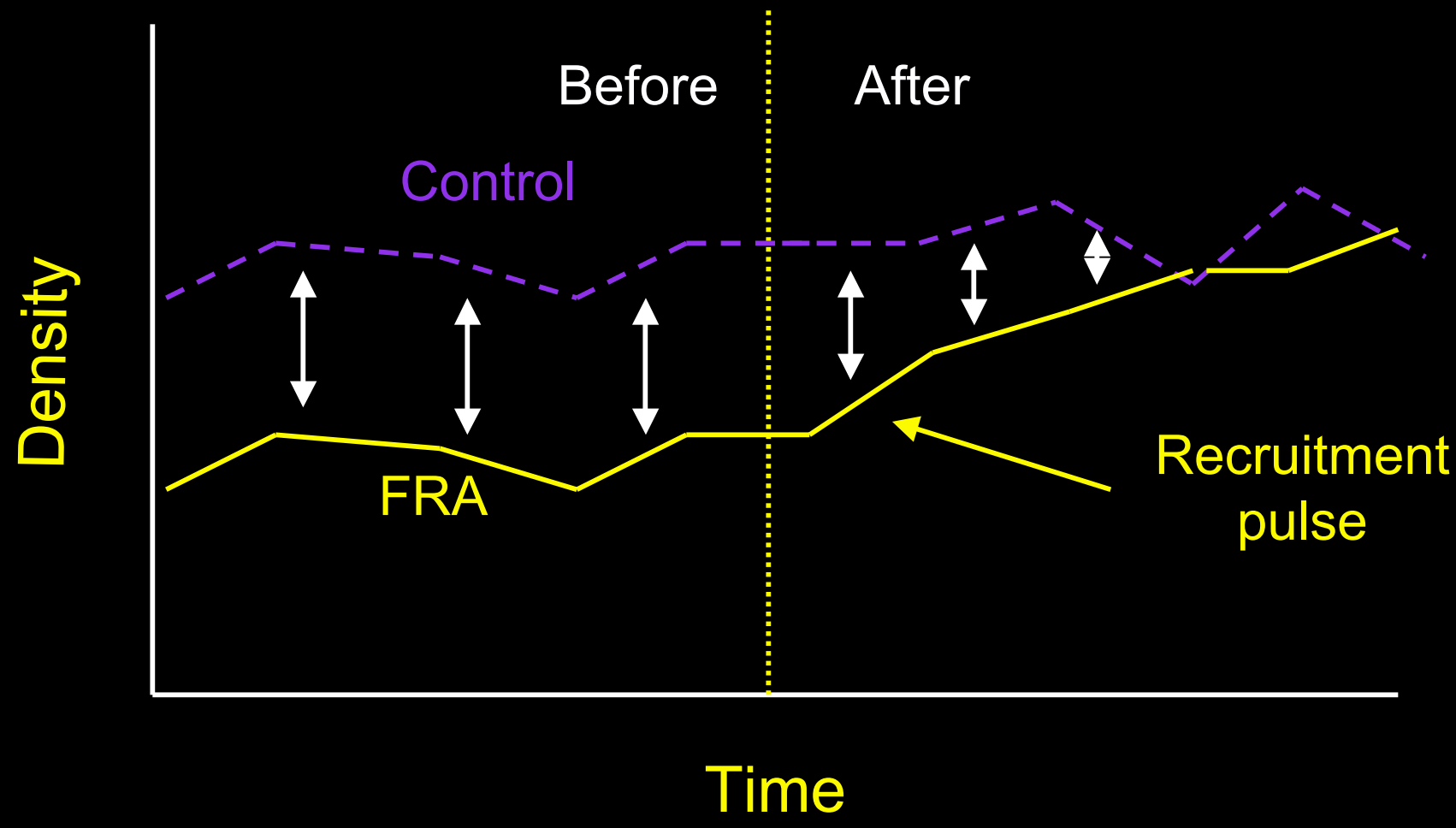


Digital video camera w/ lasers

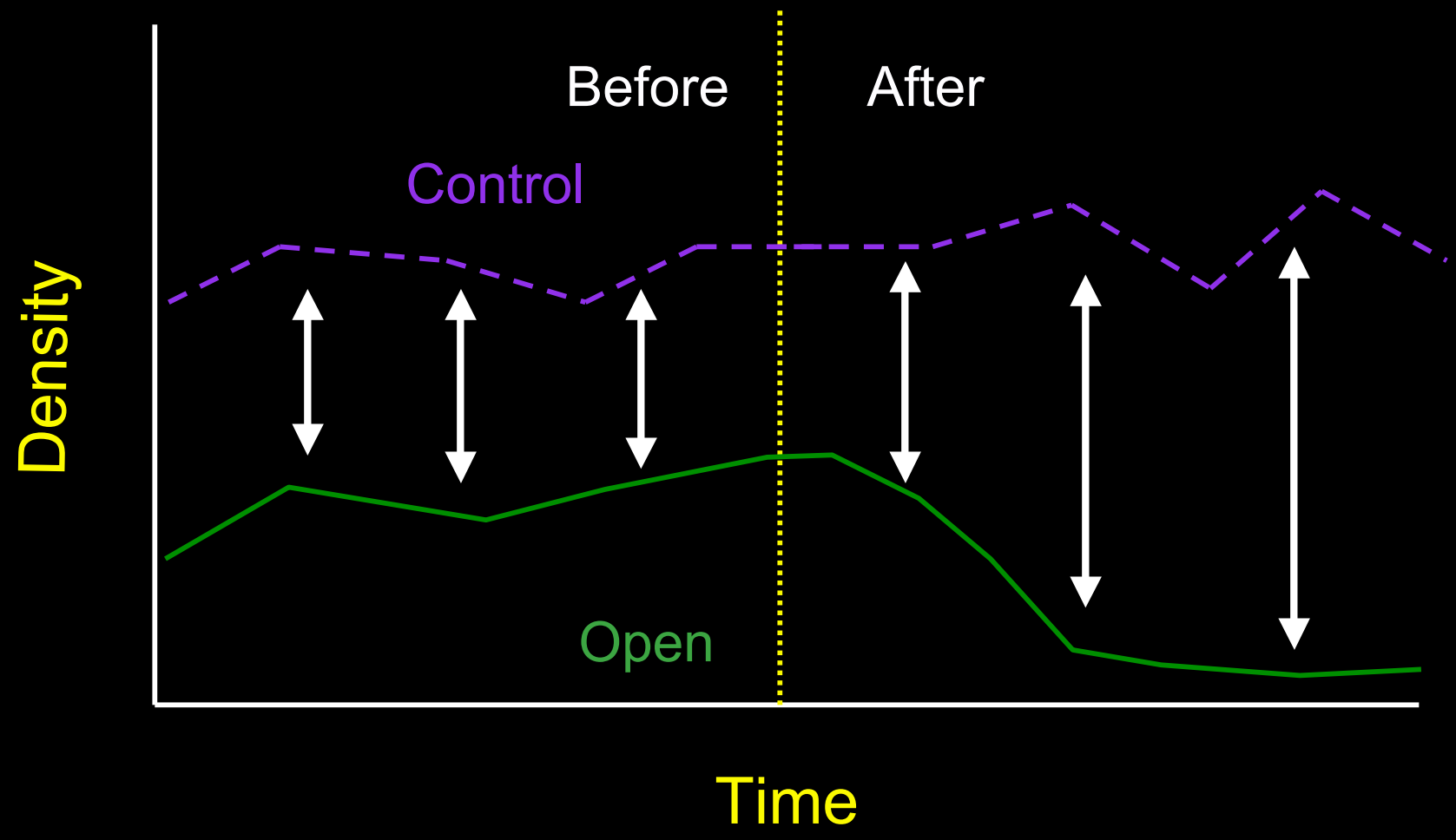
Conduct video transects

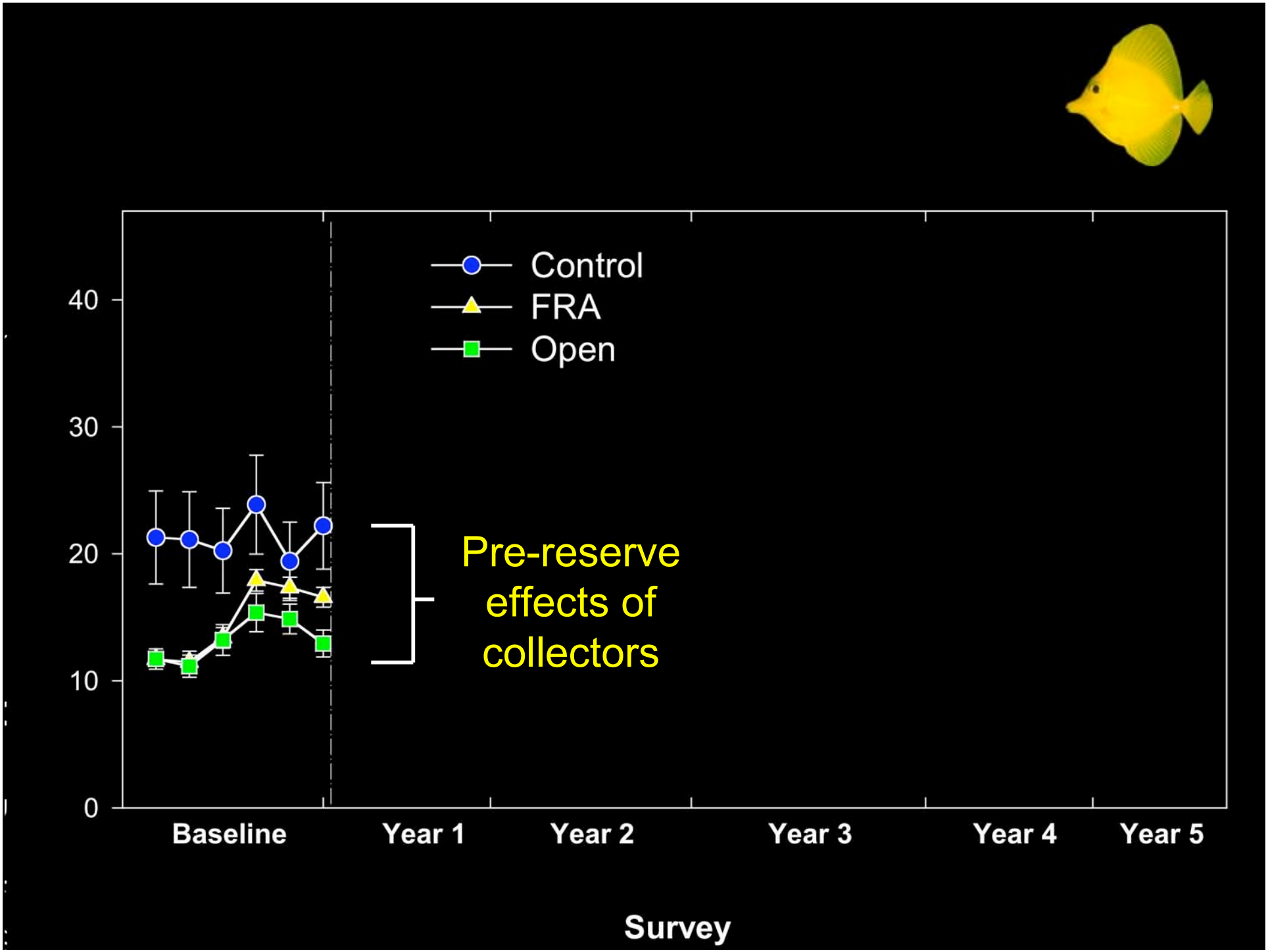
Analyze frames w/ *PointCount*

BACI: Before-After Control-Impact Comparison Procedure



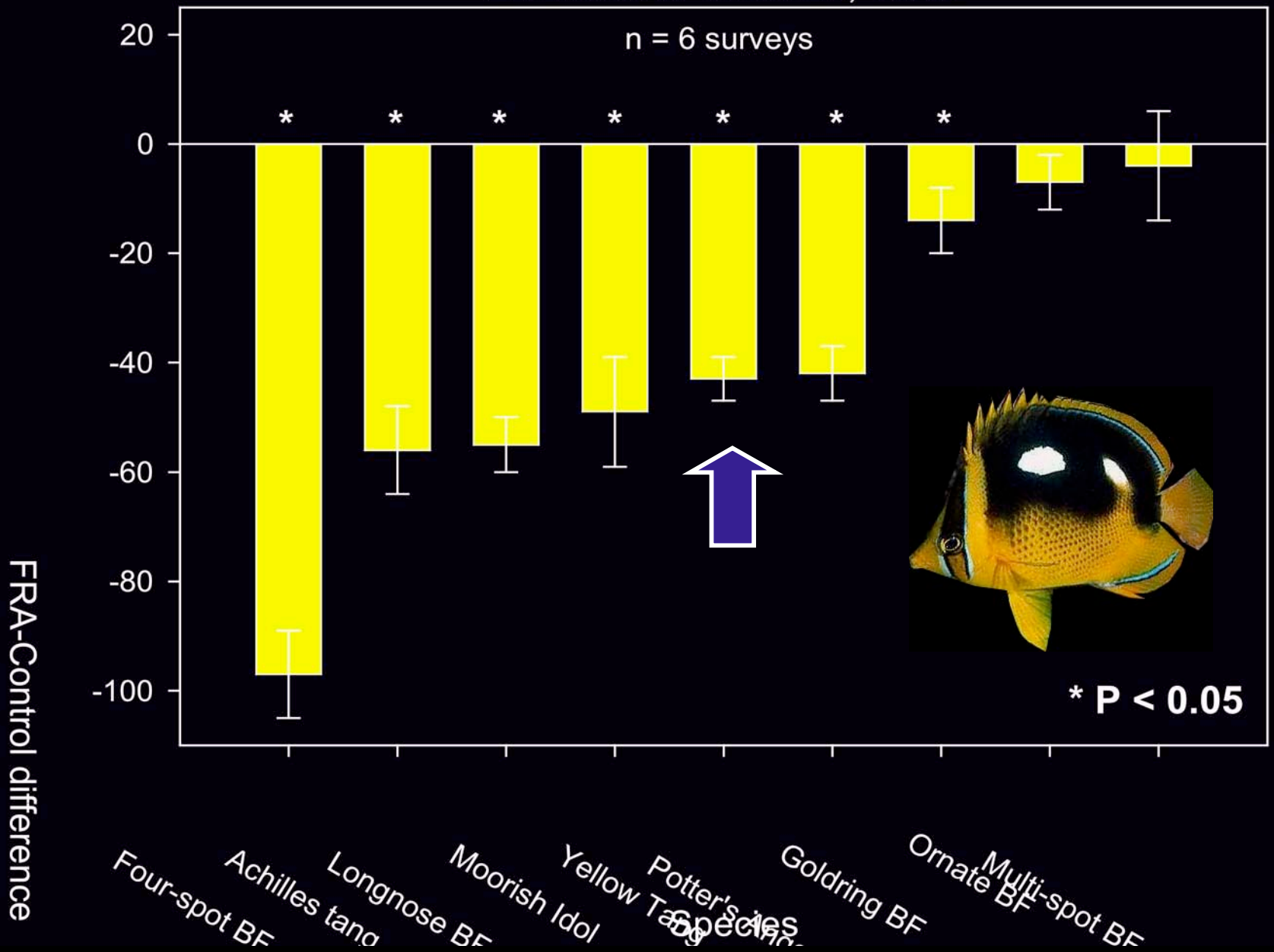
BACI: Before-After Control-Impact Comparison Procedure

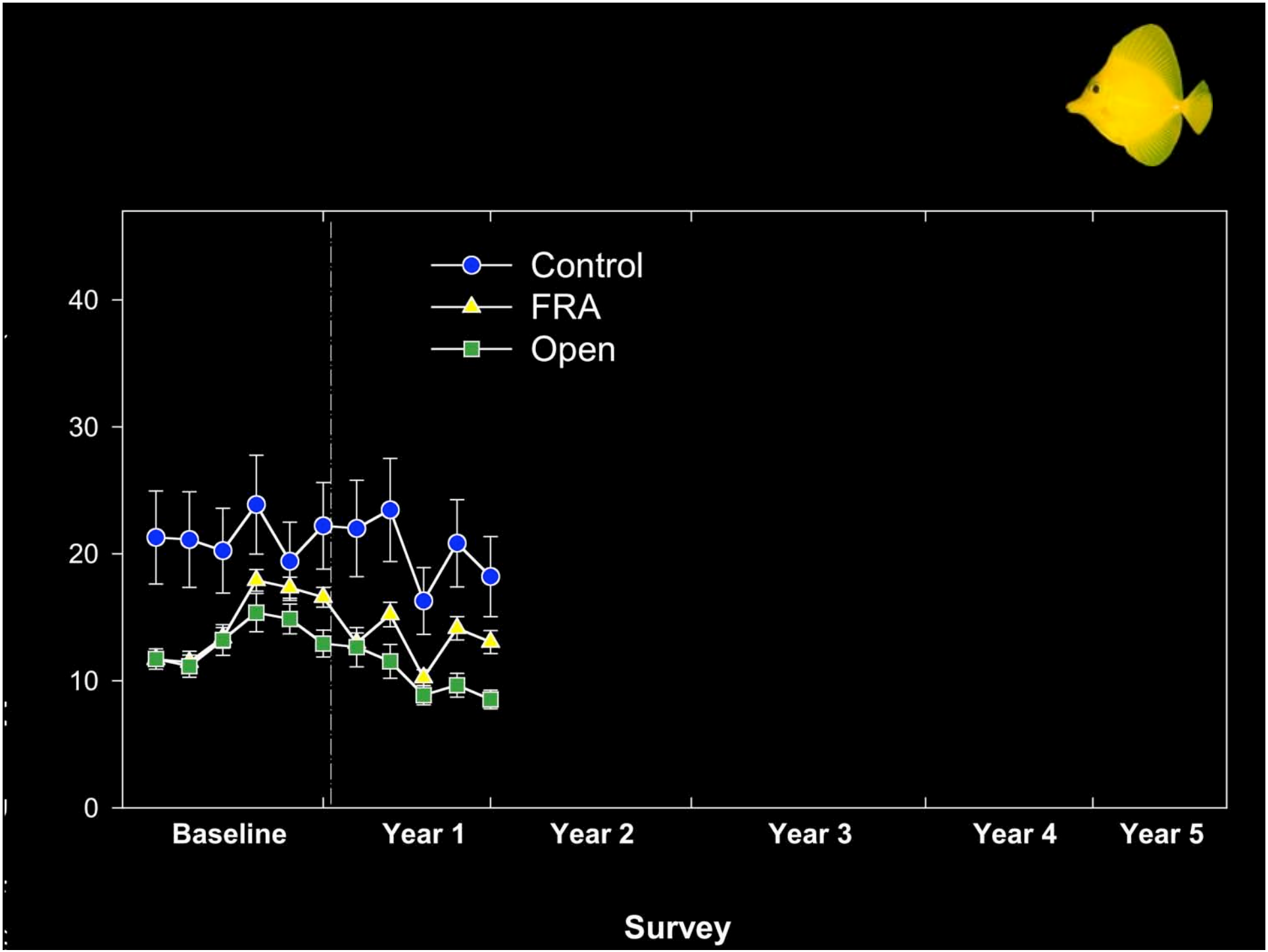


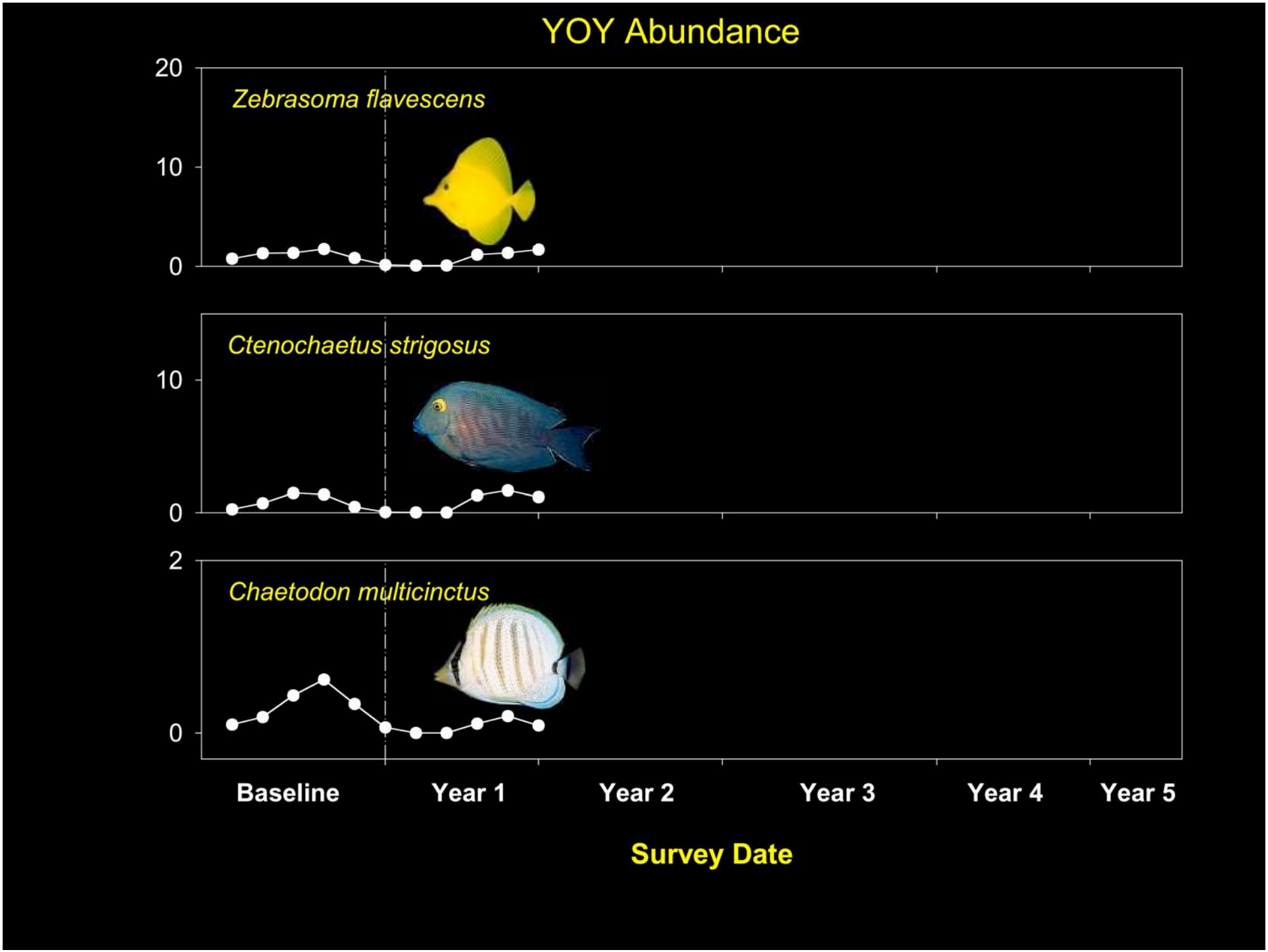

Control
FRA
Open
40
30
20
10
0
Pre-reserve
effects of
collectors
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey

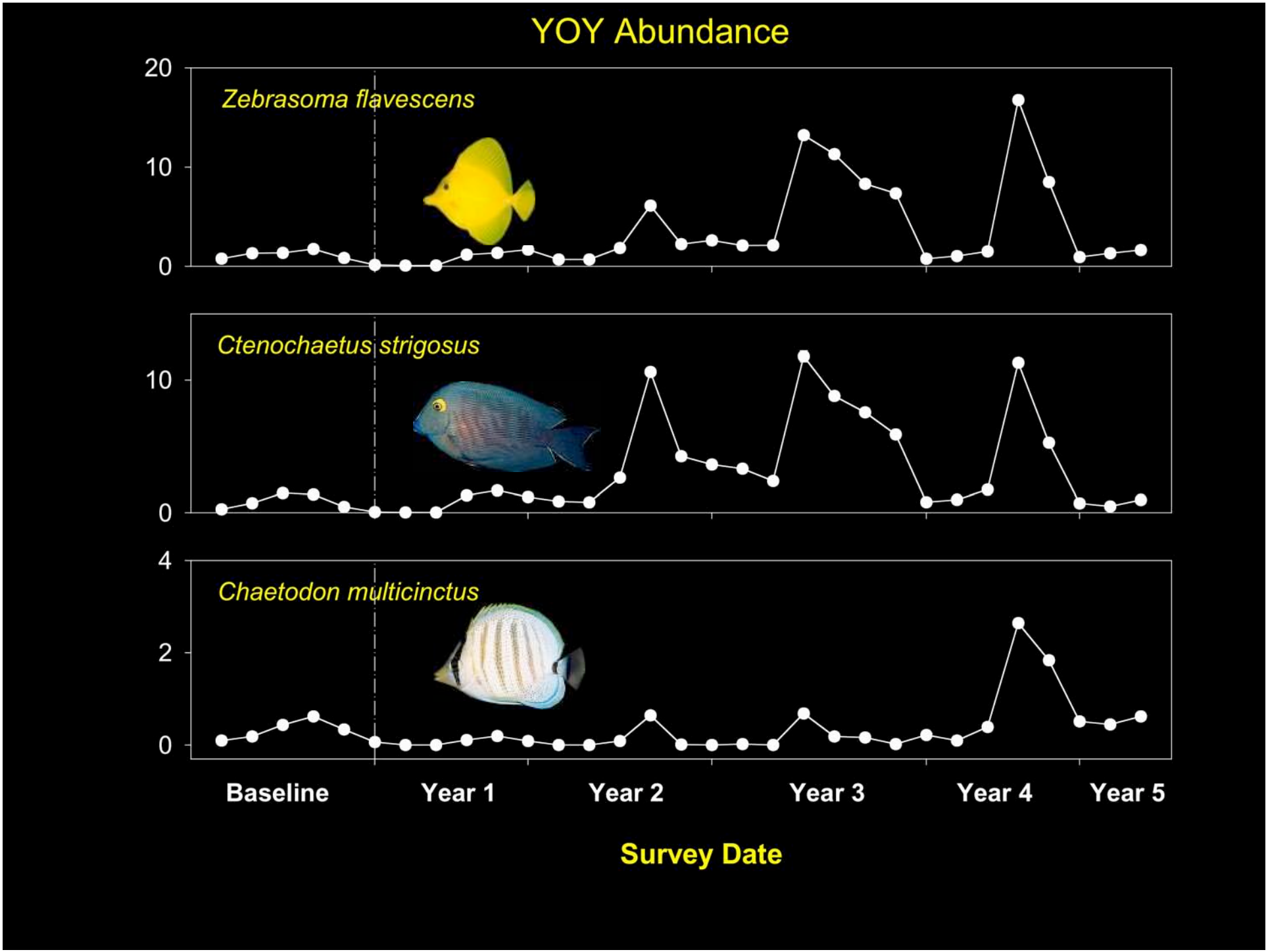
Effects of Aquarium Collectors

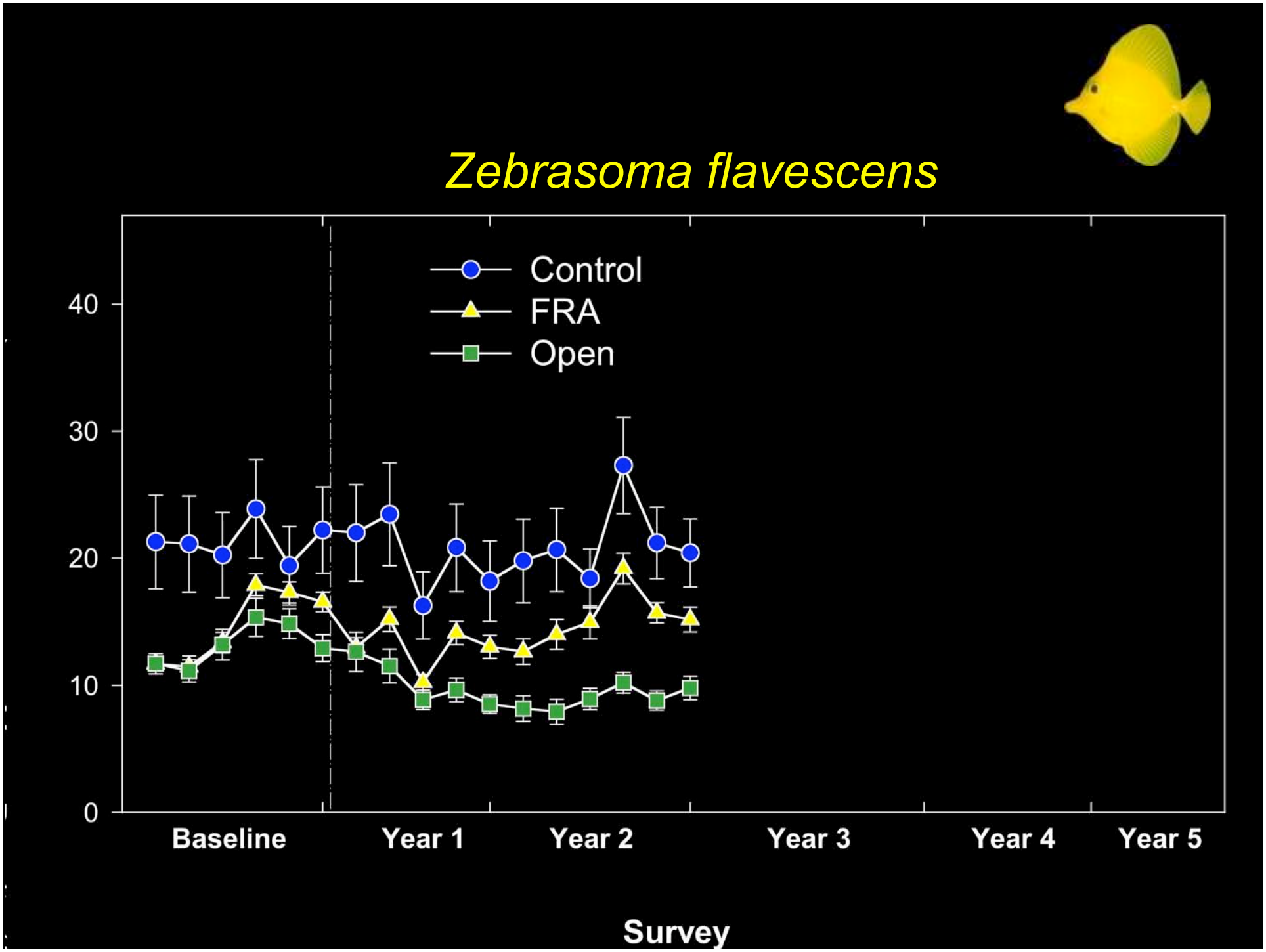
Pre-reserve baseline, 1999

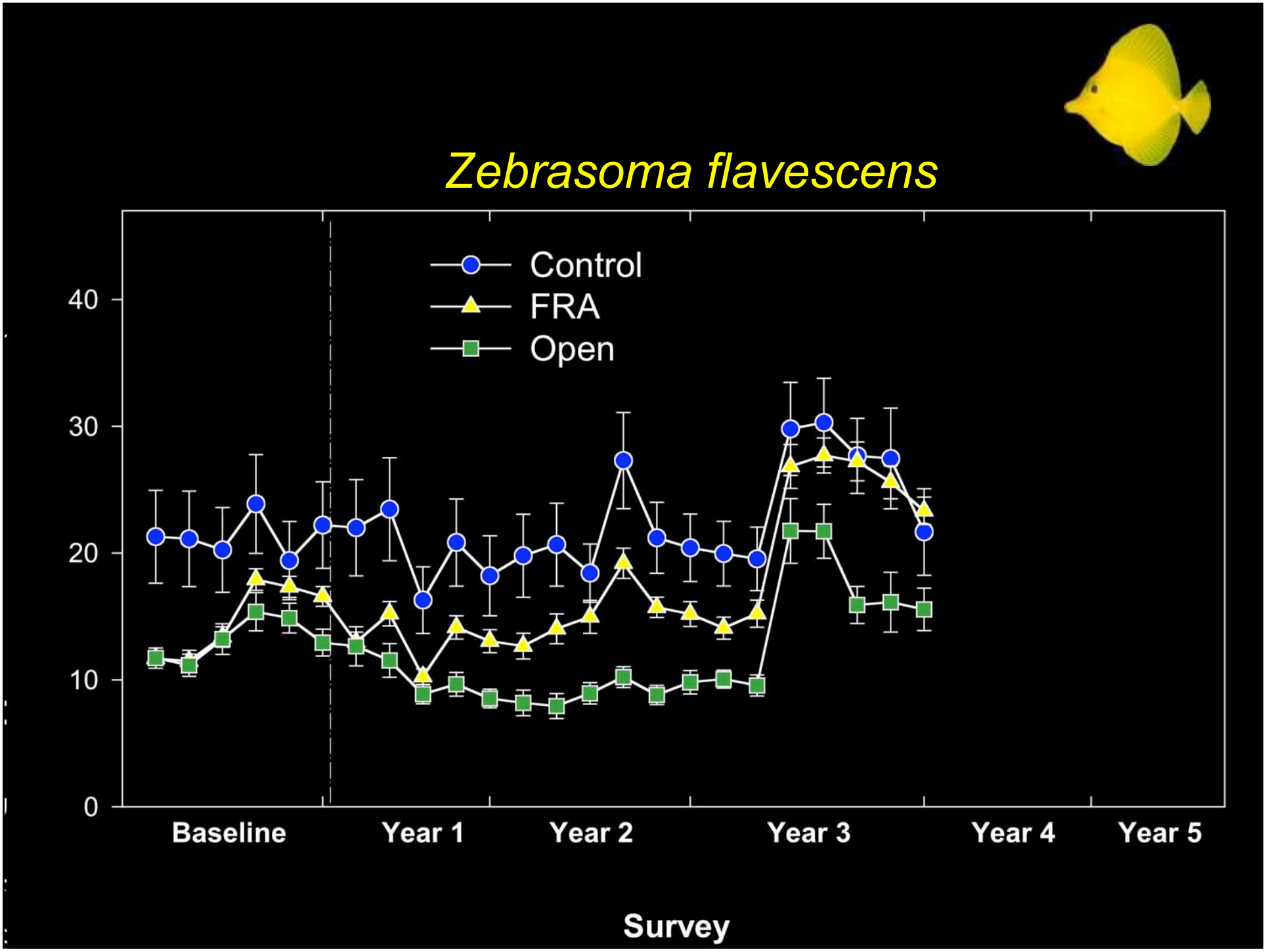


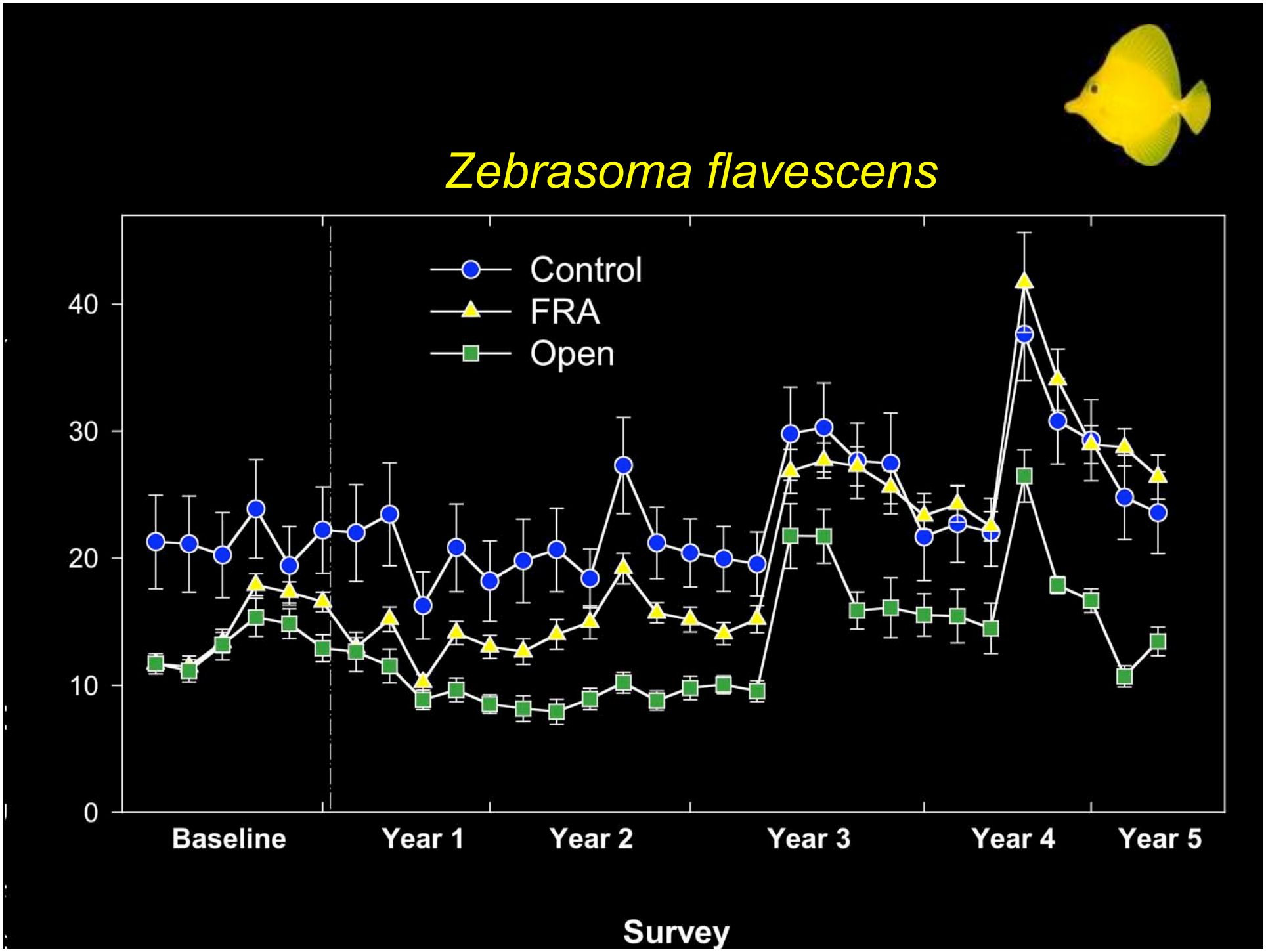

Control
FRA
Open
40
30
20
10
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey


YOY Abundance
20
10
0
Zebrasoma flavescens
10
0
Ctenochaetus strigosus
2
0
Chaetodon multicinctus
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey Date


YOY Abundance
Zebrasoma flavescens
20
10
0
Ctenochaetus strigosus
10
0
Chaetodon multicinctus
4
2
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey Date


Zebrasoma flavescens
Control
FRA
Open
40
30
20
10
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey


Zebrasoma flavescens
Control
FRA
Open
40
30
20
10
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey


Zebrasoma flavescens
Control
FRA
Open
40
30
20
10
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey

BACI ANOVA Results

Control vs. FRA

Source	DF	F	P
Before-After(BA)	1	2.0	0.170
Location	4	151.8	0.001*
BA * Location	4	2.9	0.025*
Times (BA)	20	0.77	0.075
Error	80		
Total	109		

Control vs. Open

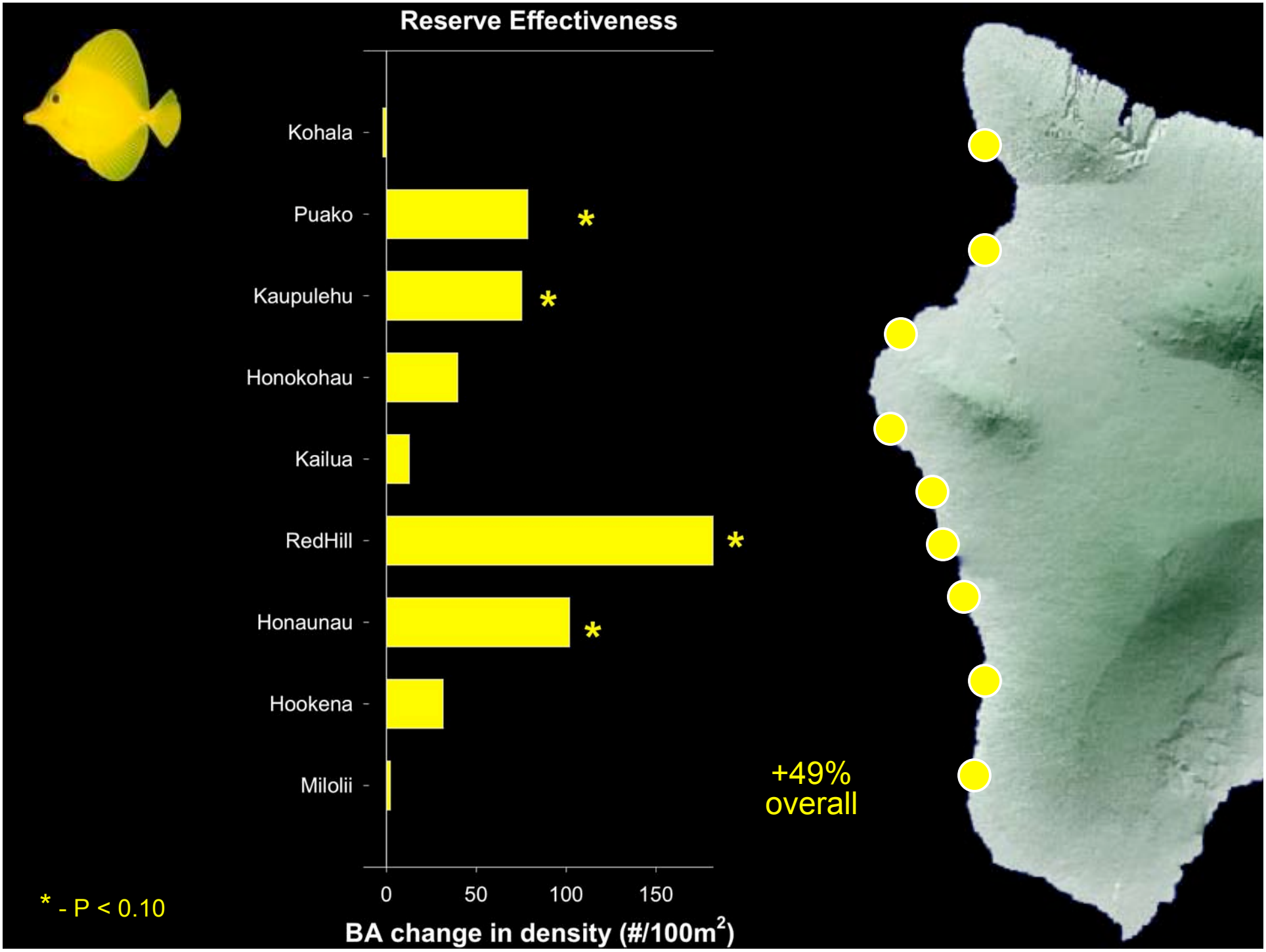
Source	DF	F	P
Before-After(BA)	1	12.51	0.002*
Location	4	30.1	0.001*
BA * Location	4	5.7	0.001*
Times (BA)	20	1.64	0.063
Error	80		
Total	109		

Before-After differences vary among locations

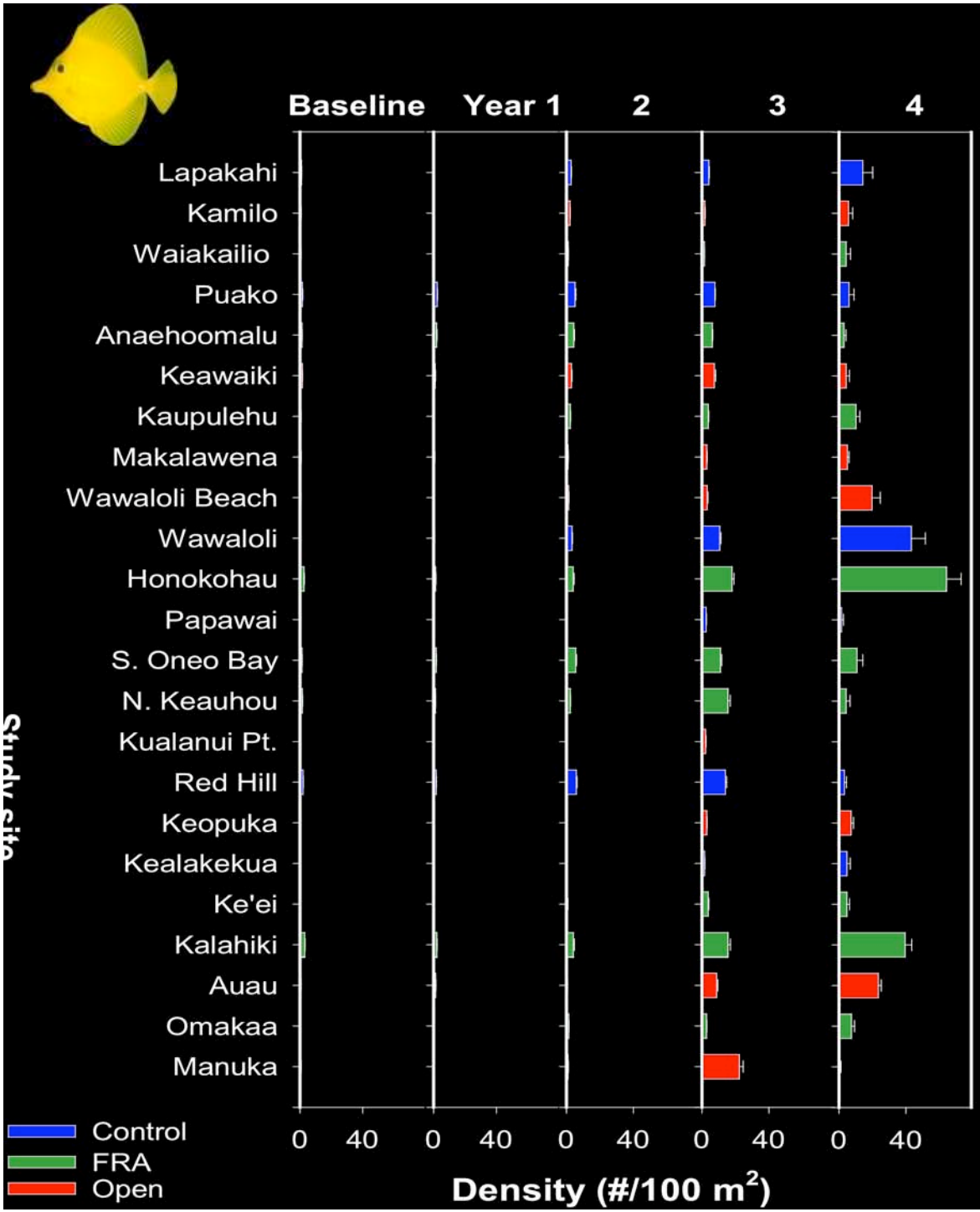
Overall Results

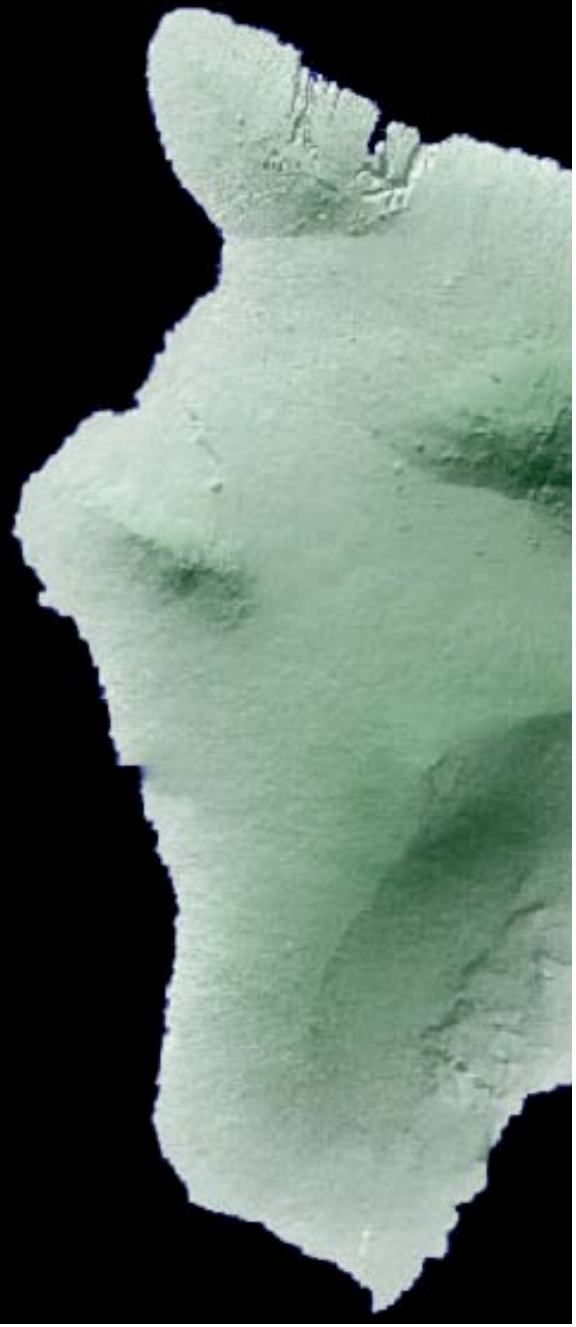
Common name	Scientific name	Mean density (No/100m^2)		Overall% change in density	R
		Before	After		
Yellow Tang	*Zebrasoma flavescens*	14.7	21.8	**+48%**	**+49%***
Goldring surgeonfish	*Ctenochaetus strigosus*	31.0	33.3	+7%	-3.8%
Achilles Tang	*Acanthurus achilles*	0.24	0.30	+26%	-46%
Clown Tang	*Naso lituratus*	0.75	0.84	+11%	-41%
Chevron Tang	*Ctenochaetus hawaiiensis*	0.22	0.23	**+2%**	**+141%***
Longnose butterflyfish	*Forcipiger spp.*	0.73	0.77	+6%	+65%
Four-spot Butterflyfish	*Chaetodon quadrimaculatus*	0.03	0.06	+100%	+116%
Ornate Butterflyfish	*Chaetodon ornatissimus*	0.87	0.75	-14%	+27%
Multiband Butterflyfish	*Chaetodon multicinctus*	5.71	5.02	-12%	-15%
Hawaiian Cleaner Wrasse	*Labroides phthirophagus*	0.88	0.73	-18%	+30%

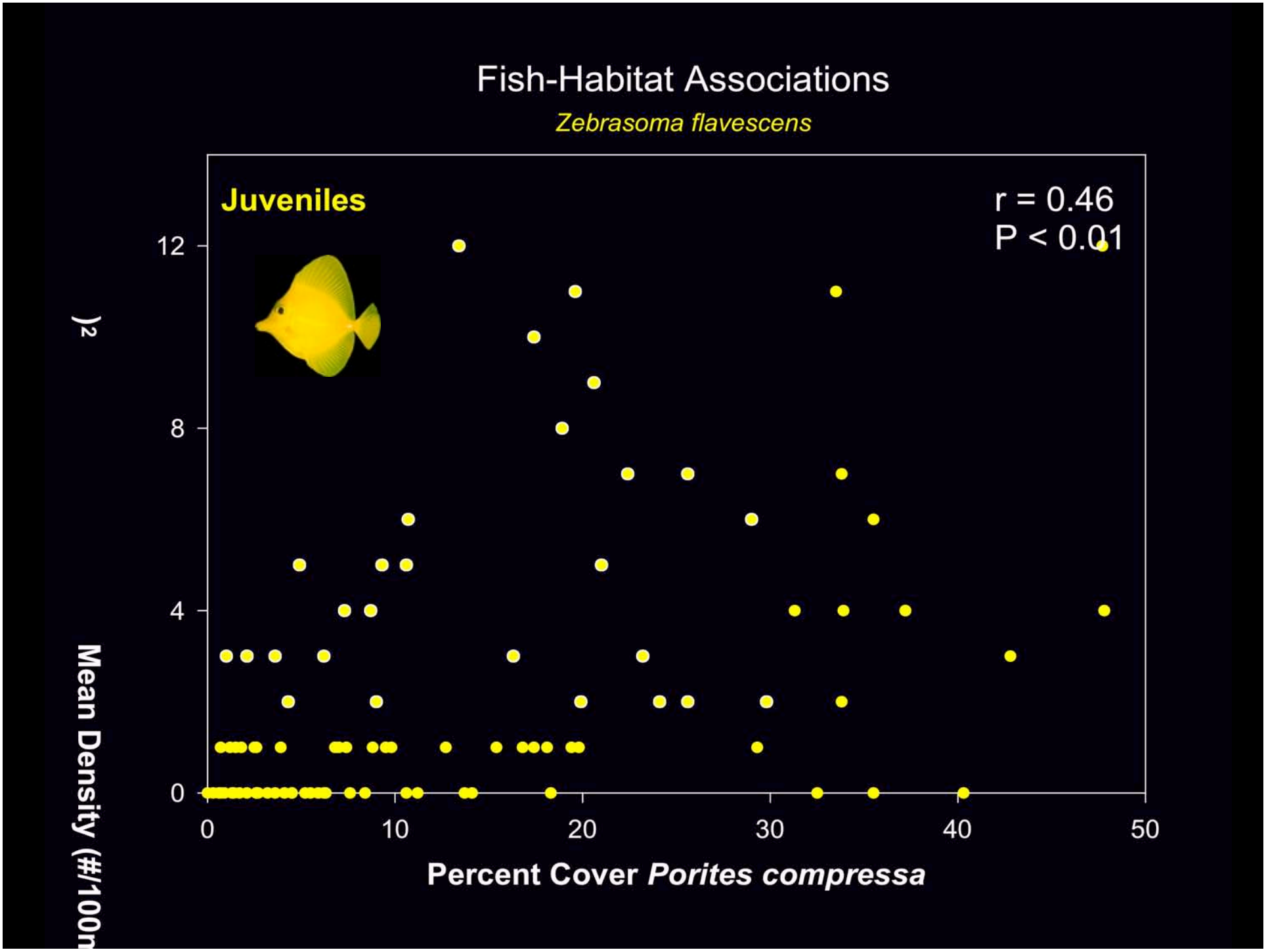
* Statistically significant at $P < 0.10$

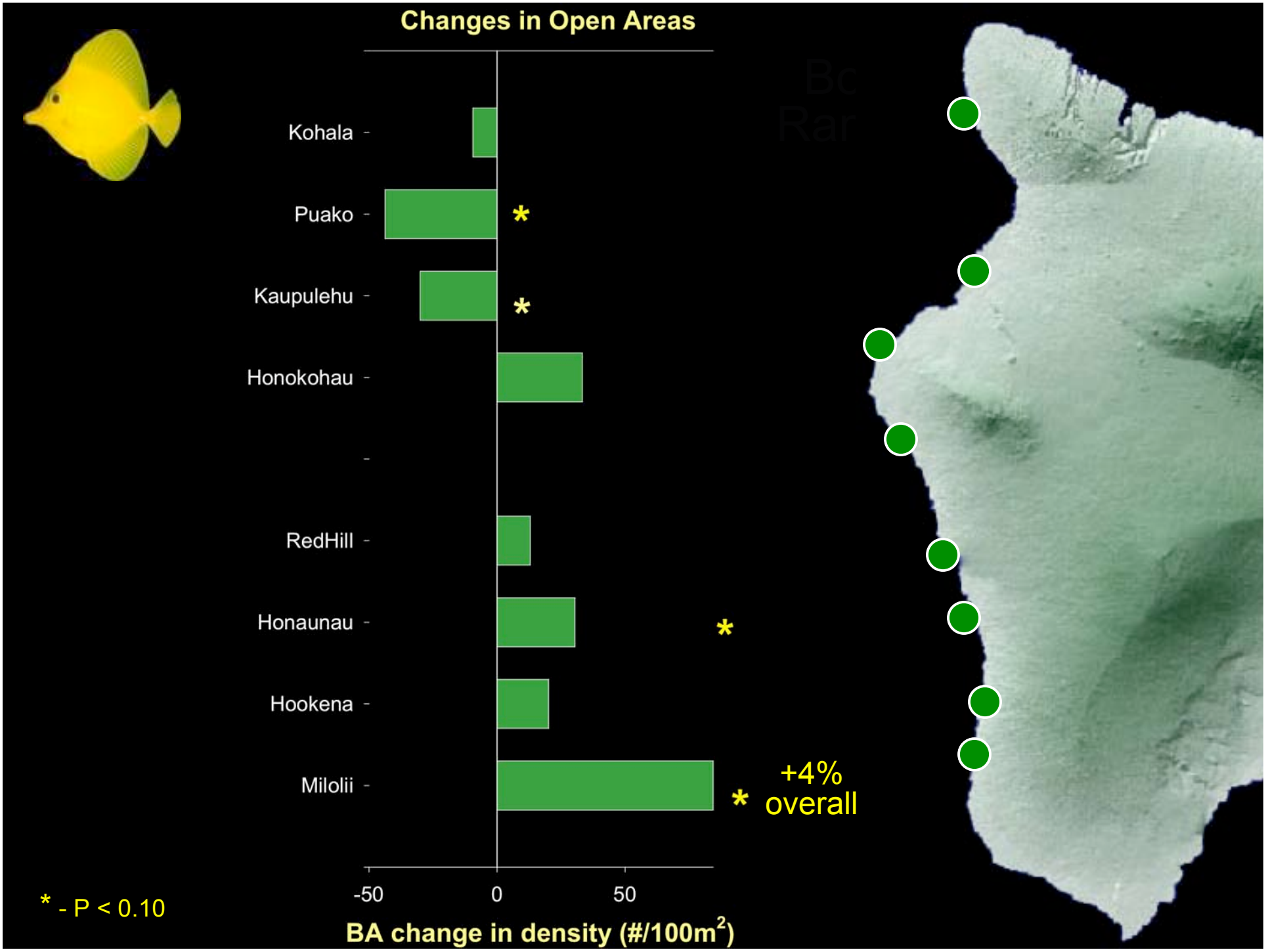

Reserve Effectiveness
Kohala
Puako
Kaupulehu
Honokohau
Kailua
RedHill
Honaunau
Hookena
Mililii
*
*
*
*
0
50
100
150
BA change in density (#/100m2)
* - P < 0.10
+49%
overall

Yellow tangs YOY






Fish-Habitat Associations
Zebrasoma flavescens
Juveniles
r = 0.46
P < 0.01
12
8
4
0
0
10
20
30
40
50
Mean Density (#/100m
)2
Percent Cover Porites compressa


Changes in Open Areas
Kohala
Puako
Kaupulehu
Honokohau
RedHill
Honaunau
Hookena
Milolii
*
*
*
*
-50
0
50
BA change in density (#/100m2)
+4%
overall
* - P < 0.10

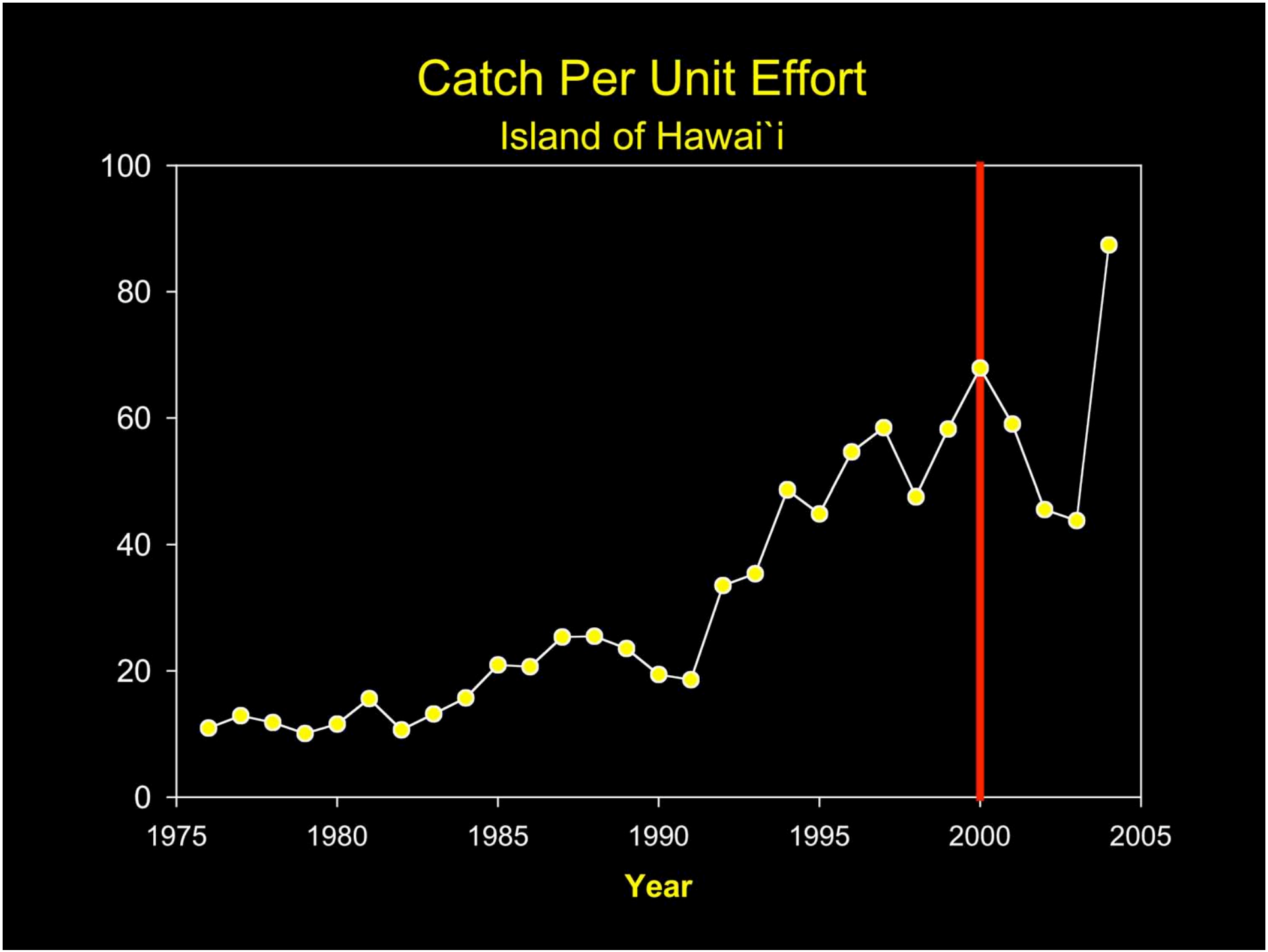
Catch of Yellow Tangs

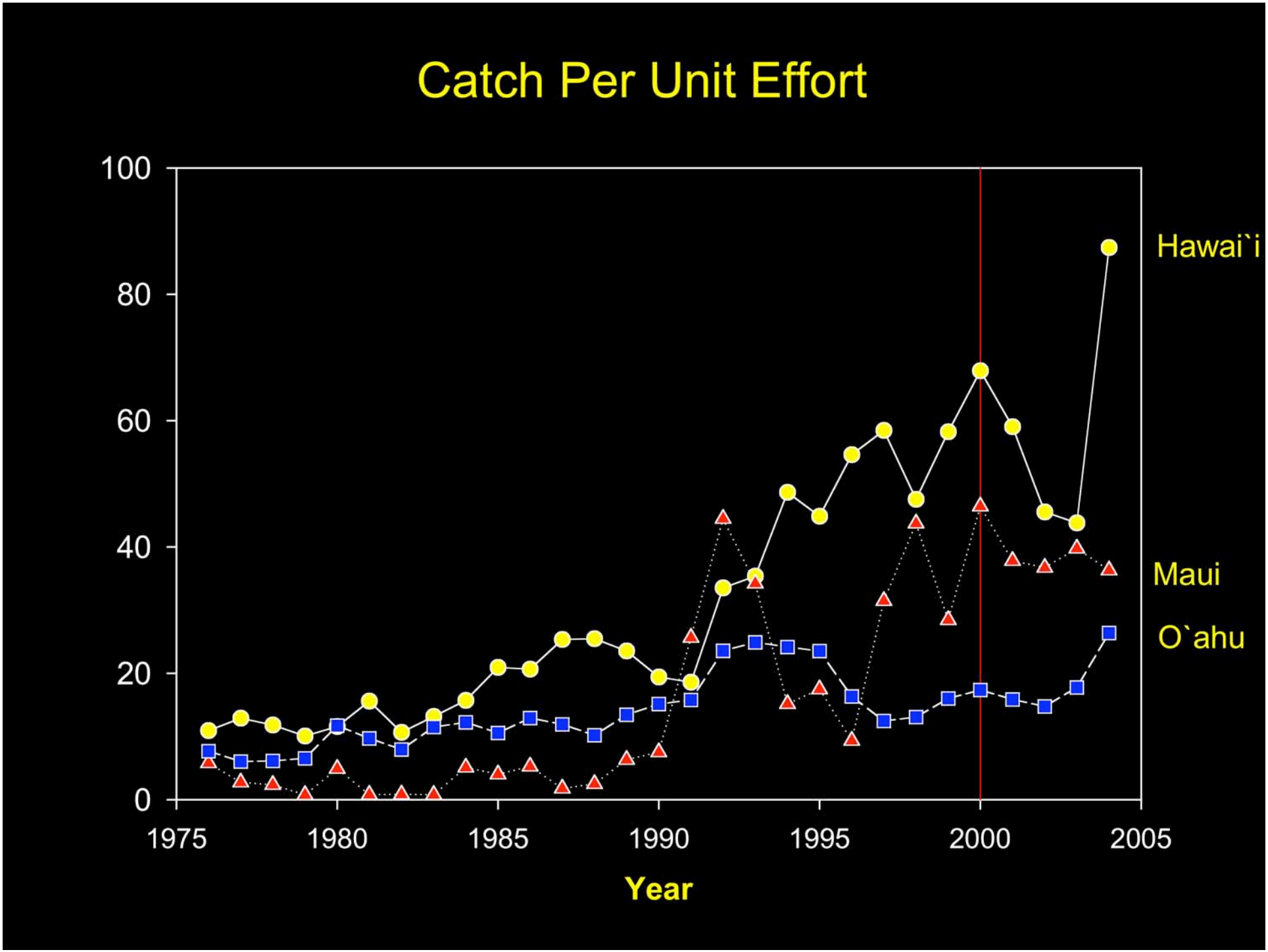
Island of Hawai`i

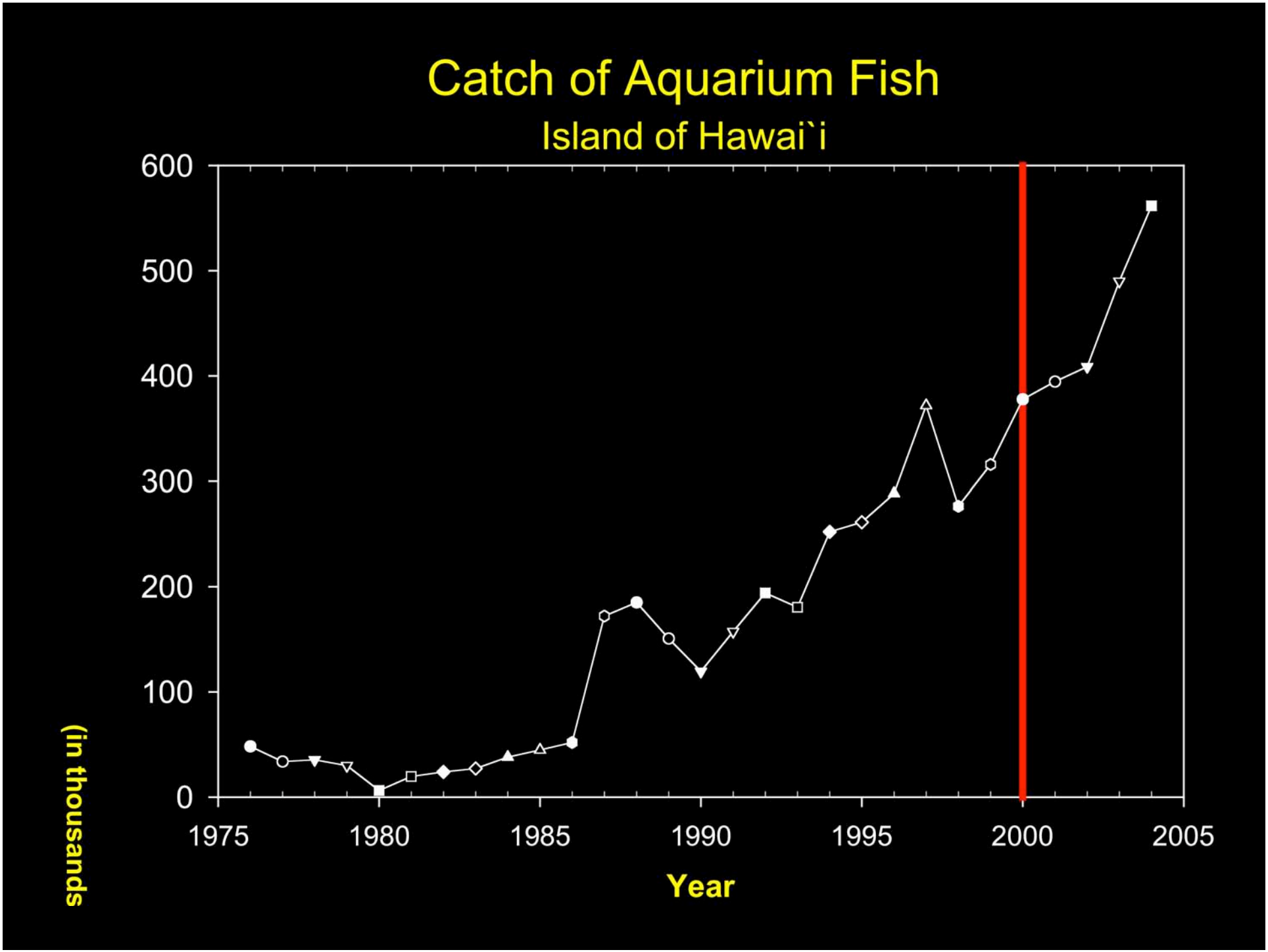
300000
250000
200000
150000
100000
50000
0

1975 1980 1985 1990 1995 2000 2005

Year


Catch Per Unit Effort
Island of Hawai`i
100
80
60
40
20
0
1975
1980
1985
1990
1995
2000
2005
Year


Catch Per Unit Effort
100
80
60
40
20
0
1975
1980
1985
1990
1995
2000
2005
Year
Hawai`i
Maui
O`ahu


Catch of Aquarium Fish
Island of Hawai`i
600
500
400
300
200
100
0
(in thousands
1975
1980
1985
1990
1995
2000
2005
Year

Social Interactions

West Hawai`i Fisheries Council:

- More support from collectors as stocks recovered and fishery prospered

Community:

- More support for MPAS; better vigilance

Type of Incident	Pre-FRA				Post-FRA			
	1996	1997	1998	1999	2000	2001	2002	2003
Complaints	0	2	2	0	3	3	1	3
Warnings	0	0	1	0	2	2	0	1
Citations/Arrests	0	1	0	0	1	0	0	2

Conclusions

MPA Network in Hawai`i:

1. Recovered fish stocks
2. Associated with high fishery catch
3. Reduced user conflicts, more community support
4. Enhanced “sustainability” of the system