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




Brian Tissot

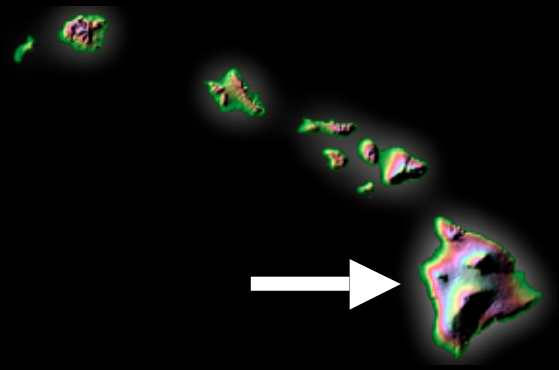
Program in Environmental Science & Regional Planning
Washington State University, Vancouver, WA USA

# MPA Efficiency

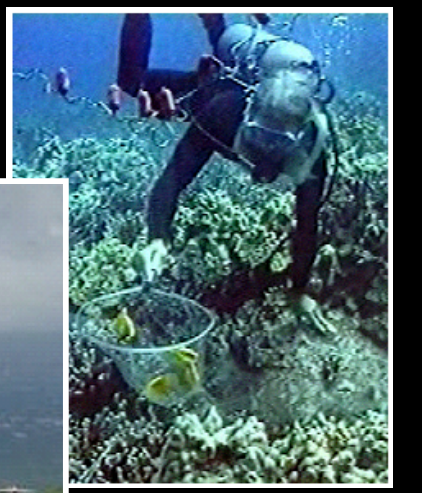
- Multiple dimensions
- Ecological:
  - Replenish species; restore biodiversity
- Economic:
  - Promote sustainable resources
- Social & Political:
  - Reduce stakeholder conflicts

# 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

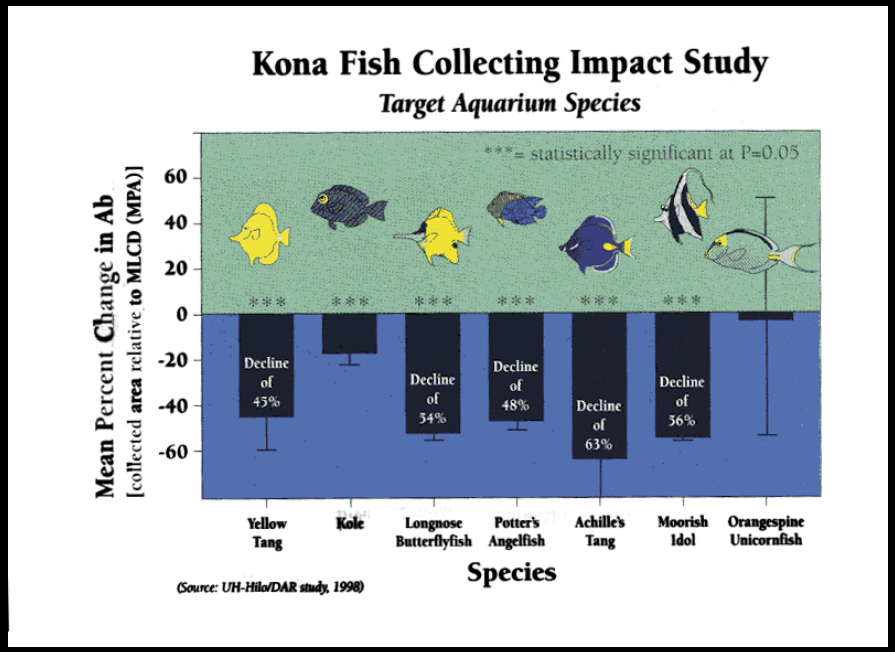


- Small, lucrative industry
- Rapidly growing
- Largely unregulated
- Long, contentious conflict:
  - Tour boat operators
  - Conservationists
  - Native Hawaiians

# Barrier Net Collecting in West Hawai'i

# Aquarium Fishery Research

- Study on effects
- Results to the public & Legislature

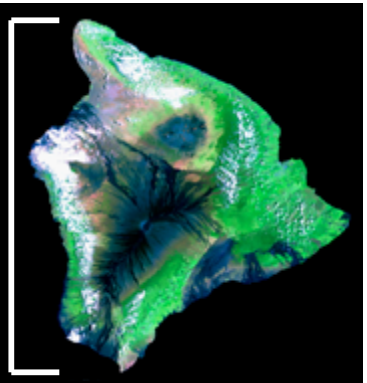





*Tissot & Hallacher, 2003, Conservation Biology, 17(6): 1759-1768*

# 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:

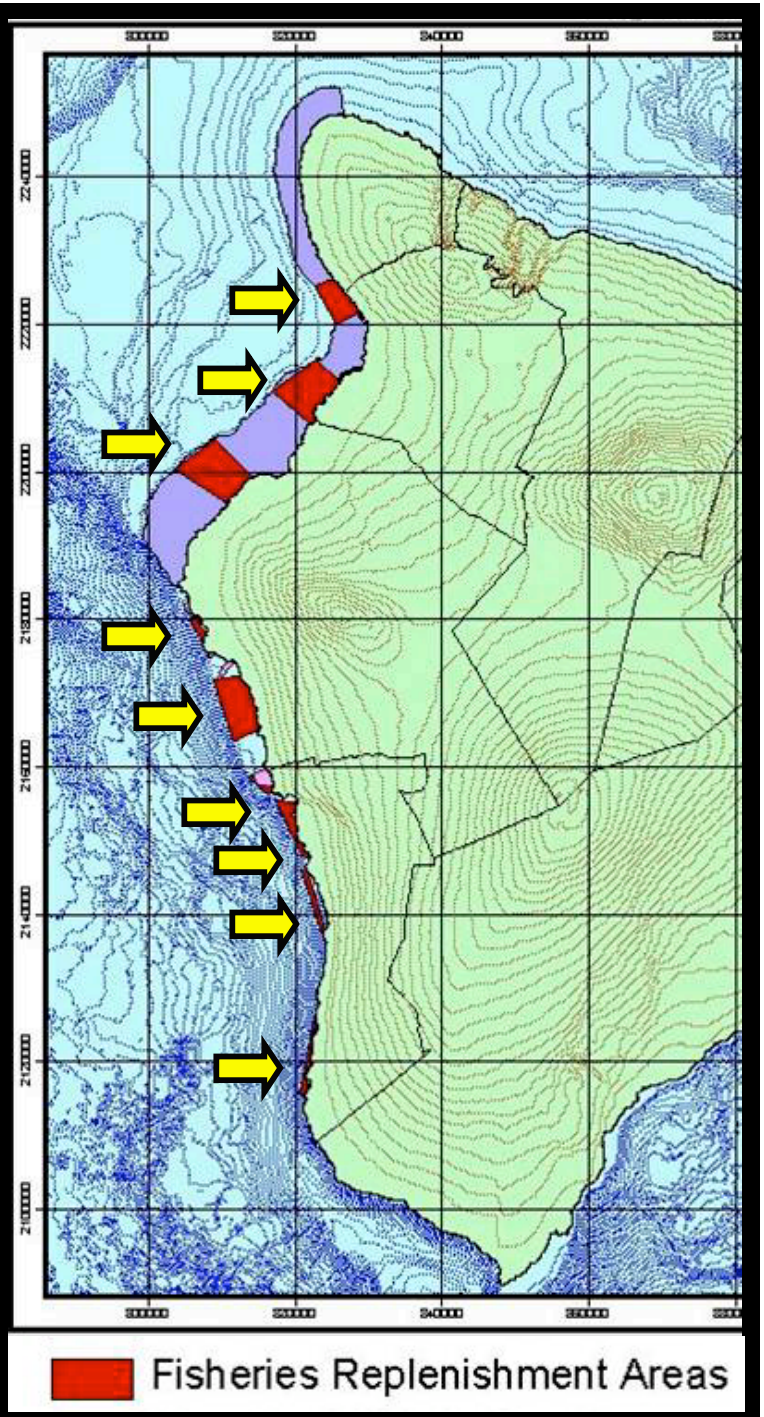
1) Establish MPAs
2) Separate conflicts

# 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

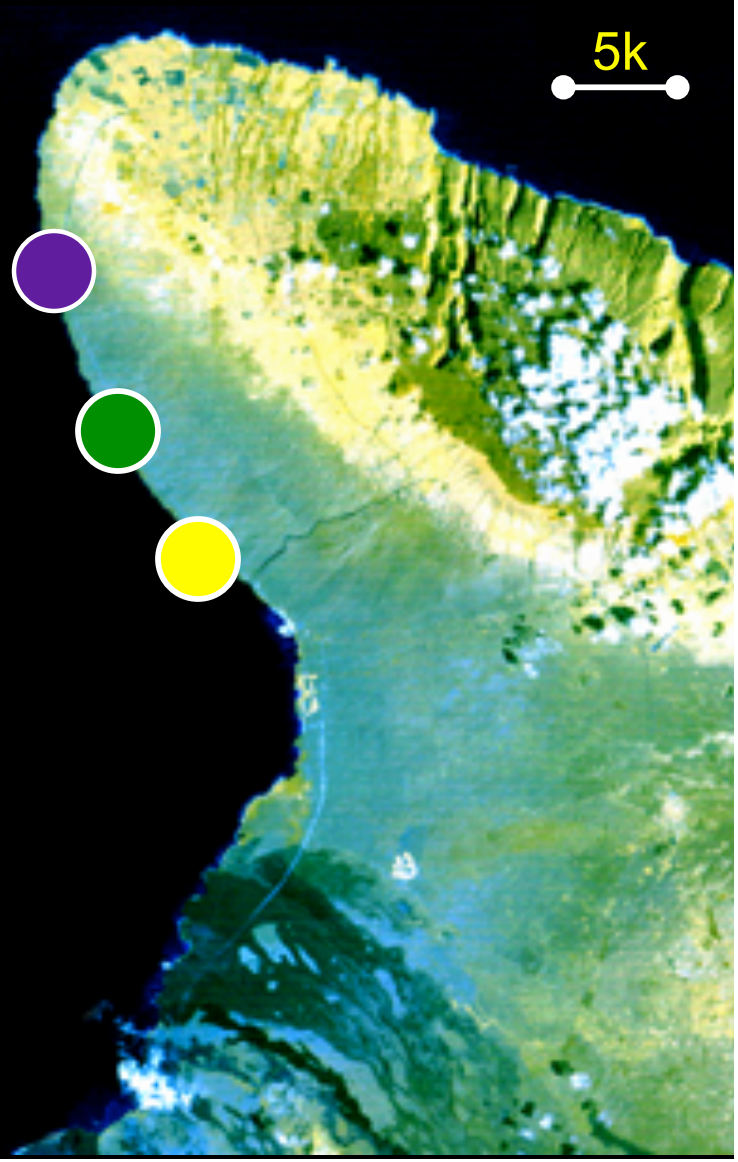




# Design of Monitoring Program

Observational design block

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




Repeated measure BACI design:

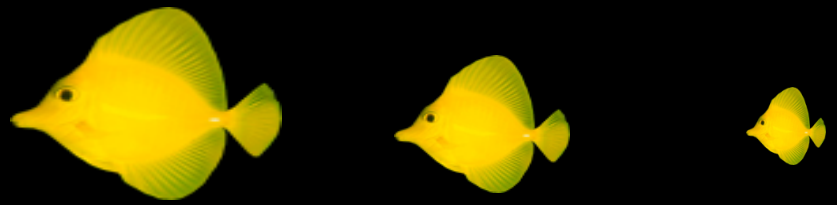
- Among treatments (C-FRA, C-O)
- Before vs. After
- Among locations

# Monitoring Program

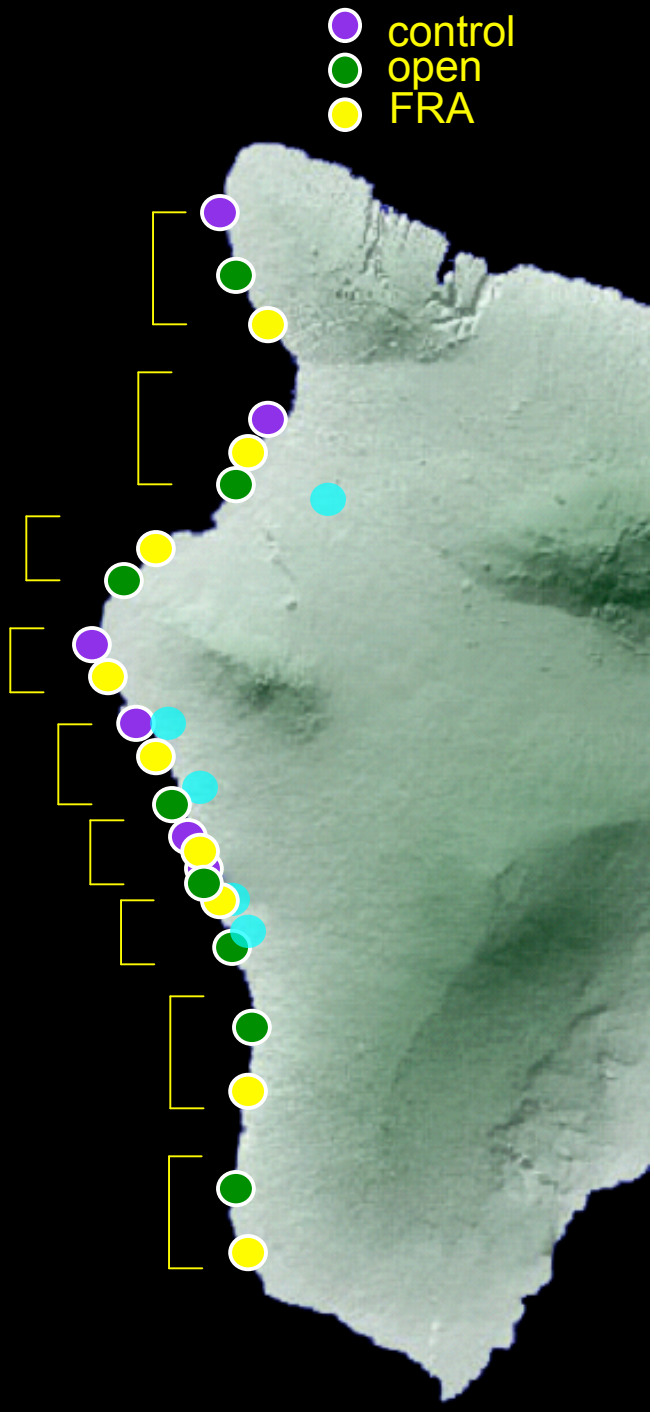
23 study sites - established pre-FRA (1999)

- 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

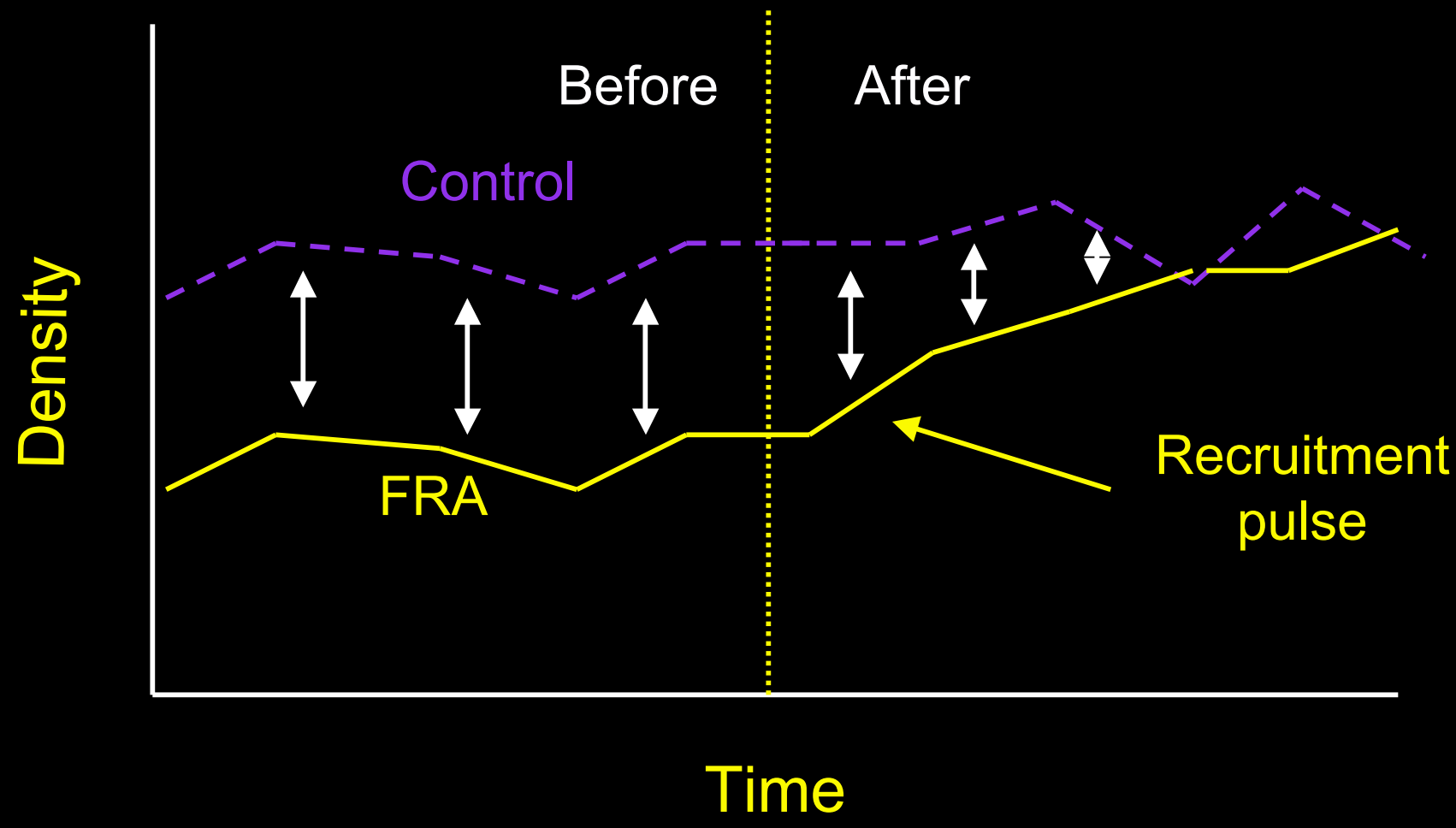
# Coral-habitat monitoring

Digital video camera w/ lasers

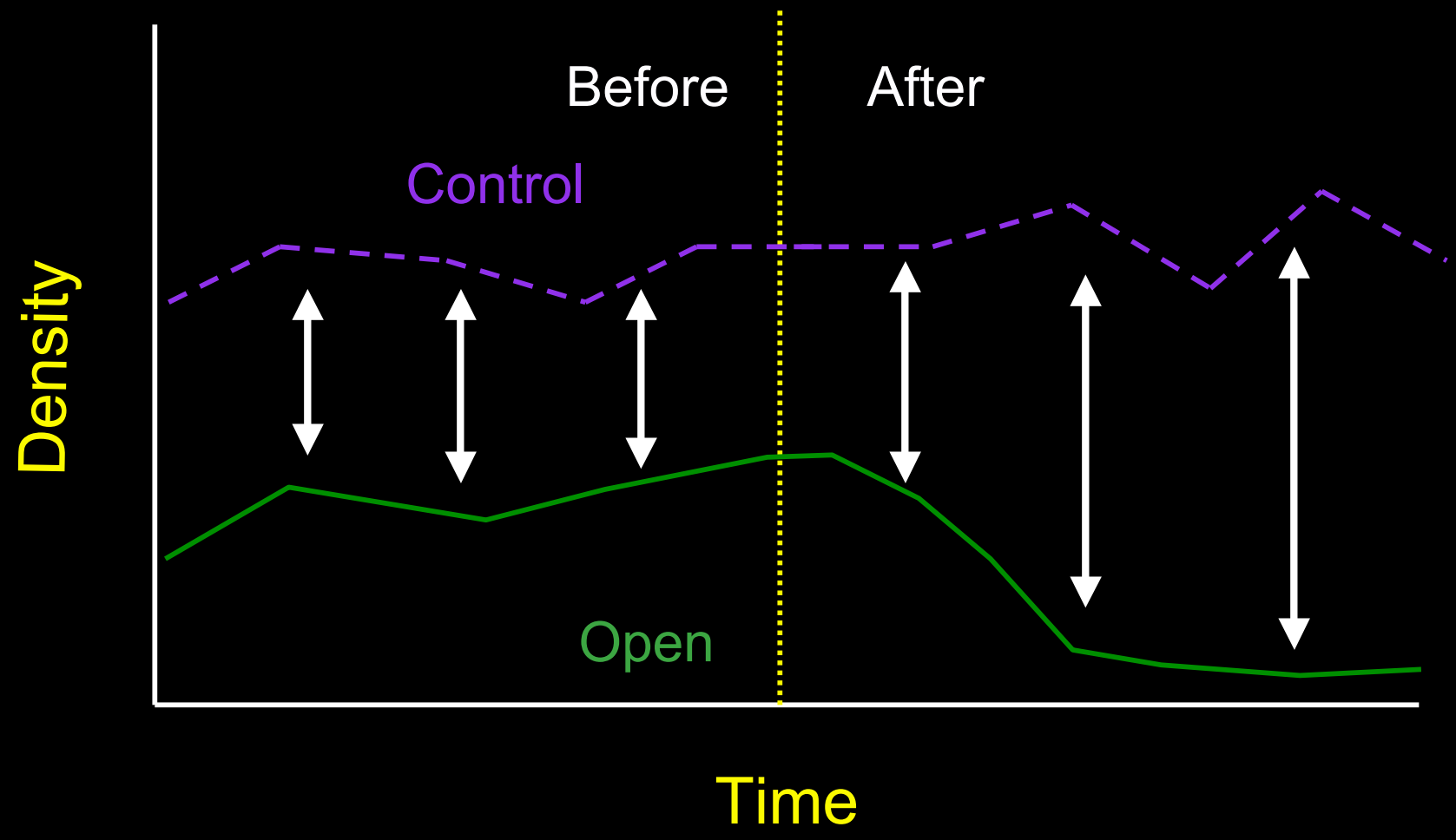
Conduct video transects

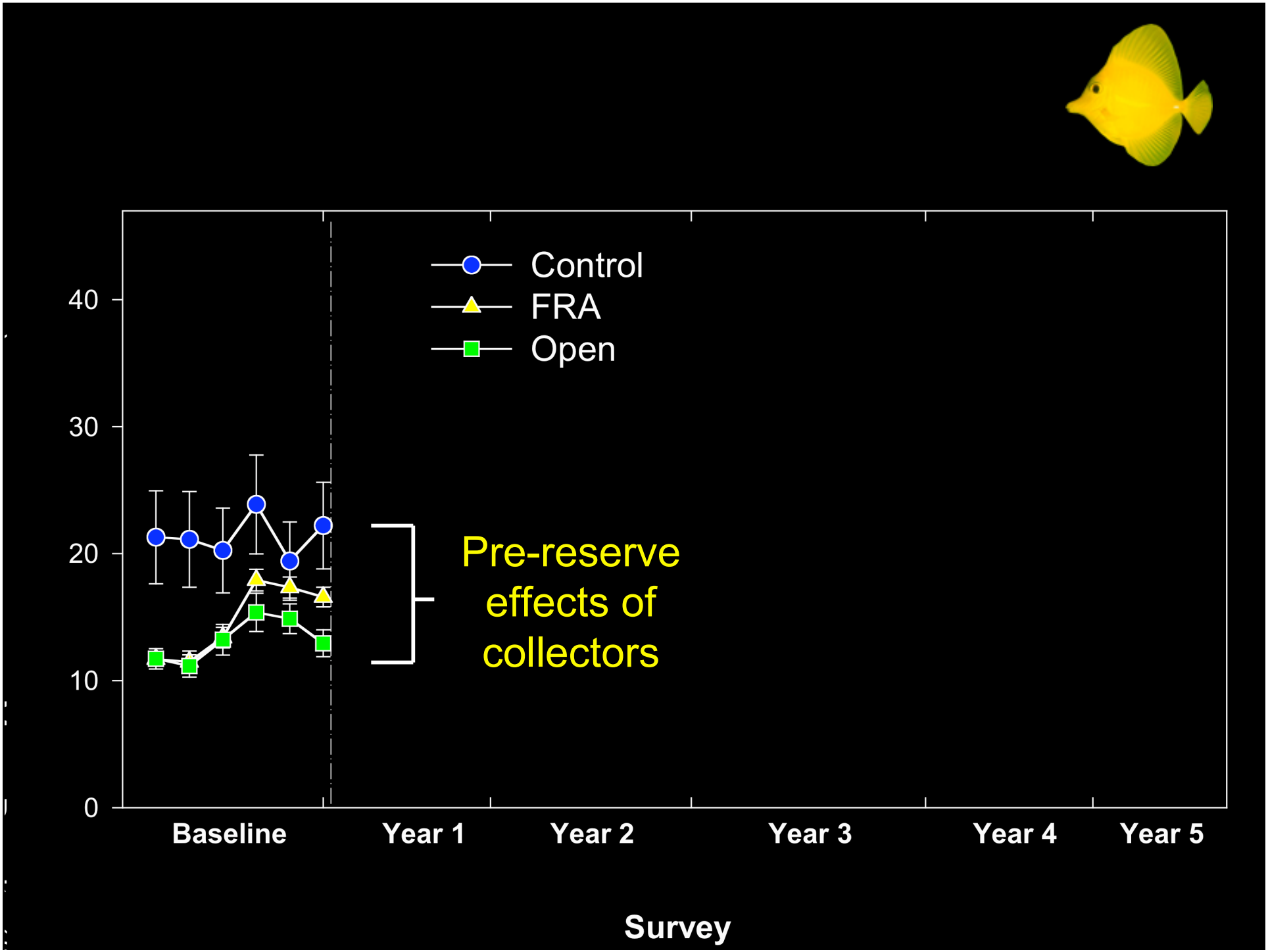
Analyze frames w/ *PointCount*

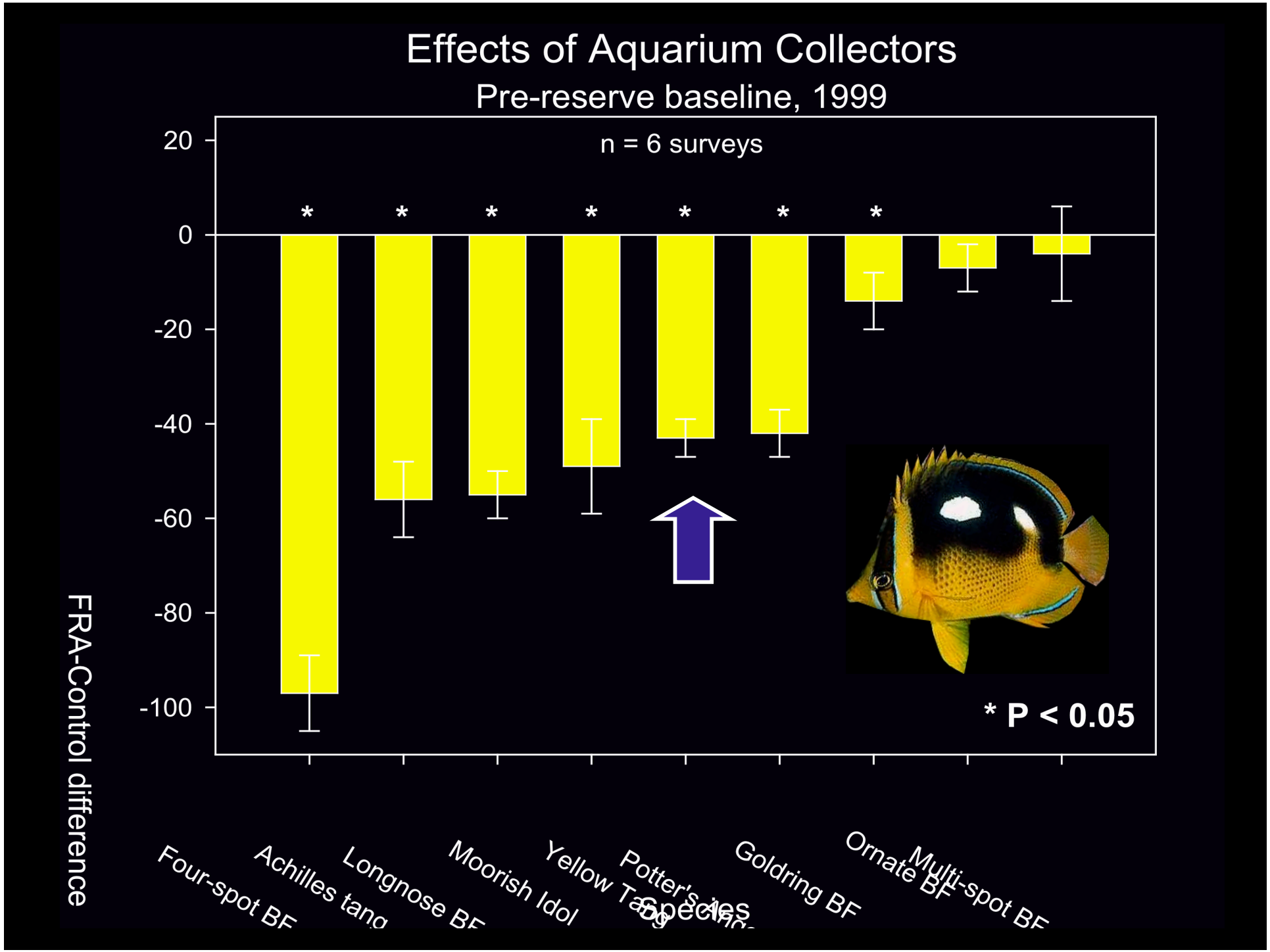
# BACI: Before-After Control-Impact Comparison Procedure

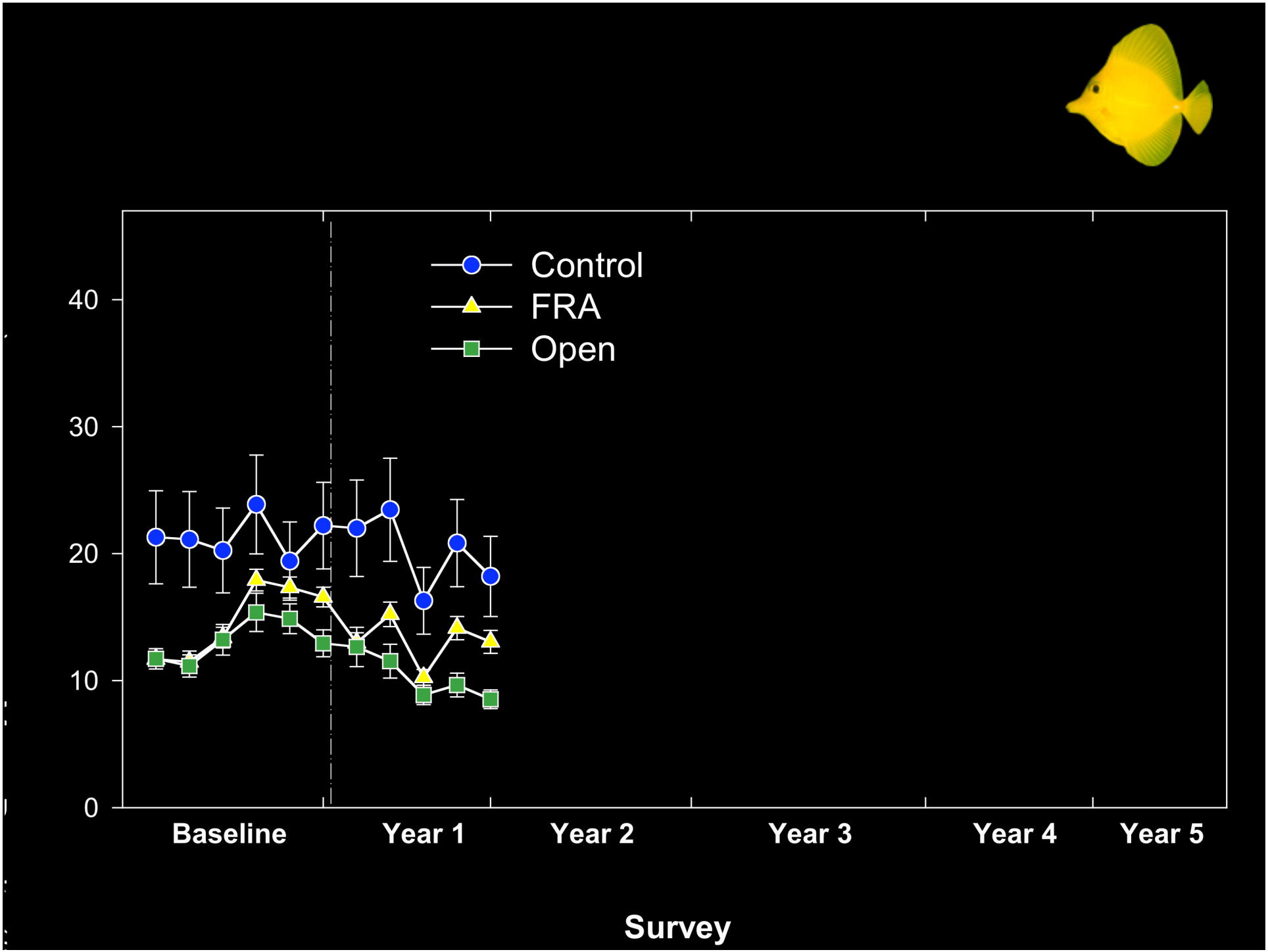


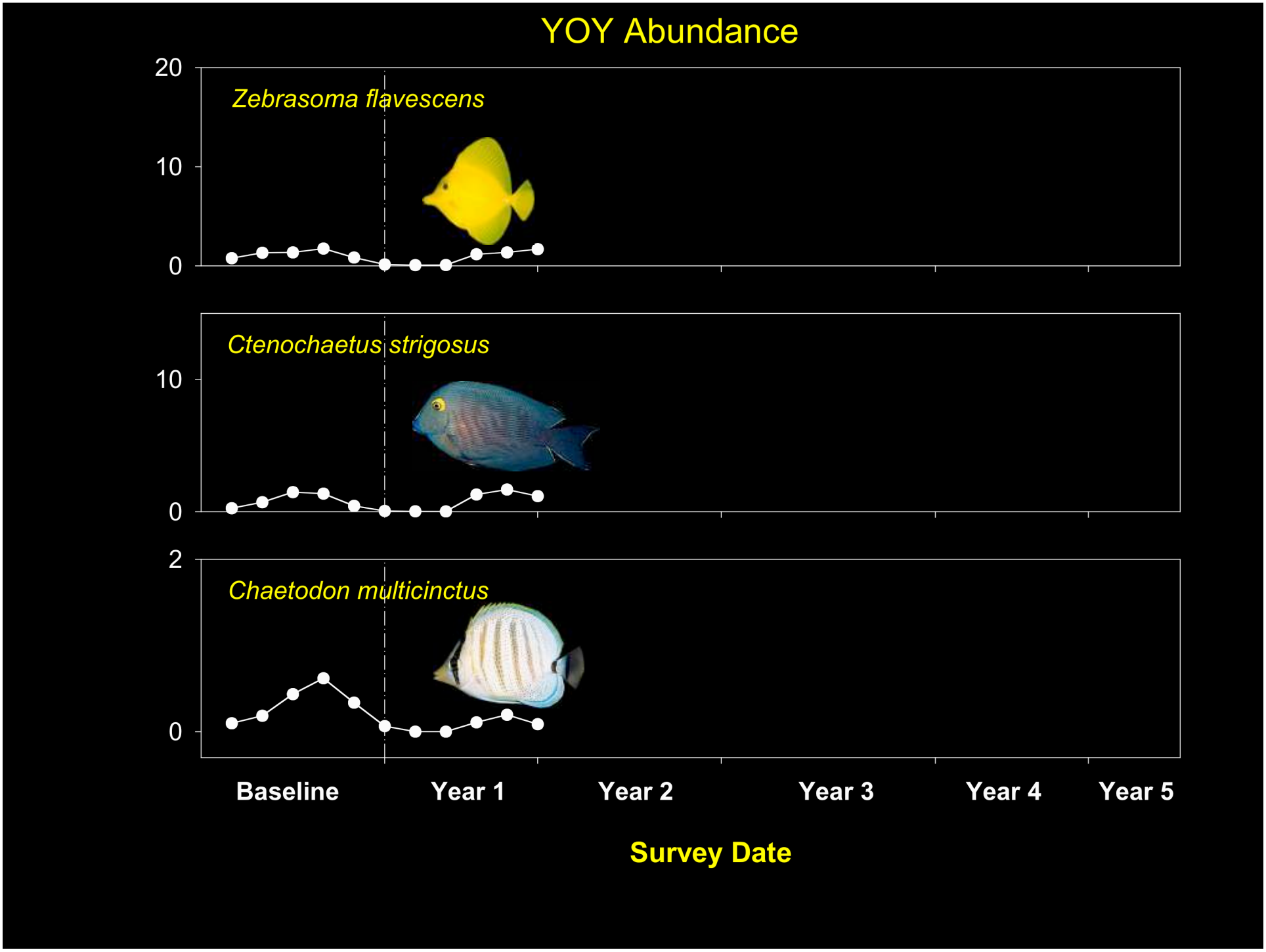
# BACI: Before-After Control-Impact Comparison Procedure

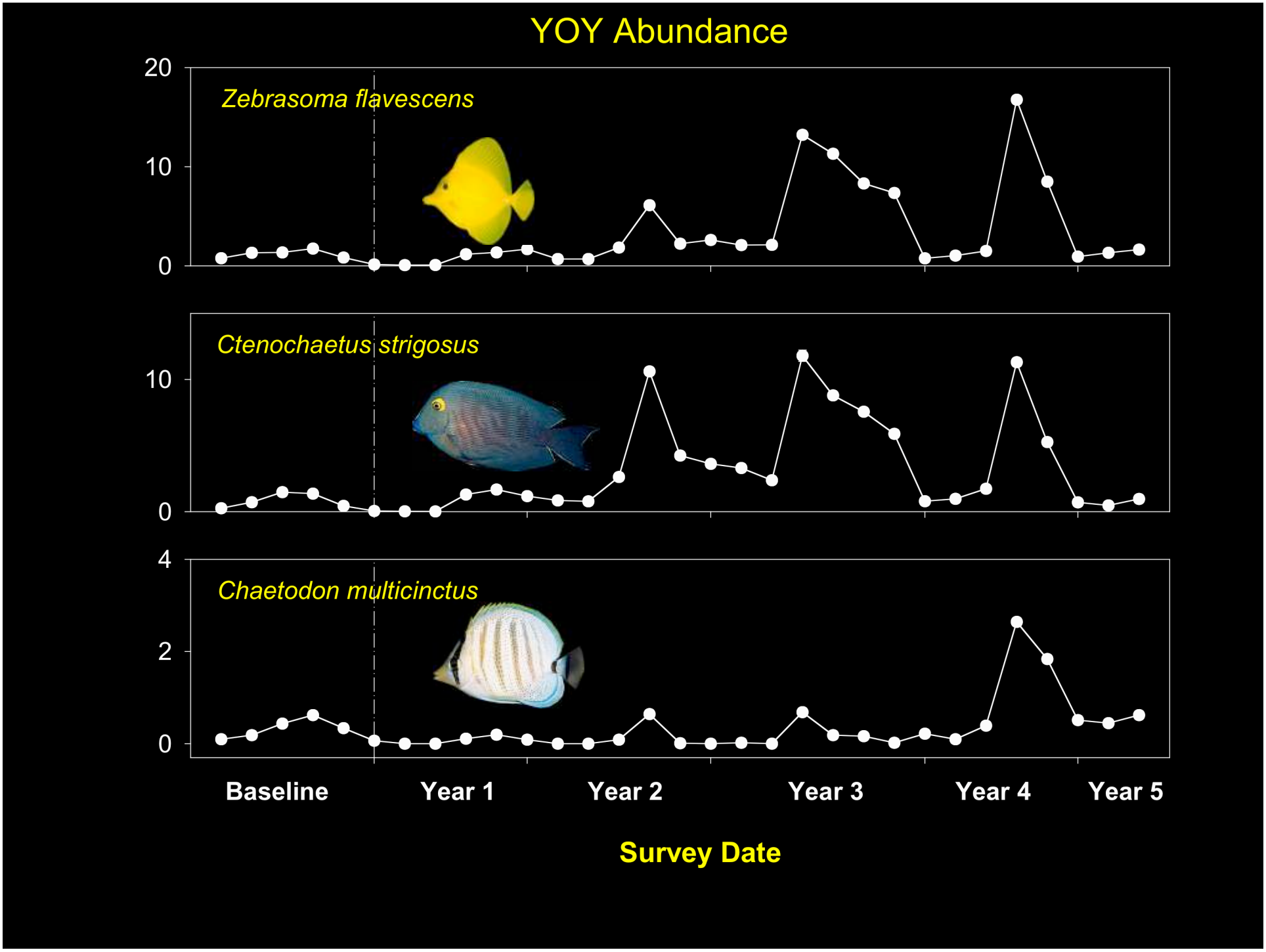


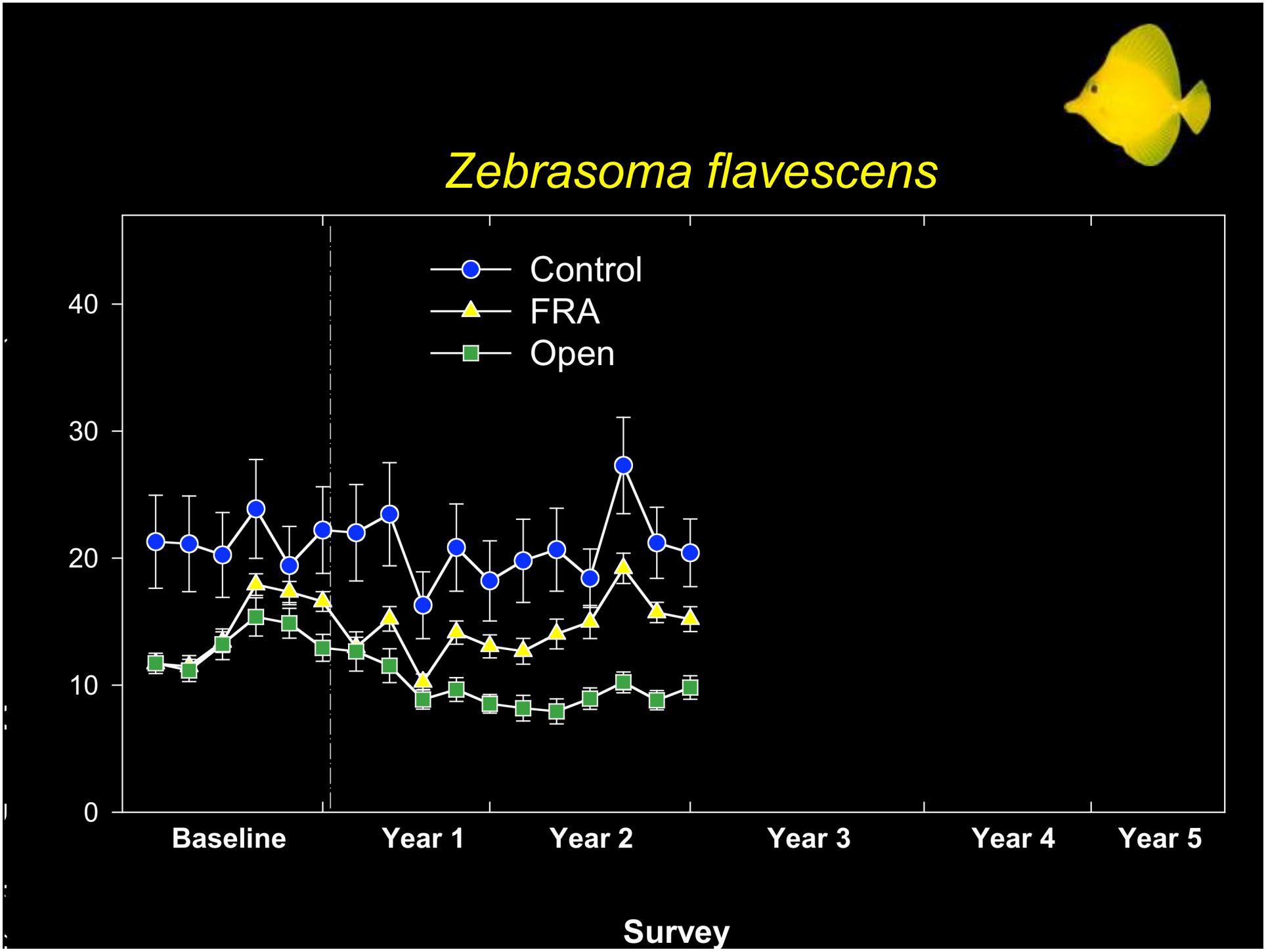

Control
FRA
Open
40
30
20
10
0
Pre-reserve
effects of
collectors
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey

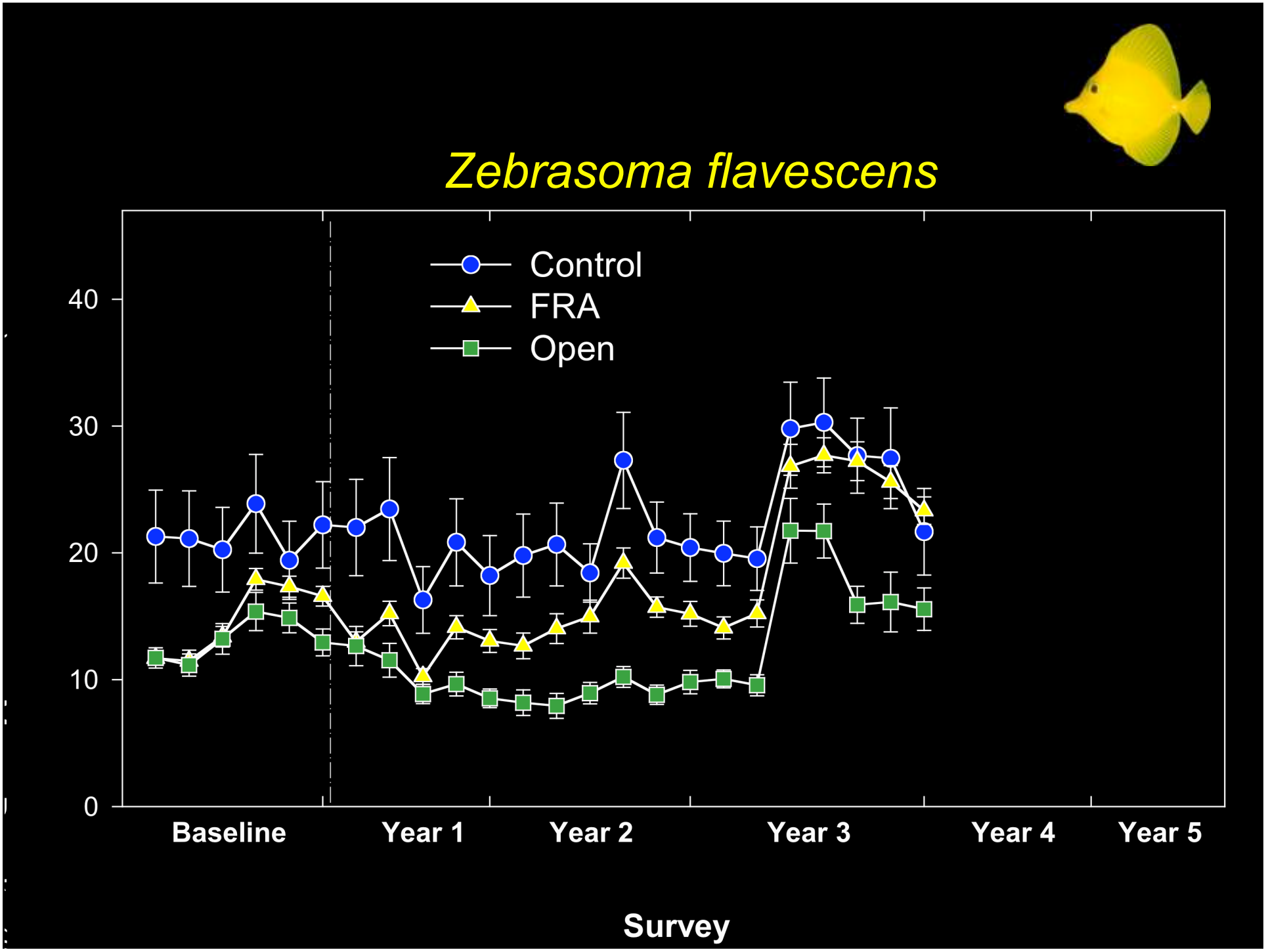

Effects of Aquarium Collectors
Pre-reserve baseline, 1999
n = 6 surveys
20
0
-20
-40
-60
-80
-100
FRA-Control difference
* P < 0.05
Four-spot BF
Achilles tang
Longnose BF
Moorish Idol
Yellow Tang
Potter's ies
Goldring BF
Ornate BF
Multi-spot BF
Species

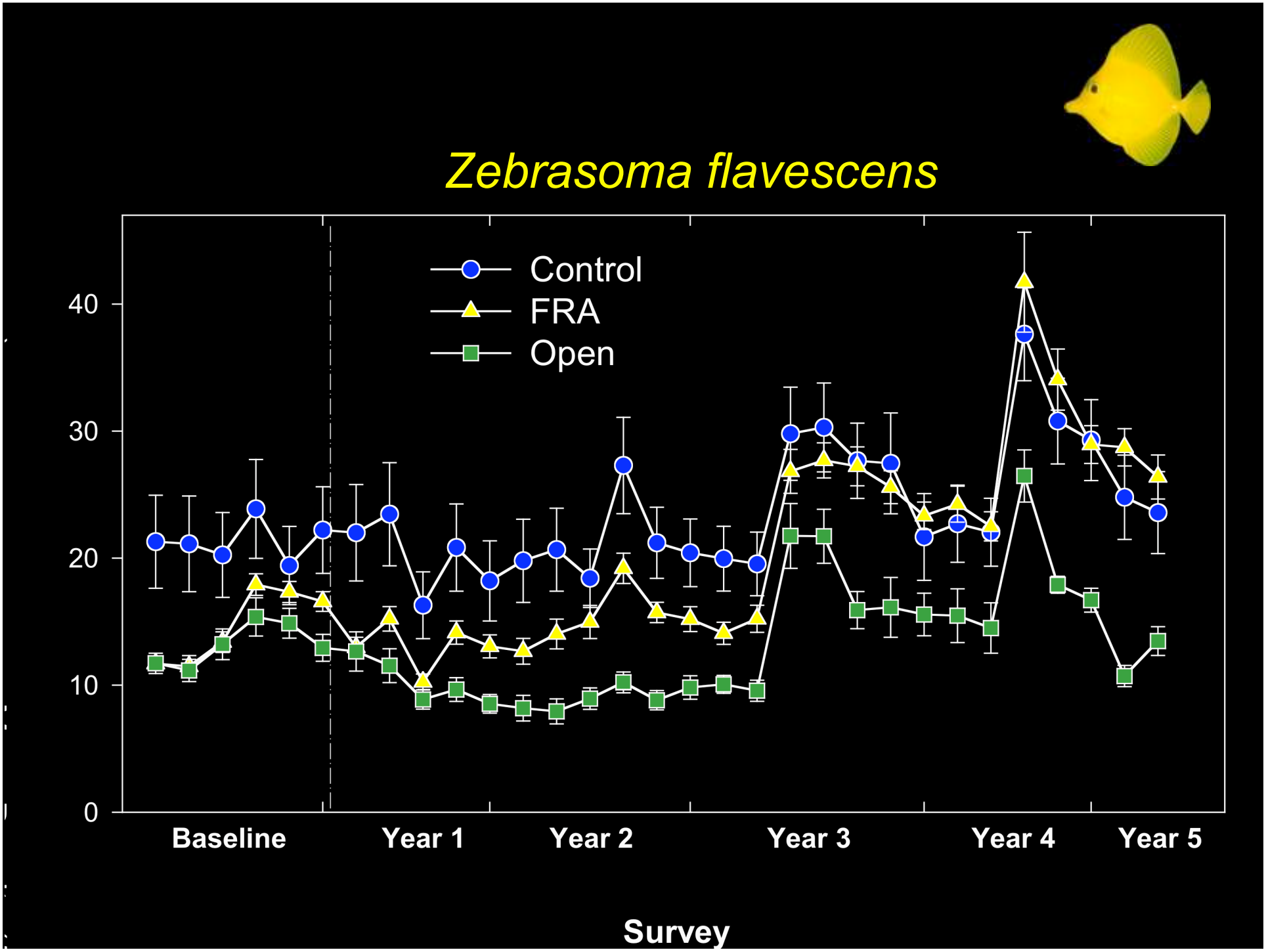

Control
FRA
Open
40
30
20
10
0
Baseline
Year 1
Year 2
Year 3
Year 4
Year 5
Survey


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
20
10
0
Zebrasoma flavescens
10
0
Ctenochaetus strigosus
4
2
0
Chaetodon multicinctus
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**

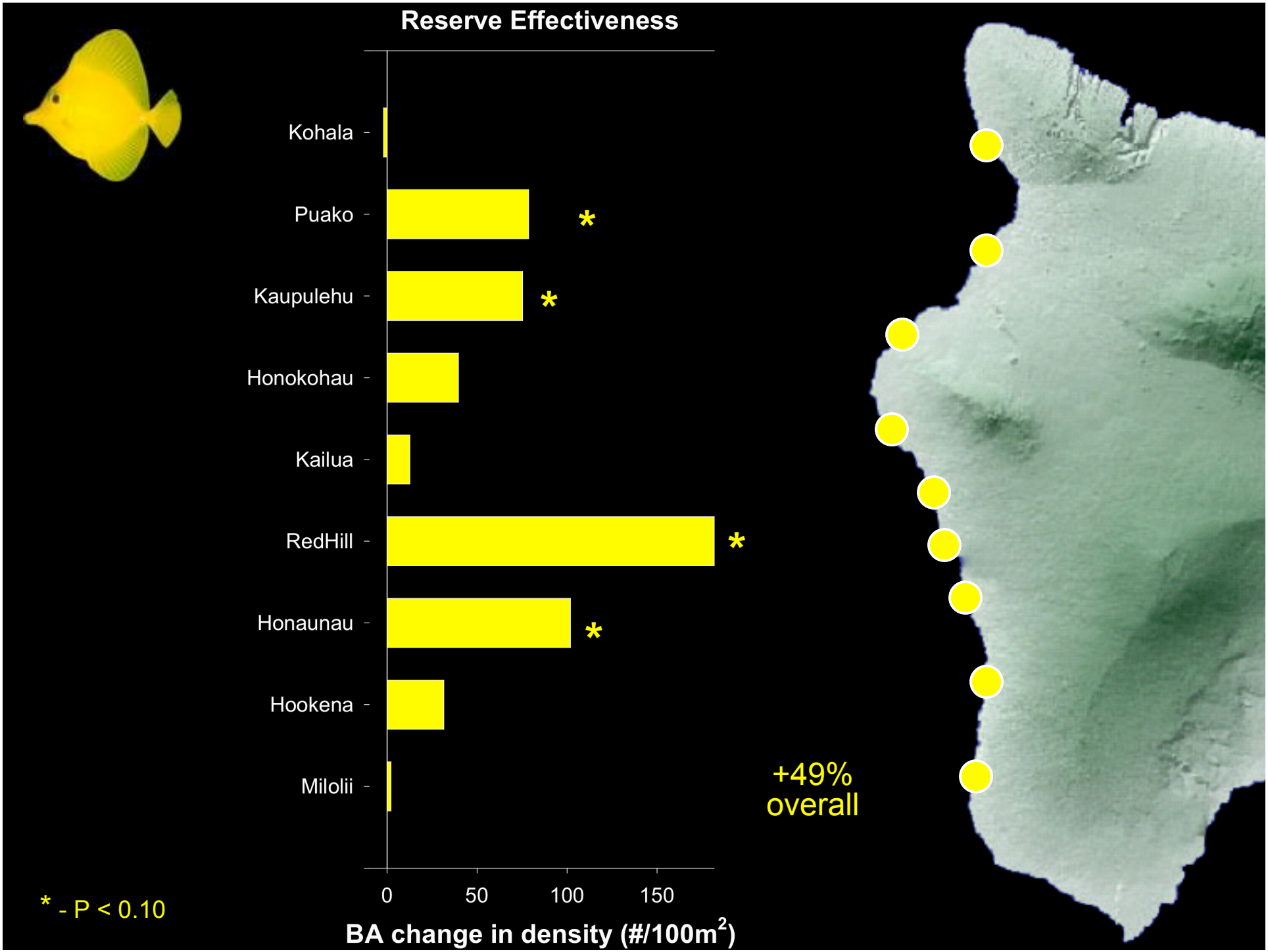
| Source | DF | F | P |
|---|---|---|---|
| Before-After(BA) | 1 | 12.51 | 0.002* |
| Location | 4 | 30.1 | 0.001* |
| BA * Location | 4 | 5.7 | 0.001* |
| Times (BA) | 20 | 1.64 | 0.063 |
| Error | 80 | | |
| Total | 109 | | |

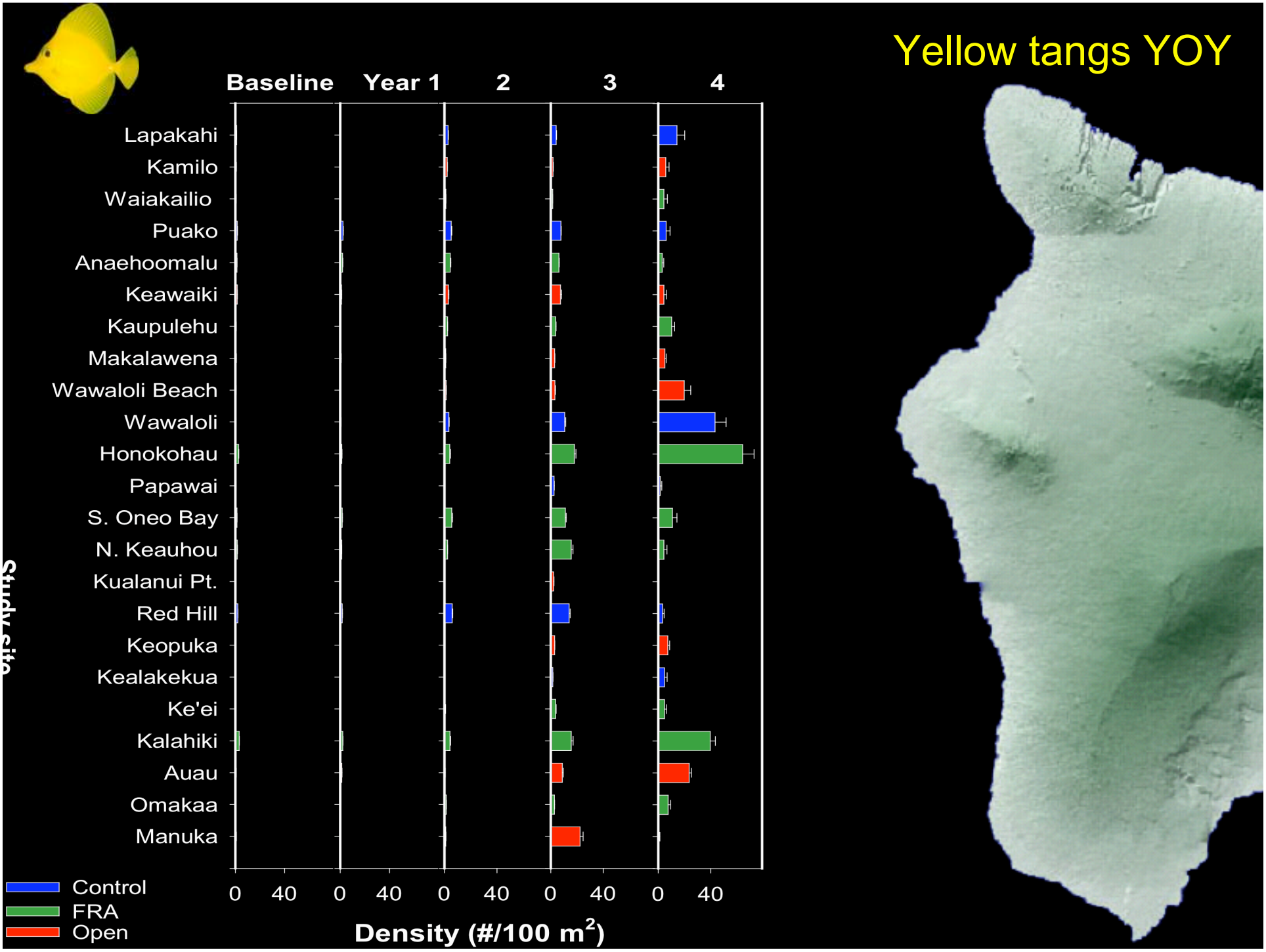
Before-After differences vary among locations

# 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% |

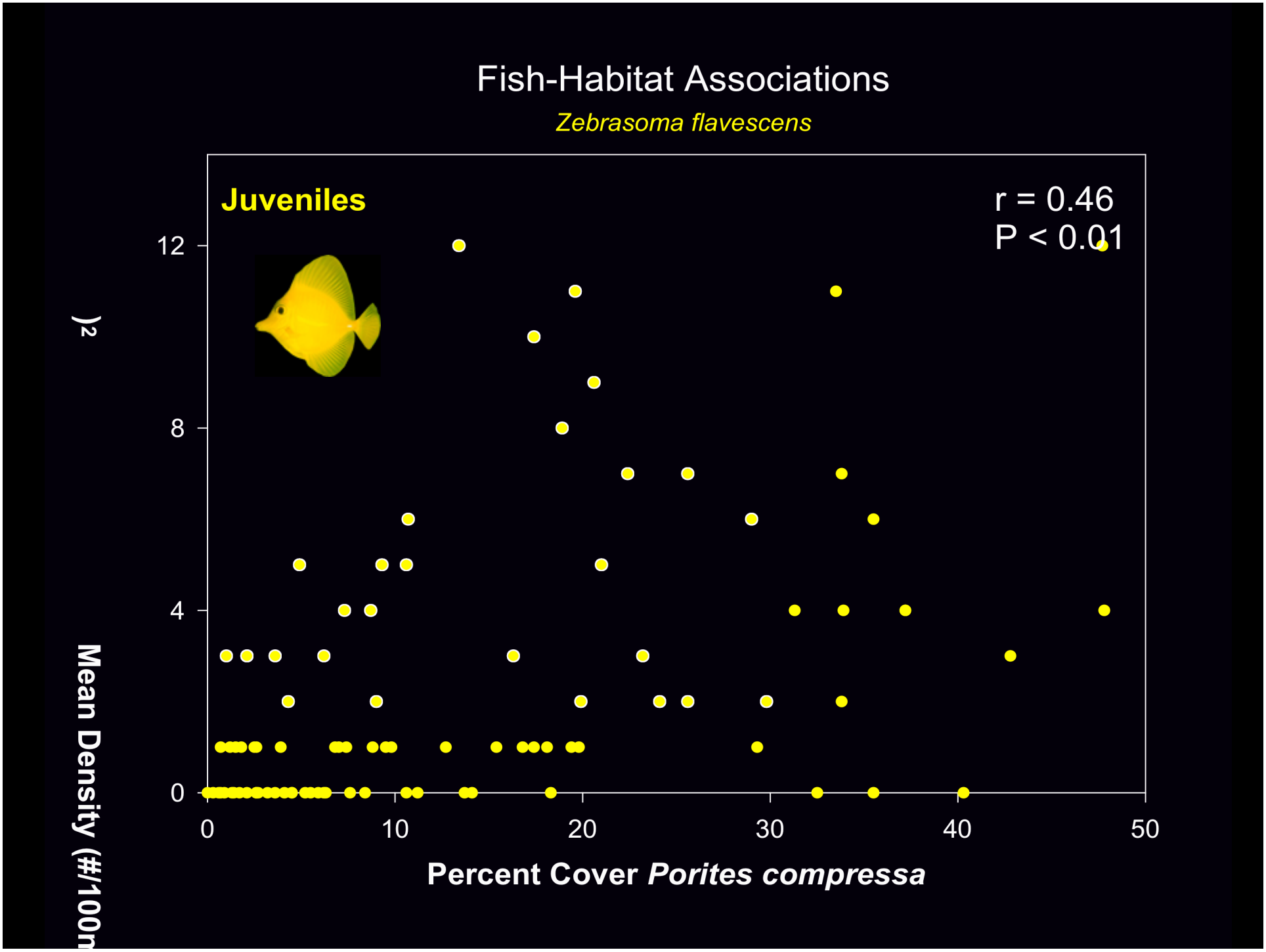
* Statistically significant at $P < 0.10$

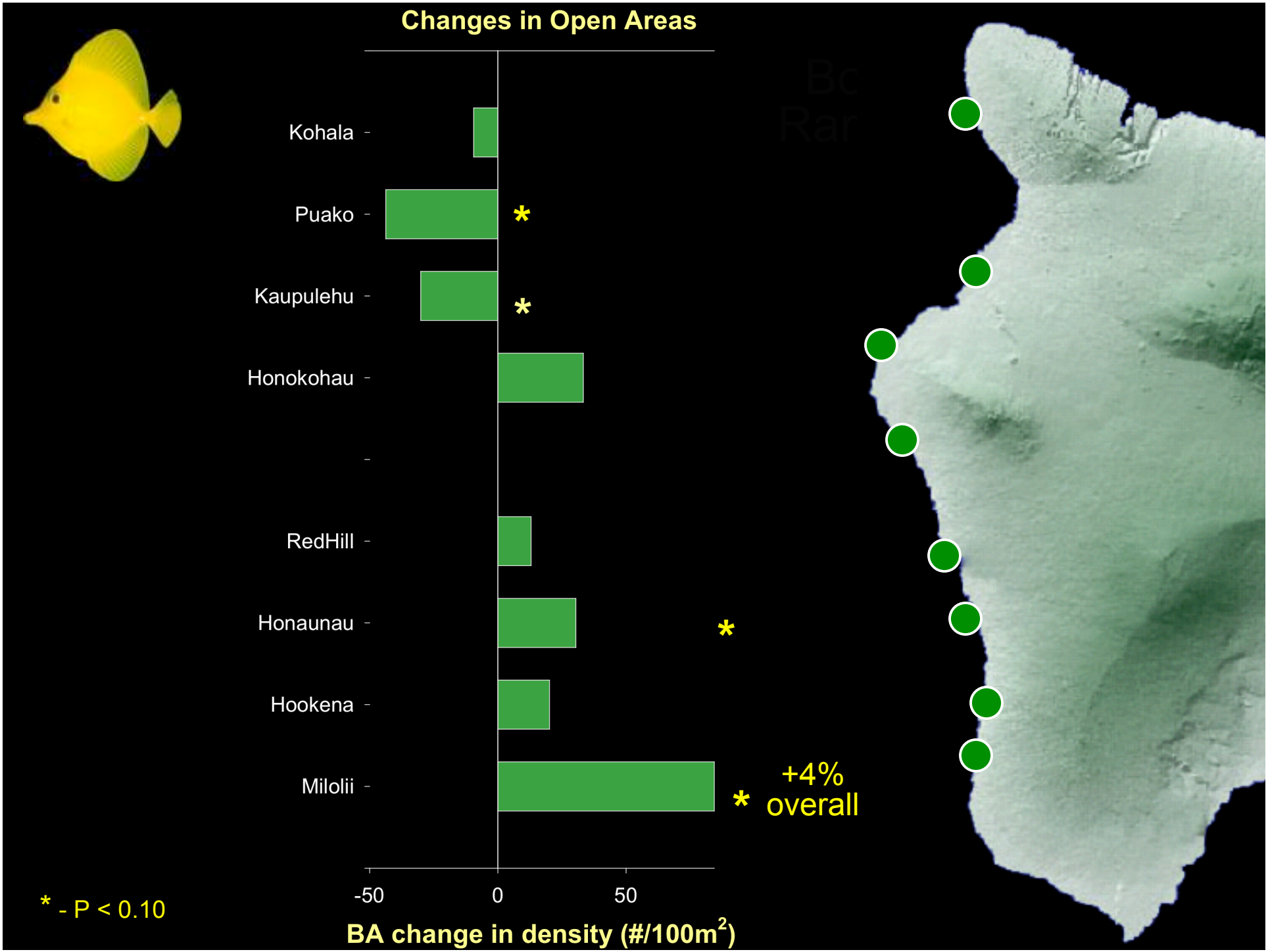

Reserve Effectiveness
Kohala
Puako
Kaupulehu
Honokohau
Kailua
RedHill
Honaunau
Hookena
Mililii
*
*
*
*
0
50
100
150
BA change in density (#/100m2)
* - P < 0.10
+49%
overall


Yellow tangs YOY
Baseline
Year 1
2
3
4
Lapakahi
Kamilo
Waiakailio
Puako
Anaehoomalu
Keawaiki
Kaupulehu
Makalawena
Wawaloli Beach
Wawaloli
Honokohau
Papawai
S. Oneo Bay
N. Keauhou
Kualanui Pt.
Red Hill
Keopuka
Kealakekua
Ke'ei
Kalahiki
Auau
Omakaa
Manuka
Study site
0
40
Control
FRA
Open
Density (#/100 m²)

# Fish-Habitat Associations

*Zebrasoma flavescens*




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

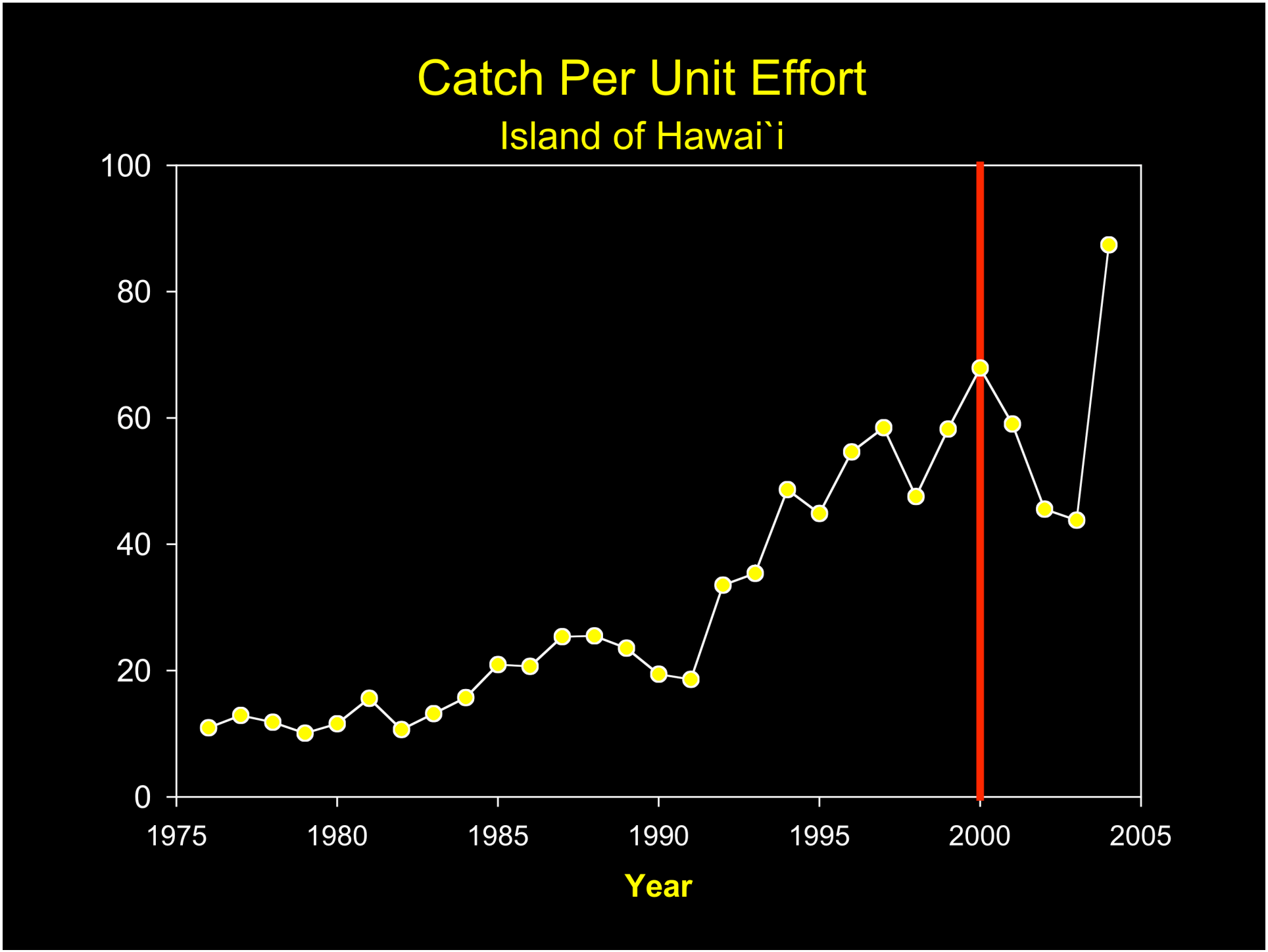
# Catch of Yellow Tangs

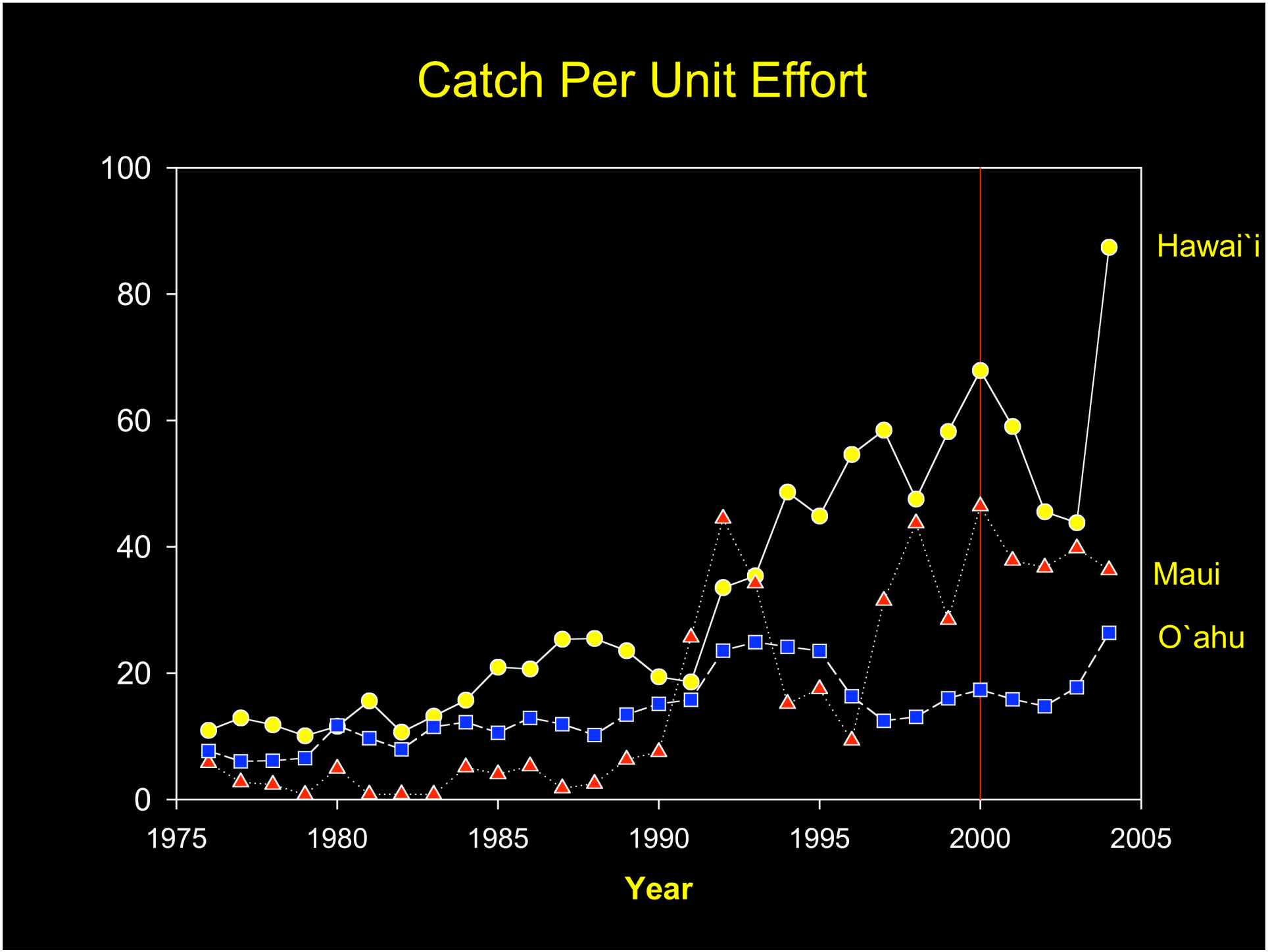
## Island of Hawai`i

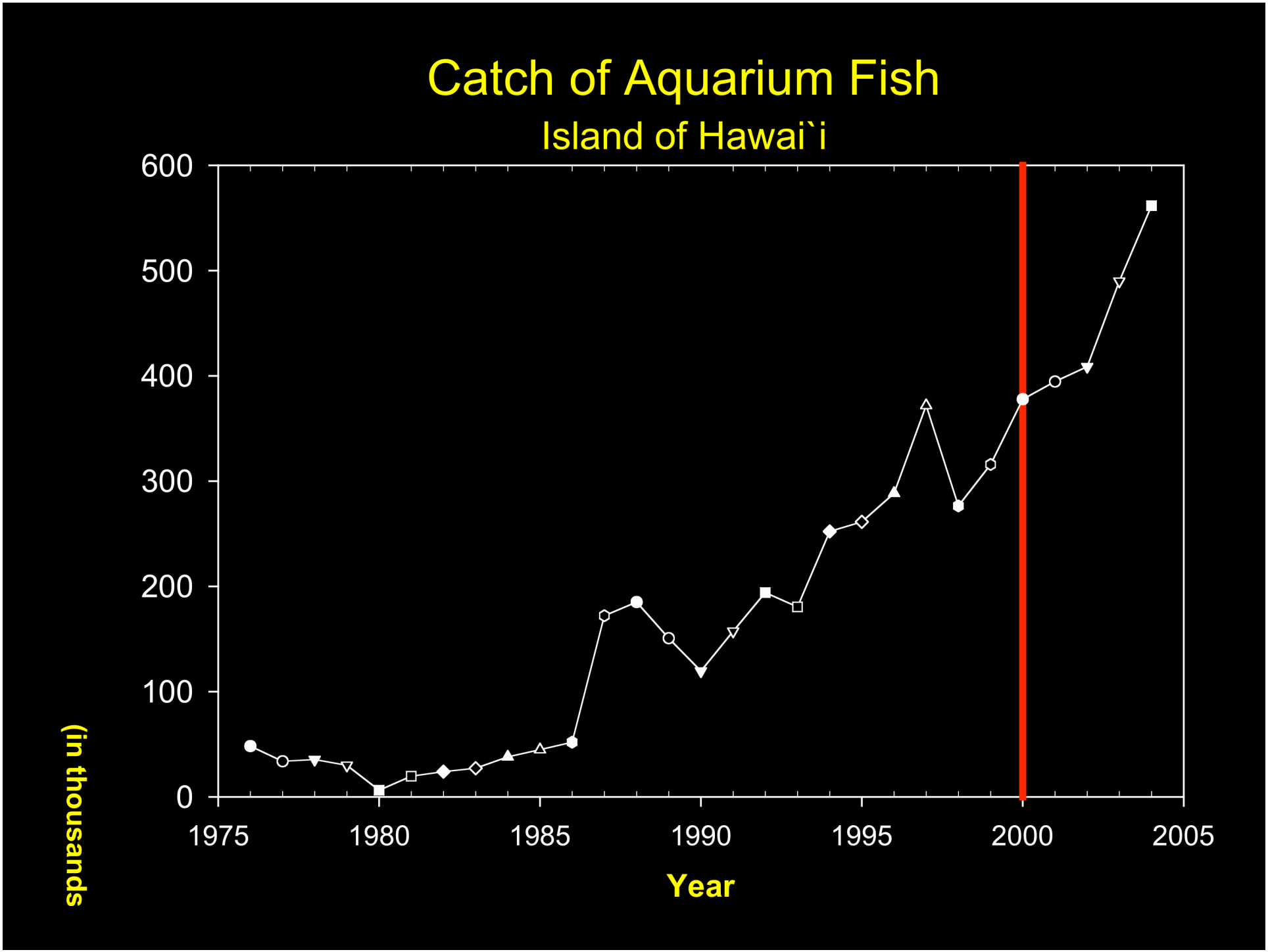
300000
250000
200000
150000
100000
50000
0

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