The effects of predators and habitat on sea urchin density and behavior in southern California kelp forests

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Outline

- Introduction
  - Factors that determine community structure in kelp forests
  - Study species
- Research questions
- Survey methods and experiment
- Results
- Significance

Community structure

- Bottom up vs. top down (Foster et al. 2006, Halpern et al. 2006, Steele et al. 2006)
- Bottom up
  - Temperature
  - Nutrients
- Top down
  - Predators can alter prey
    - Direct = consumption
    - Indirect =
      - changes in competitive interactions (Schmitt 1987)
      - behavior modification (Grabowski 2005)

Community structure in kelp forests

- Top-down effects are critical
  - Trophic cascades

    (Estes & Palimisano 1974, Estes et al. 1998)

(Tegner & Levin 1983, Lafferty 2004)

Panulirus interruptus

Semicossyphus pulcher

(Tegner & Levin 1983, Lafferty 2004)

Previous research

1. Lobster predation on sea urchins is size specific (Tegner & Levin 1983, Mayfield et al. 2001, Pederson & Johnson 2006)
2. Availability of shelter alters predation rates (Hereu et al. 2005)
3. Predatory fish presence can reduce urchin grazing & movement (Cowen 1983, Hereu 2005)
4. Marine reserve data suggests correlations between predators and urchin abundances (Tegner & Levin 1983, Mayfield & Branch 2000, Lafferty 2004)

Research questions

1. Does the abundance, size and behavior of red and purple sea urchins vary with the abundance of their potential predators?

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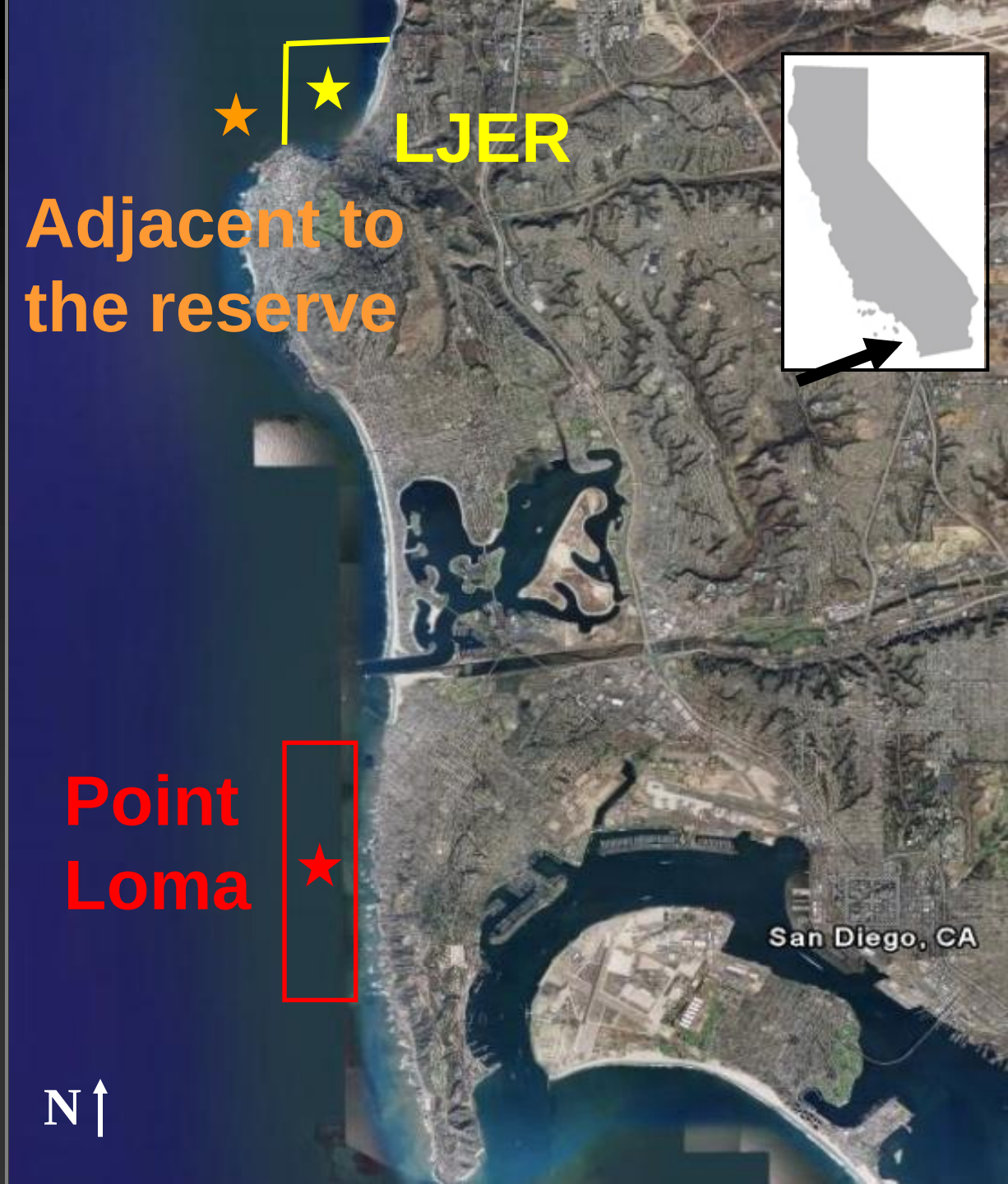
2. How do habitat and urchin density interact to affect urchin proportional mortality?

Study sites

- LJER
  - ~ 2.16 km^2
  - Est. 1971
- ATR
- PL
  - Visibly reduced density of large predatory fishes (Dayton et al. 1998, Loflen 2007)



Study species

Strongylocentrotus purpuratus

Strongylocentrotus franciscanus

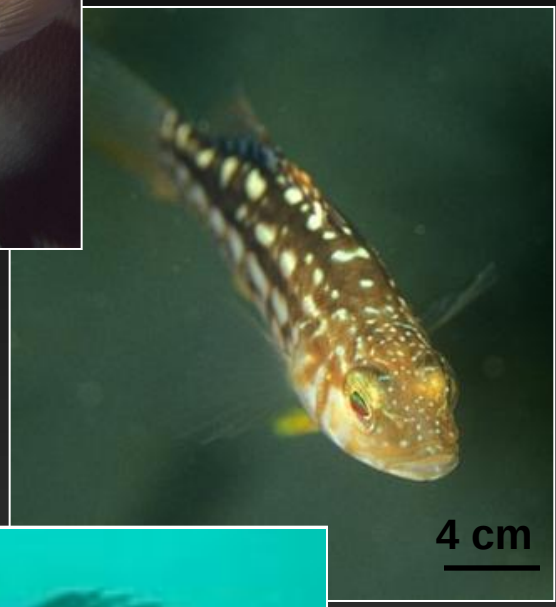
Research question

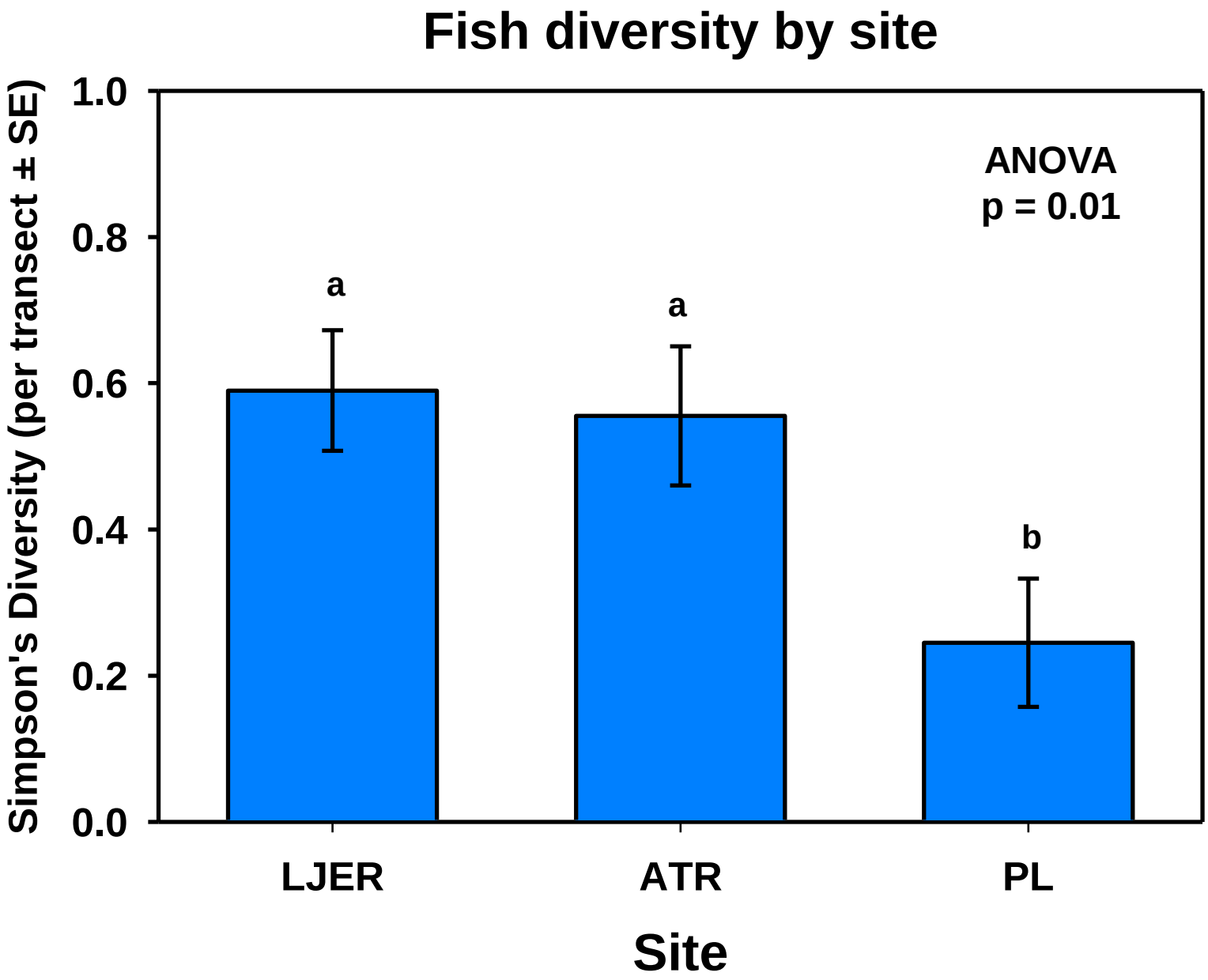
1. Does the abundance, size and behavior of red and purple sea urchins vary with the abundance of their potential predators?

Potential urchin predators

Methods

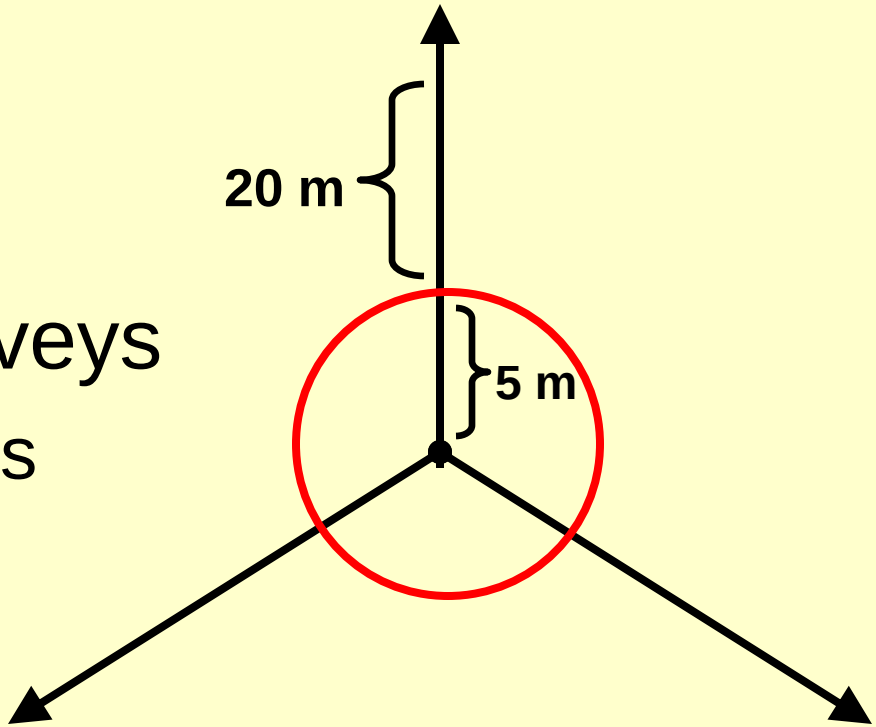
- Fish surveys
  - 25 m transects 4 x 4 m window
  - 13 species counted

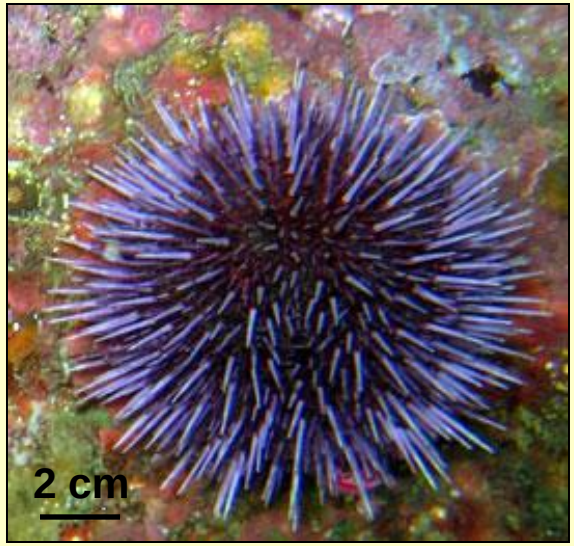


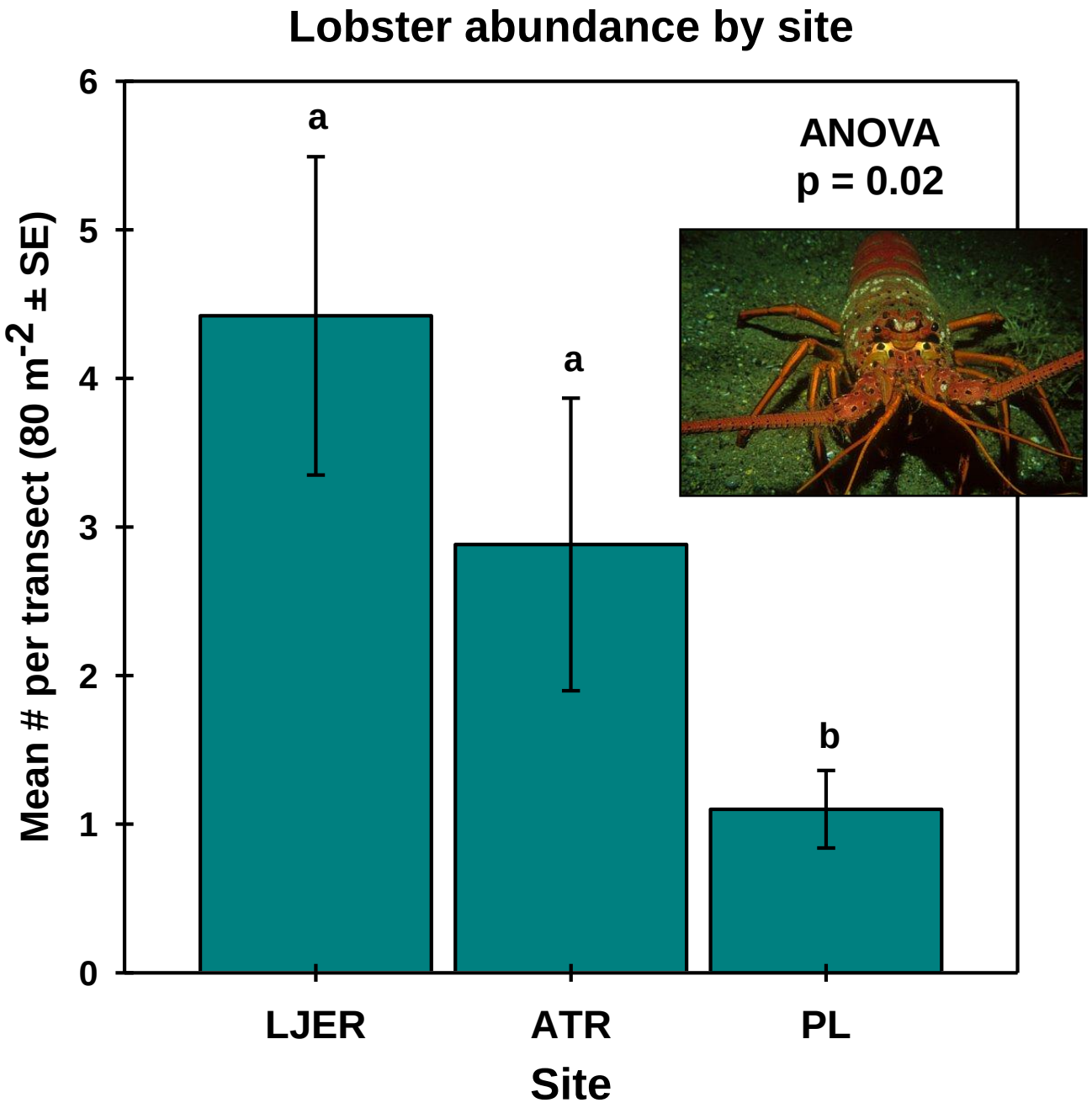

Fish diversity by site
Simpson's Diversity (per transect ± SE)
1.0
0.8
0.6
0.4
0.2
0.0
ANOVA
p = 0.01
a
a
b
LJER
ATR
PL
Site

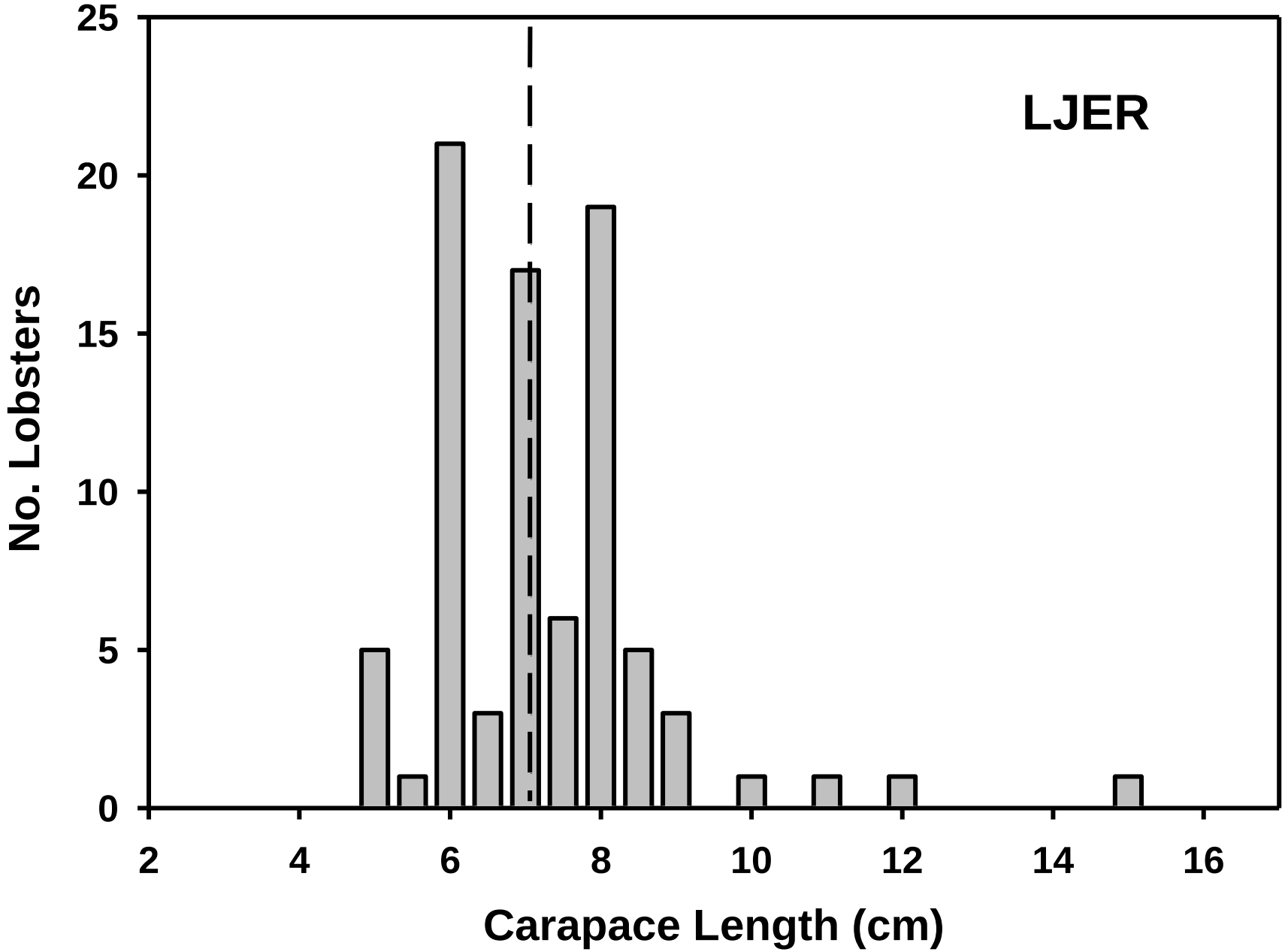
Methods

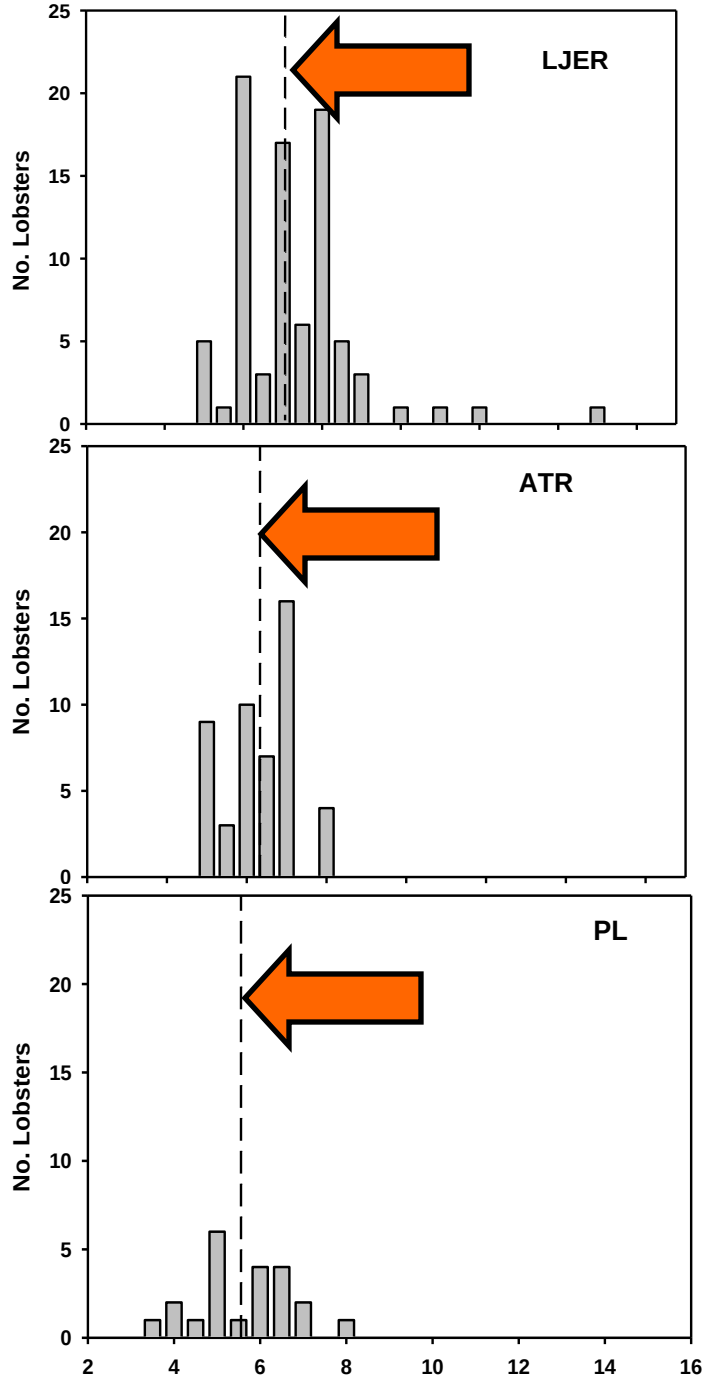
- Lobster and urchin surveys
  - 20 x 4 m radial transects
    - Size (CL & TD)
    - Habitat status






Lobster abundance by site
ANOVA
p = 0.02
a
a
b
6
5
4
3
2
1
0
Mean # per transect (80 m-2 ± SE)
LJER
ATR
PL
Site


LJER
No. Lobsters
Carapace Length (cm)
0
5
10
15
20
25
2
4
6
8
10
12
14
16



Means

ANOVA $p < 0.001$

LJER 7.25

N = 84

ATR 6.34

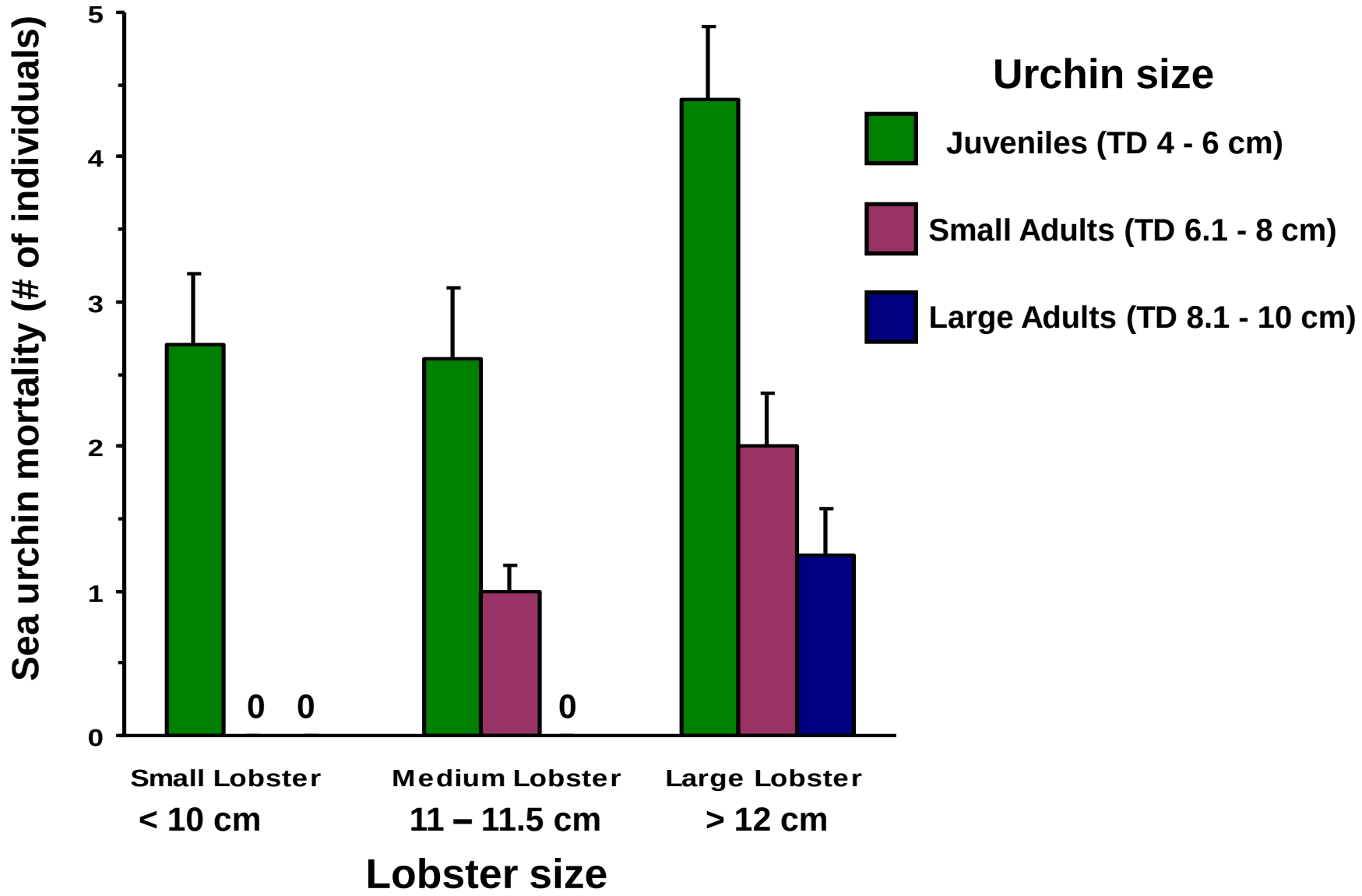
N = 49

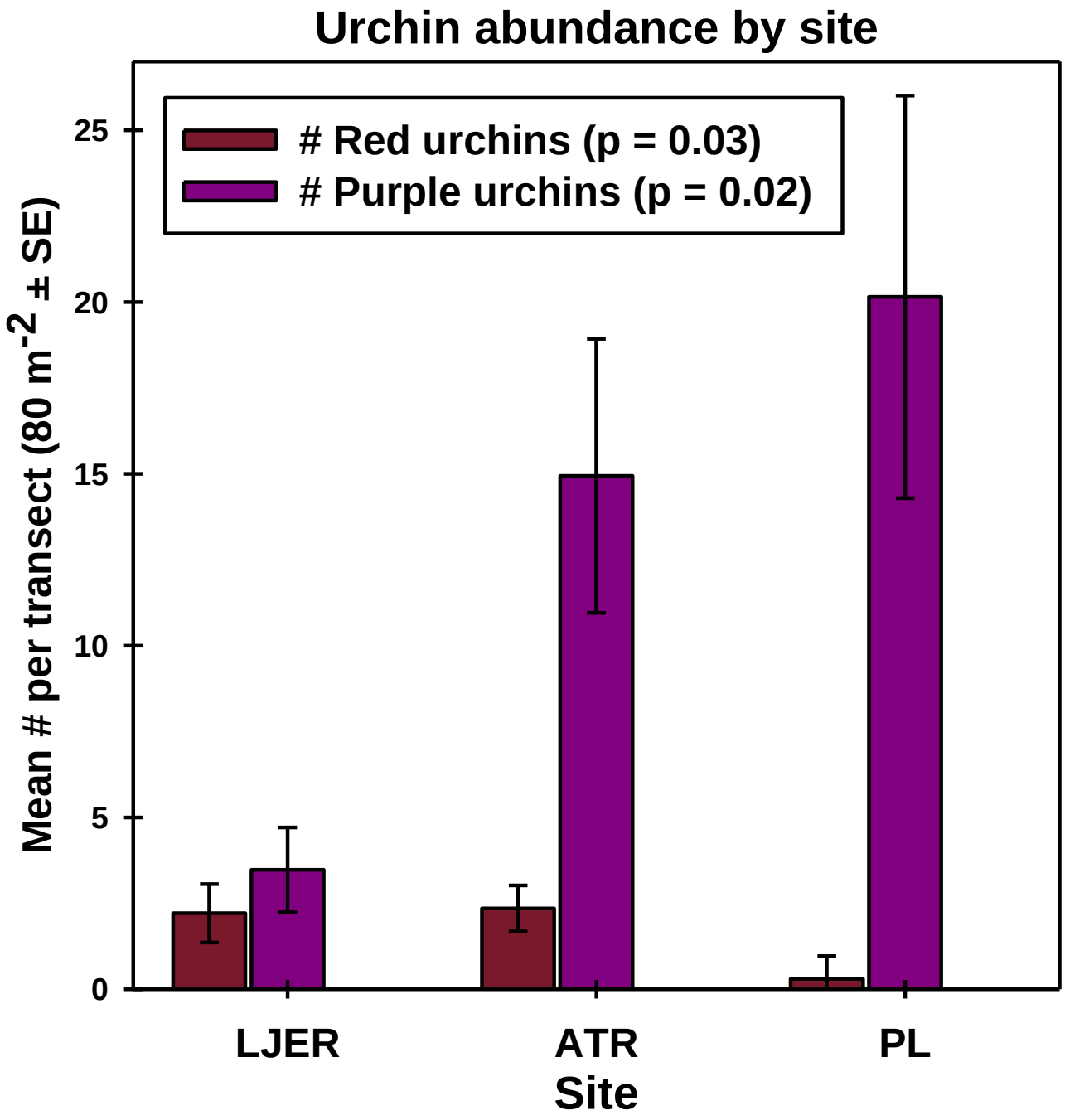
PL 5.61

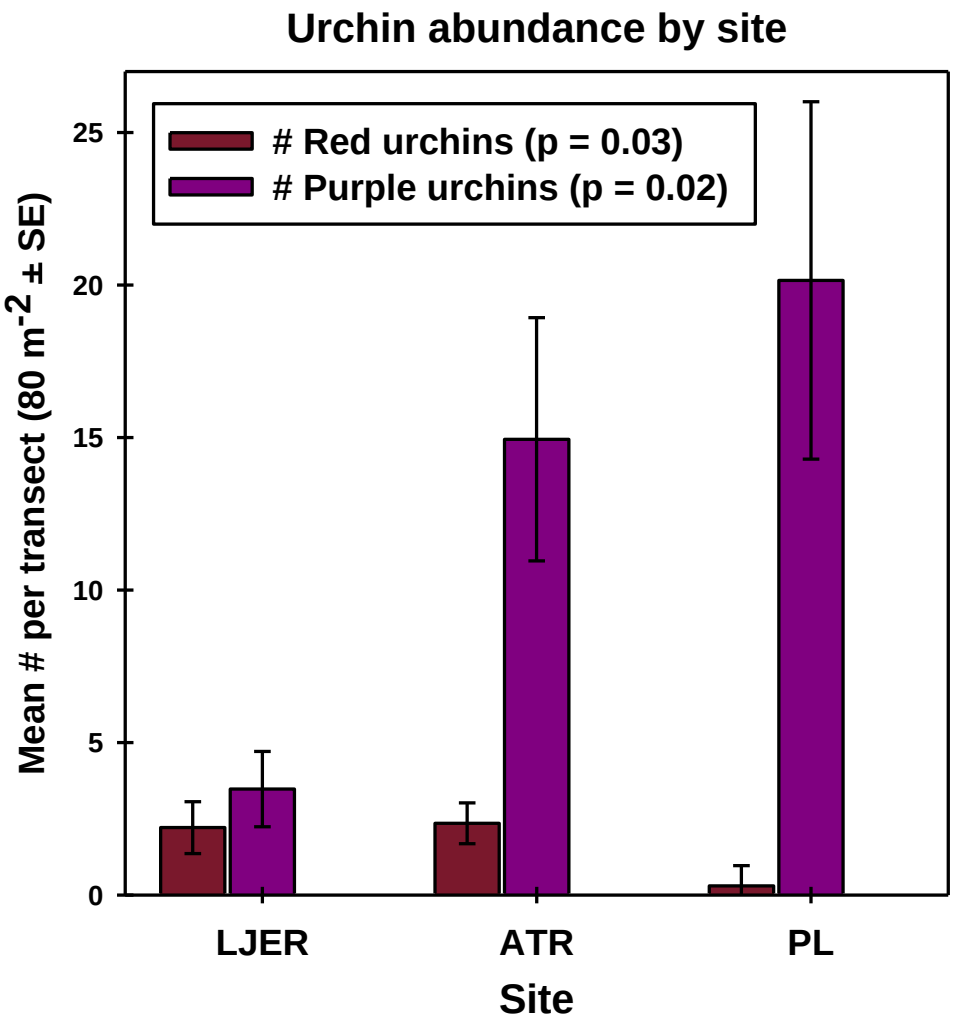
N = 22

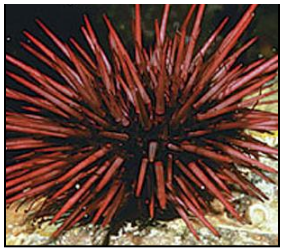
KS test $p < 0.001$

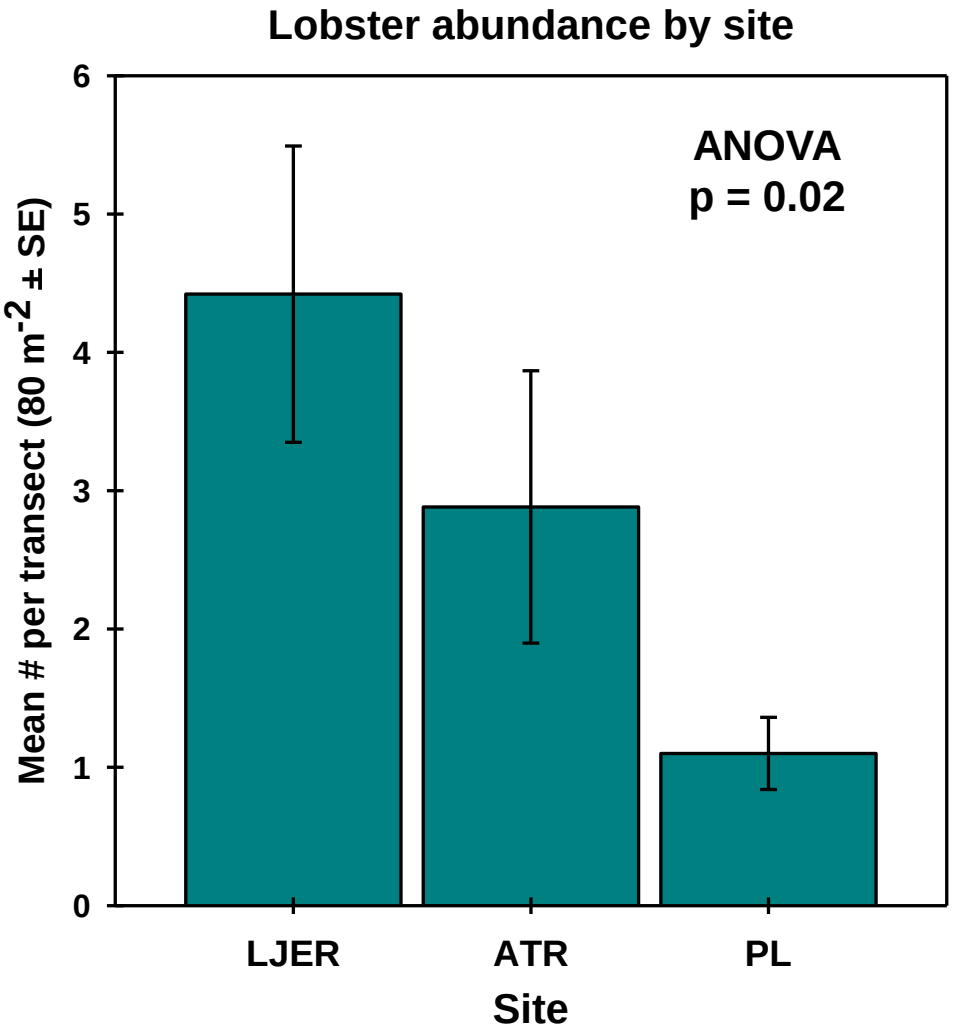
Previous research (adapted from Pederson & Johnson 2006)




Urchin abundance by site
Red urchins (p = 0.03)
Purple urchins (p = 0.02)
Mean # per transect (80 m-2 ± SE)
0
5
10
15
20
25
LJER
ATR
PL
Site


Urchin abundance by site
Red urchins (p = 0.03)
Purple urchins (p = 0.02)
Mean # per transect (80 m-2 ± SE)
0
5
10
15
20
25
LJER
ATR
PL
Site




Lobster abundance by site
ANOVA
p = 0.02
Mean # per transect (80 m-2 ± SE)
0
1
2
3
4
5
6
LJER
ATR
PL
Site

Research question

1. Does the abundance, size and behavior of red and purple sea urchins vary with the abundance of their potential predators?

Urchin behavior

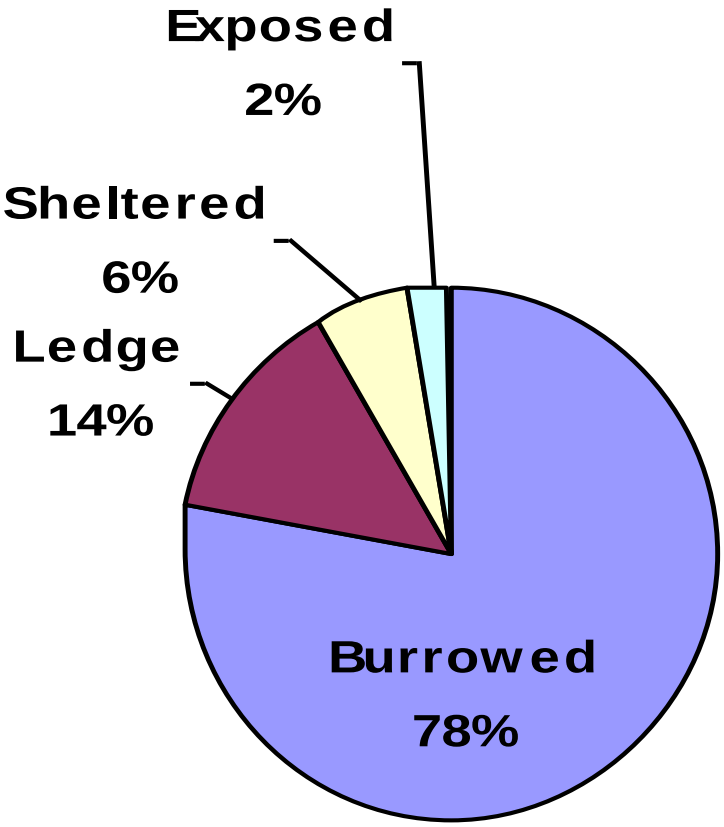
- Does urchin behavior change due to predation risk?
- Urchin habitat status quantified as:

- Sheltered
- Burrowed
- Ledge
- Exposed

Purple urchin habitat status

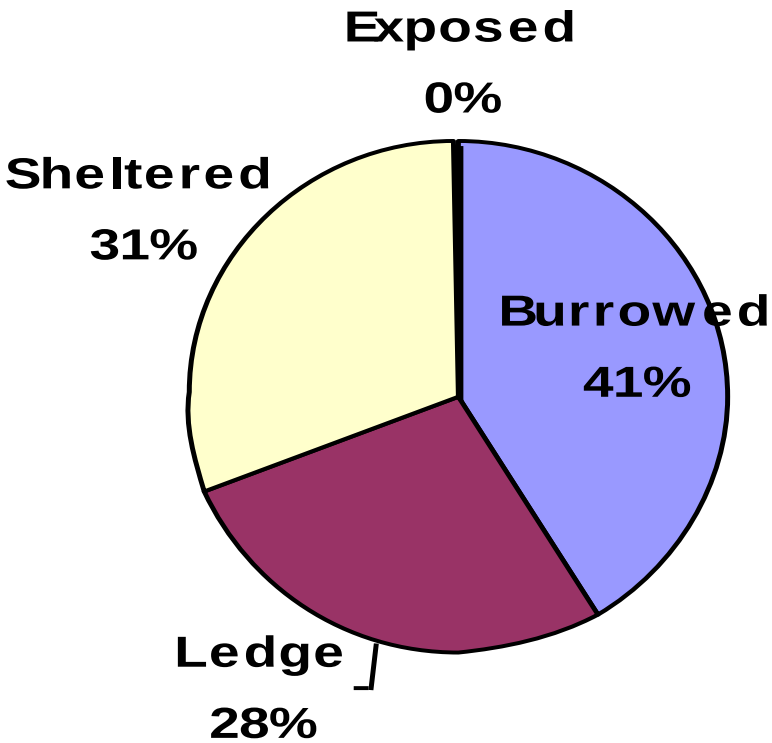
Pt. Loma

N = 85



LJER

N = 87



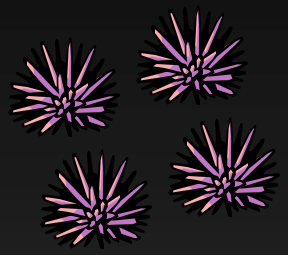
Summary

1. Does the abundance, size and behavior of red and purple sea urchins vary with the abundance of their potential predators?
   - In general, predators were less abundant outside the reserve
   - Purple urchins more abundant outside the reserve
   - Behavioral changes present

Research question

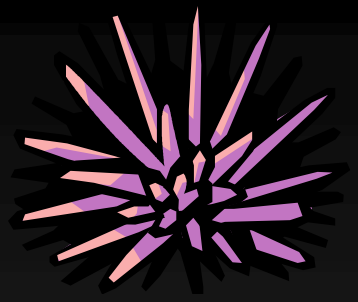
1. Does the abundance, size and behavior of red and purple sea urchins vary with the abundance of their potential predators?
2. How do habitat and urchin density interact to affect urchin proportional mortality?

Methods – Proportional mortality experiment



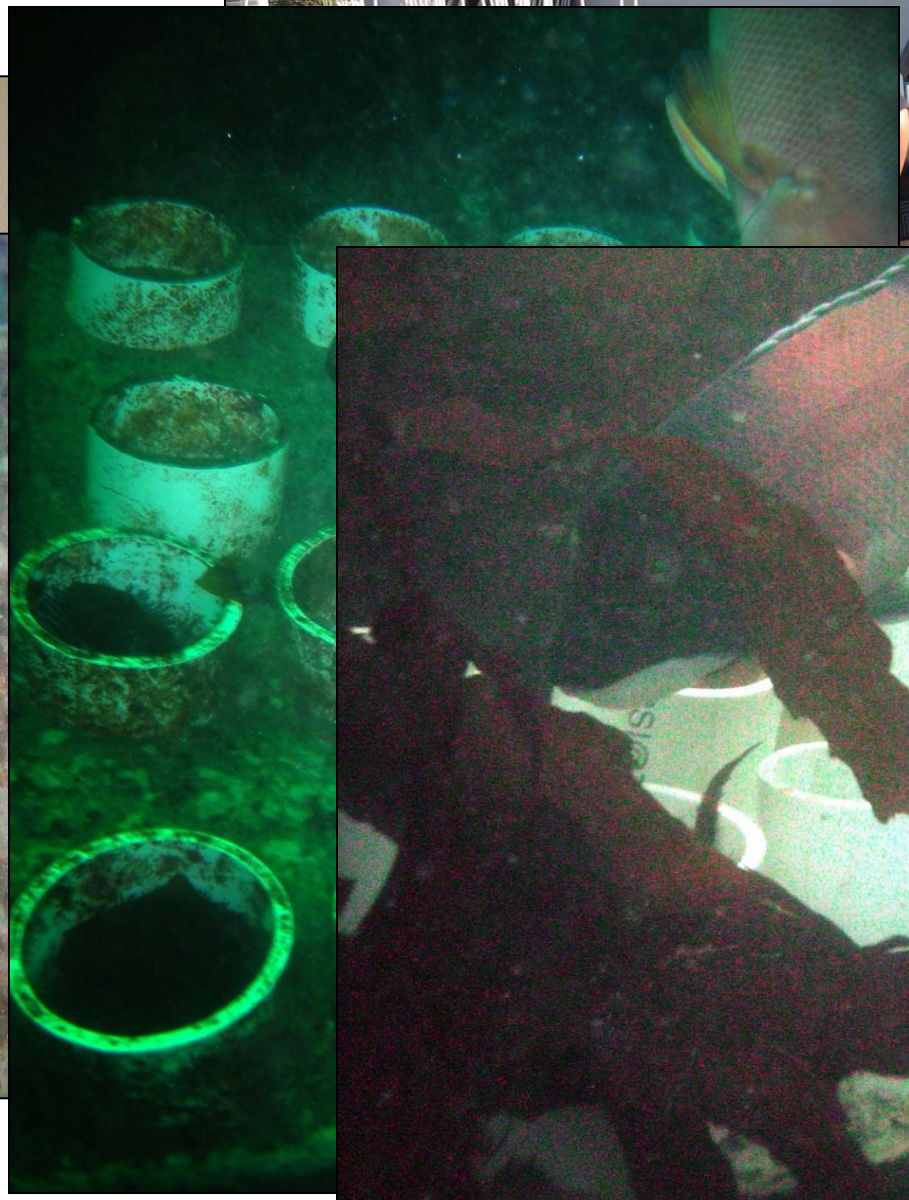
- Density (4, 8, 16 & 24 urchins)
- Time of day (diurnal vs. nocturnal)
- Algal cover

Methods



- Urchin habitat units (UHUs)
- Purple urchins
  - 6 - 8 cm TD (Tegner & Levin 1983, Pederson & Johnson 2006)
- 3 variables
  - Density (4 levels)
  - Time of day (day vs. night)
  - Algal cover (cover vs. no cover)
- 1 hour exposure

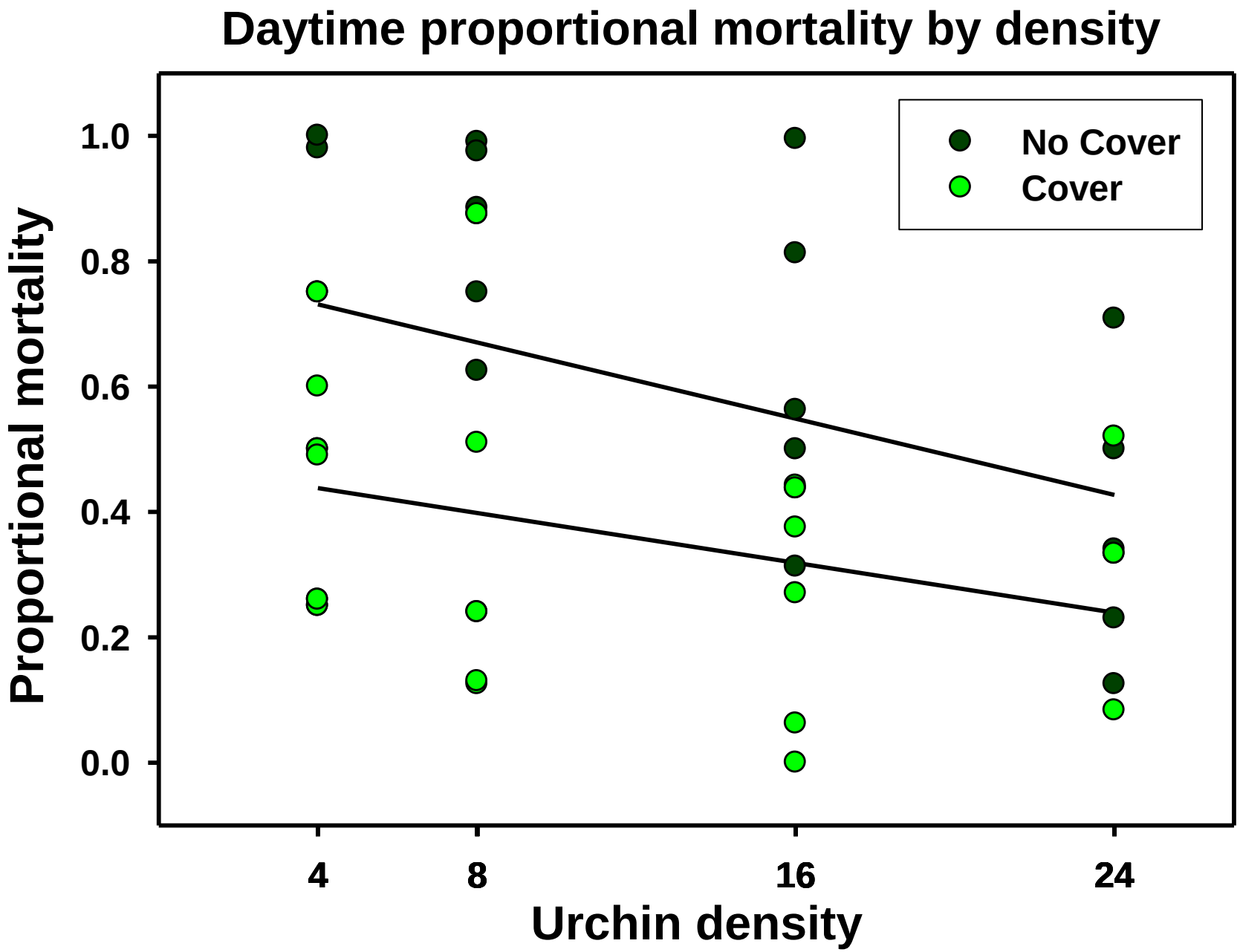
Methods

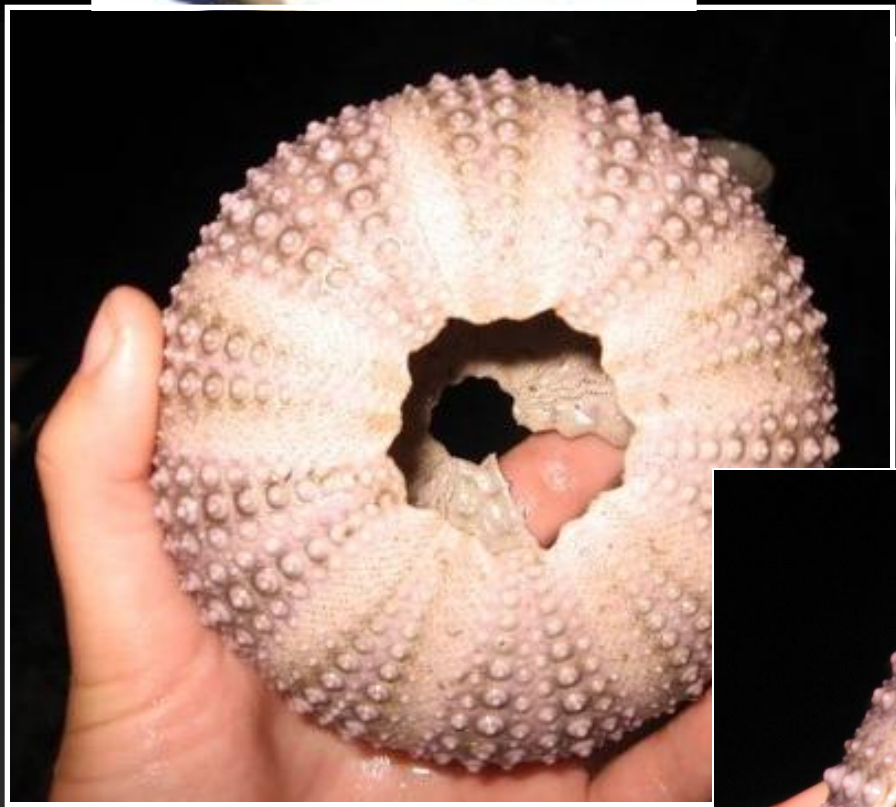


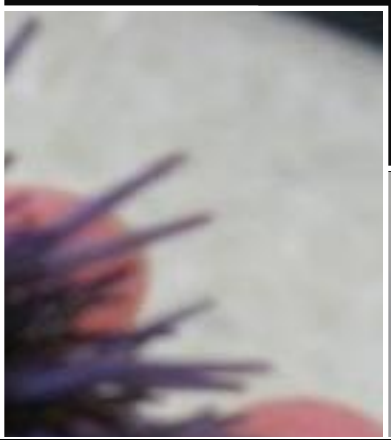
ANCOVA results

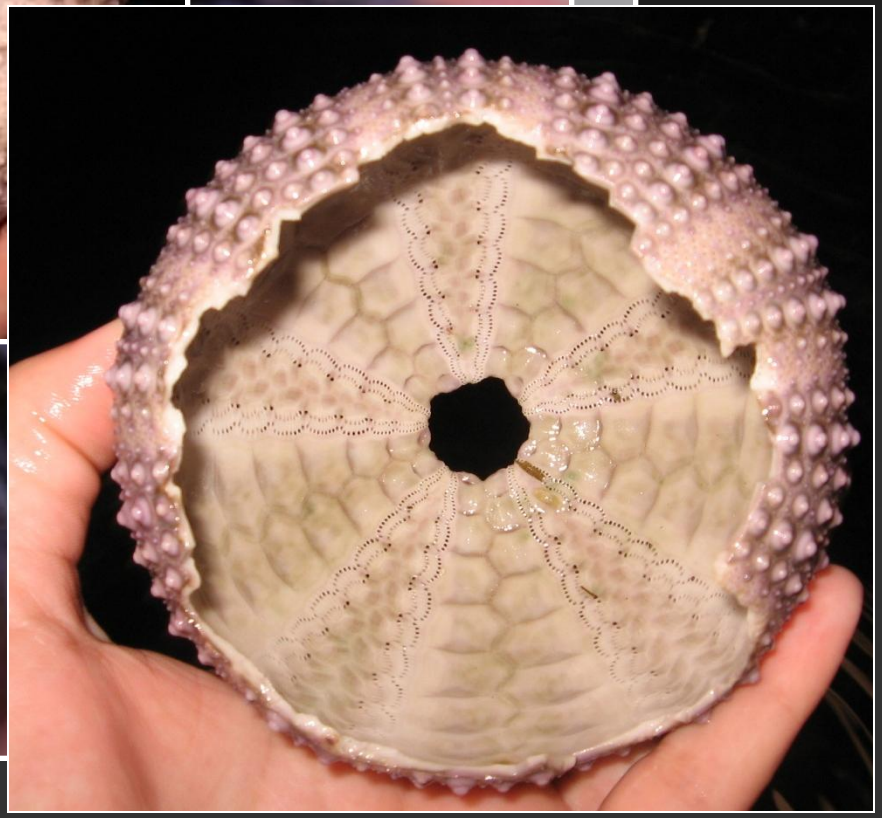
Source	Type III SS	df	MS	F-ratio	P
Time of day	0.498	1	0.498	7.834	**0.007**
Density	0.421	3	0.140	2.210	**0.099**
Cover	0.089	1	0.089	1.407	0.241
Time of day x cover	0.209	1	0.209	3.296	**0.076**
Error	3.113	49	0.064		

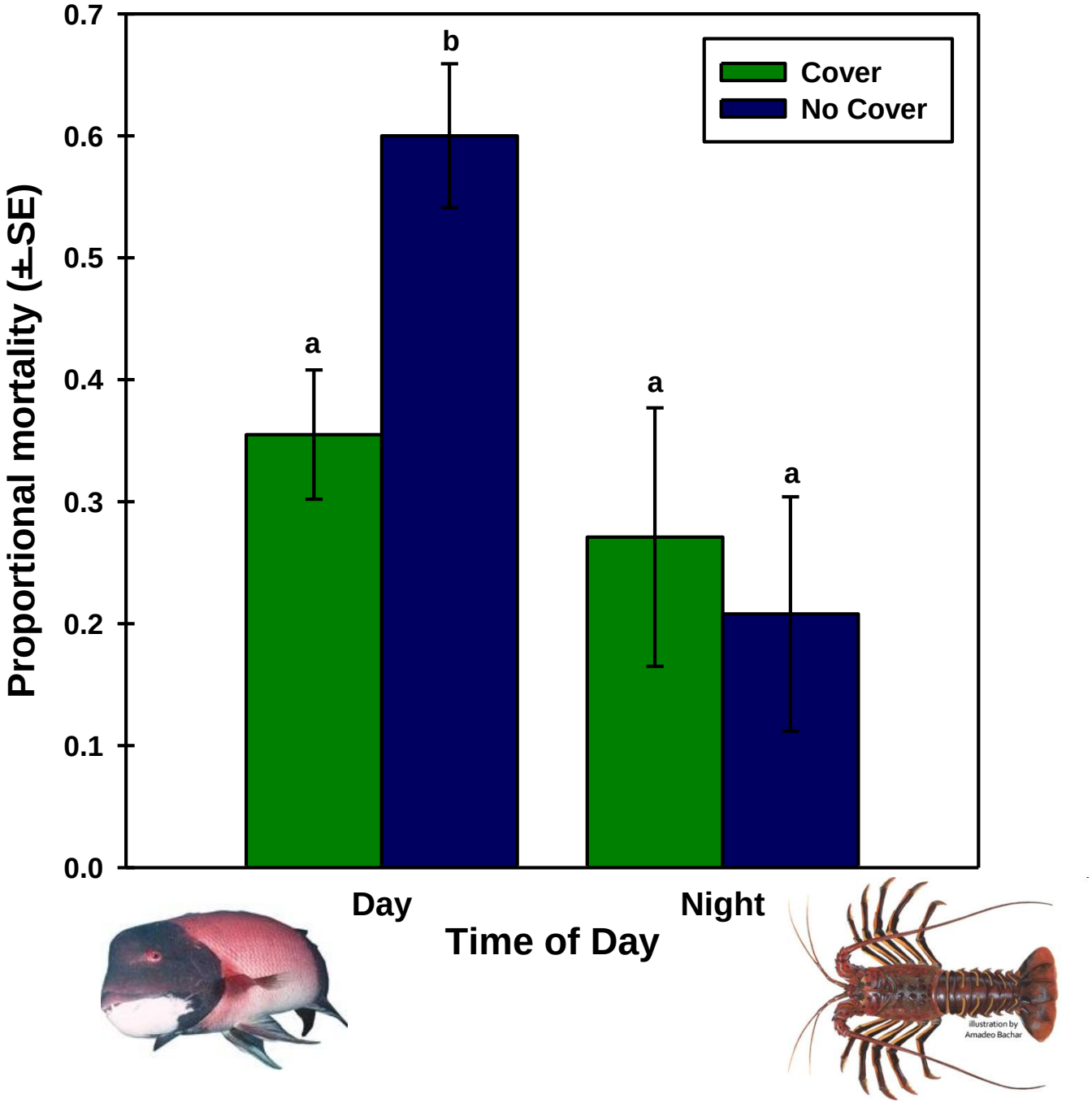
- **Post hoc pooling (Underwood 1997)**
- **Adopted an alpha level of 0.1 (Dayton et al. 1999)**


Daytime proportional mortality by density
No Cover
Cover
Proportional mortality
1.0
0.8
0.6
0.4
0.2
0.0
4
8
16
24
Urchin density








0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Proportional mortality (±SE)
b
a
a
a
Cover
No Cover
Day
Night
Time of Day
illustration by
Amadeo Bachar

Summary

2. How do habitat and urchin density interact to affect urchin proportional mortality?
   - Proportional mortality decreased with urchin density
   - There was an interactive effect of cover and time of day
   - Algal cover reduced urchin mortality during the day, but not at night

Summary

- Urchin abundances and behavior varied among sites
- Predators may influence urchin abundances and behavior
- Habitat and urchin density influence proportional mortality
- Proportional mortality was inversely density dependent

Significance

- Examining population regulation of urchins is important due to potential cascading effects
- Overexploitation of species could have dramatic effects in kelp forests
- Promote practical management of fished species
- Increase information on marine reserves

Acknowledgements

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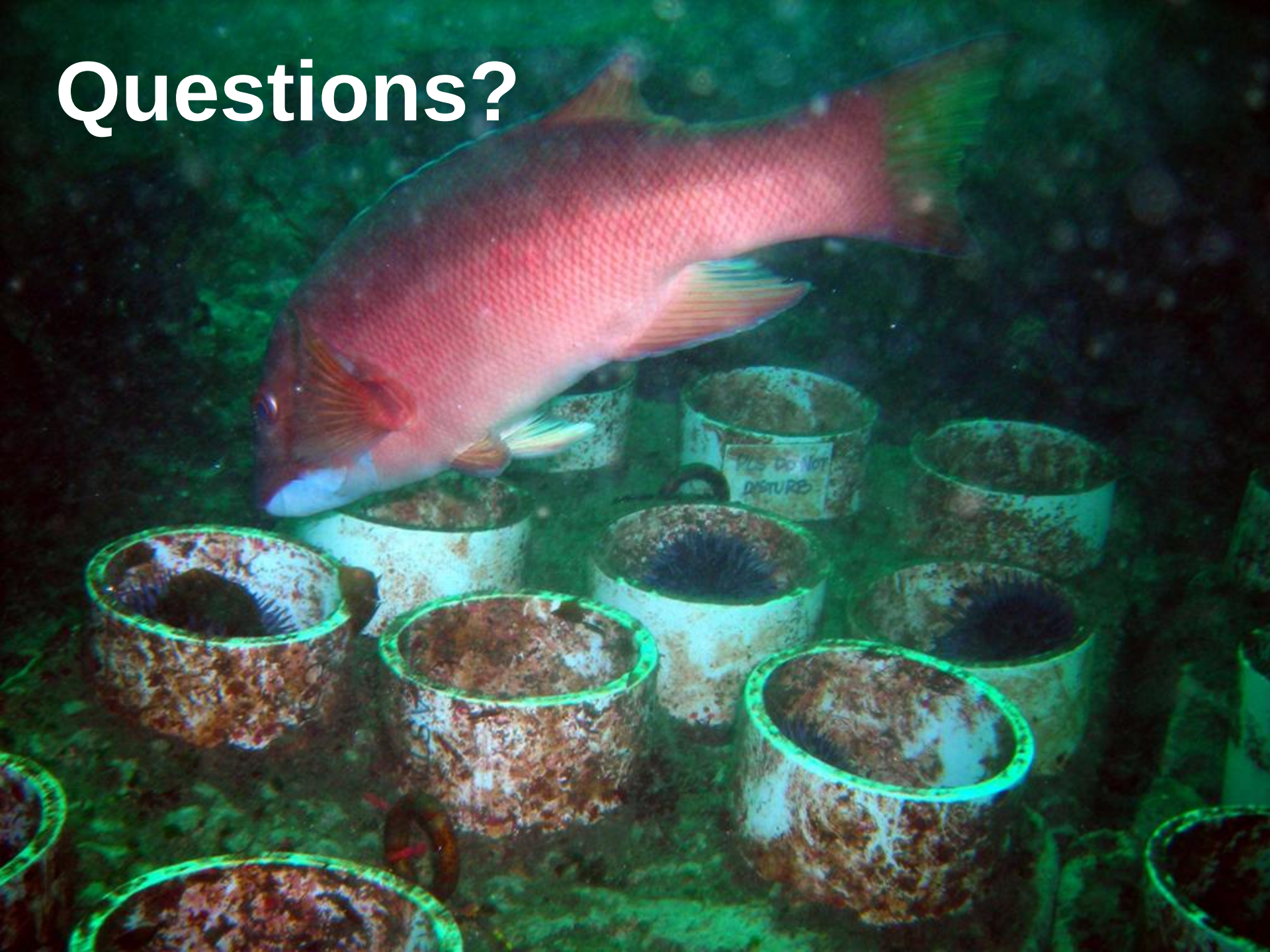
Questions?