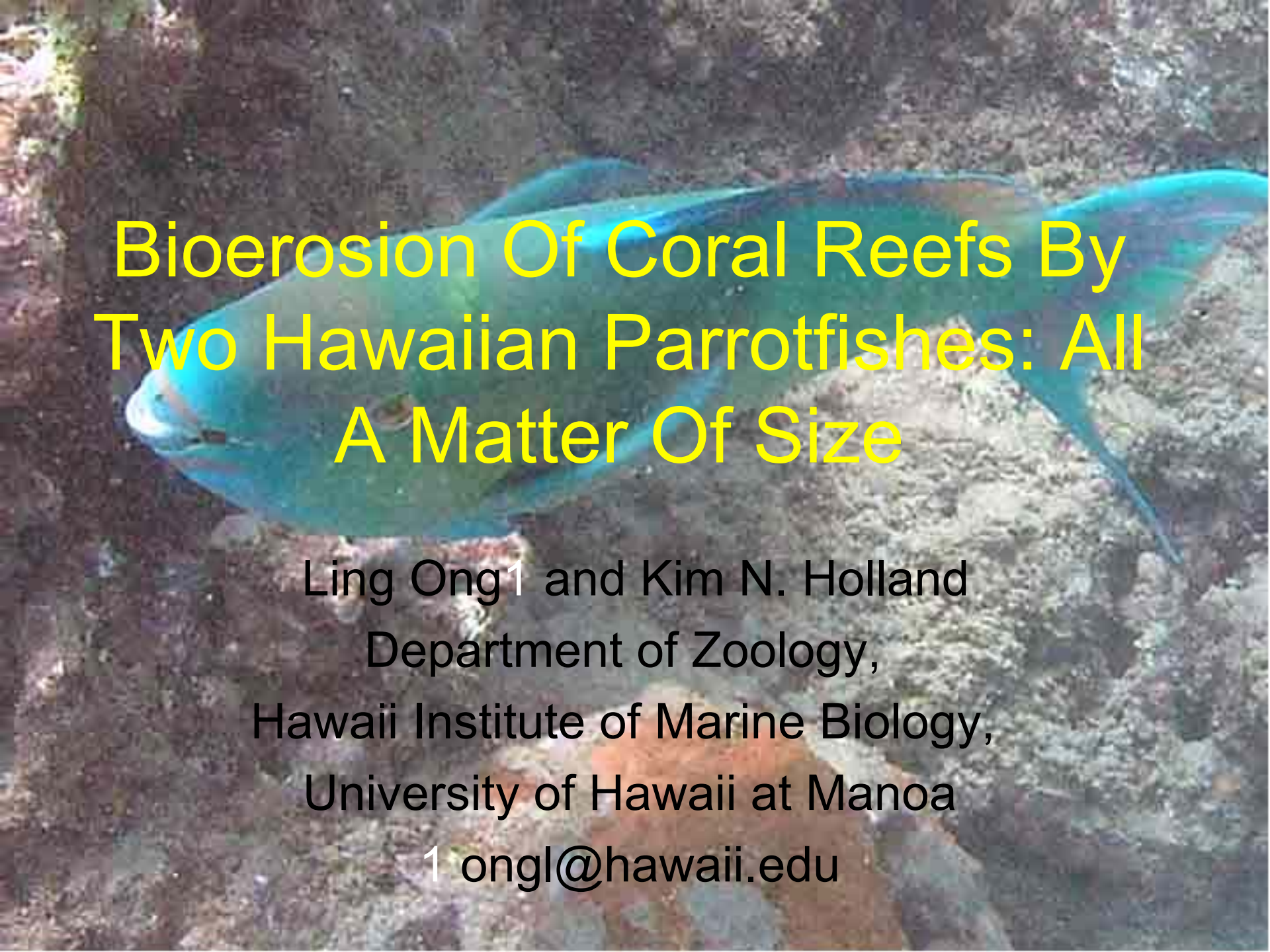

Bioerosion Of Coral Reefs By Two Hawaiian Parrotfishes: All A Matter Of Size

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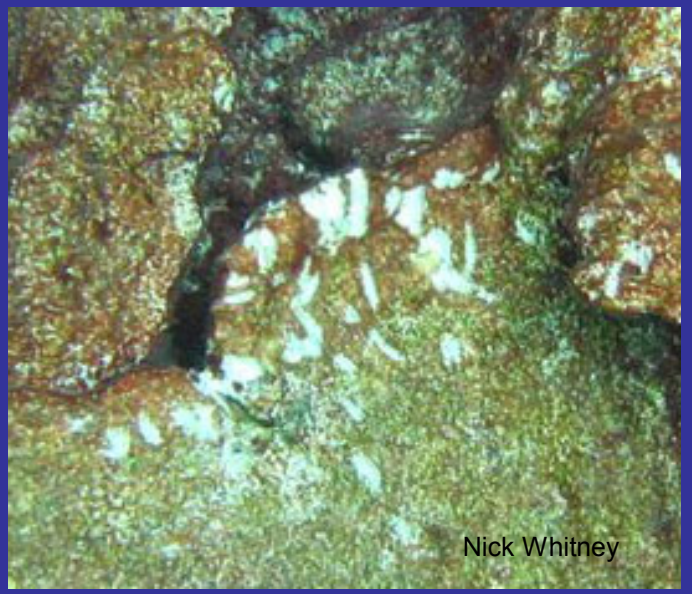
What are parrotfish?

- Herbivores
- Beaklike oral jaws of fused teeth

Humphead parrotfish
Bolbometopon muricatum

Bioerode the reef



- Pharyngeal mill - eroded substrate is ground up and defecated as sediment

What are parrotfishes?

Terminal phase

Initial phase

Protogynous haemaphrodites

Why are parrotfish of concern?

- 13 to 31 tons annual commercial harvest between 1997 and 2006 (DAR, 2005)
- Little known about the ecological importance of parrotfish in Hawaii

- Ecologically important as grazers
  - reduce macroalgal cover
  - maintain coral cover

  (Mumby et al. 2006, 2007)

- Ecologically important as bioeroders

  (Bruggemann et al. 1996, Bellwood 1995)

Immediate effects

Near future

Geologic future

Incorporation of sediment into reef matrix

Increased juvenile coral survival

Reef accretion

Maintain coral cover

Maintain Sediment communities

Reef erosion

Grazing of coralline algae

Bioerosion of reef substrate

Goal

- Determine ecological importance of 2 species of parrotfishes in Hawaii as bioeroders and sand producers

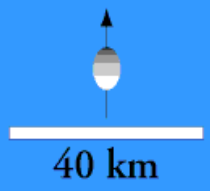
Hawaii

Kauai

Molokai

Maui

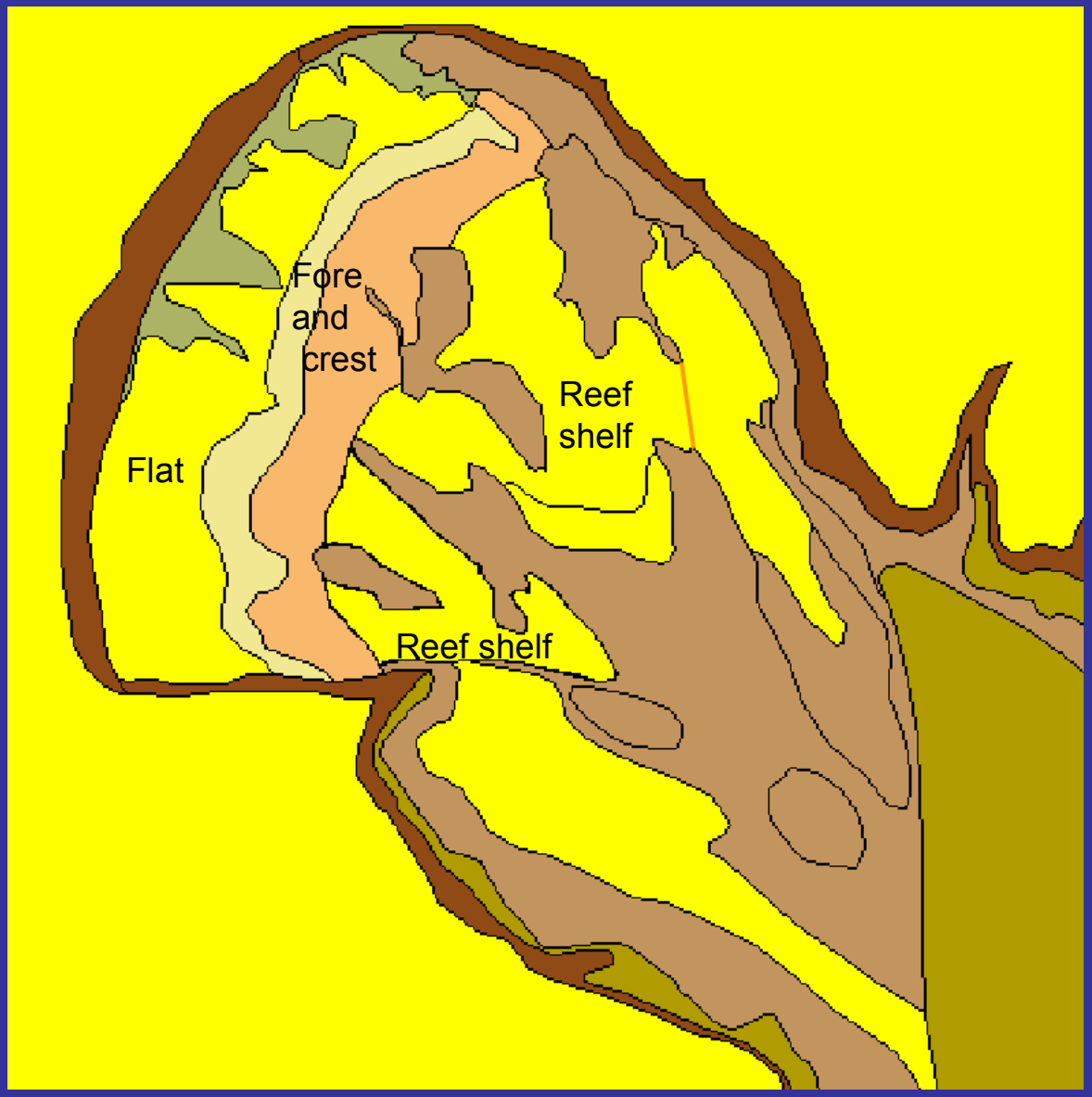
Lanai



Hanauma Bay

Scarus rubroviolaceus
Redlip parrotfish *60 cm*

Chlorurus perspicillatus
Spectacled parrotfish *55 cm*


Fore
and
crest
Reef
shelf
Flat
Reef shelf

How much reef does a parrotfish erode in a year (Bellwood 1995, Bruggemann et al. 1996)?

Bioerosion per fish

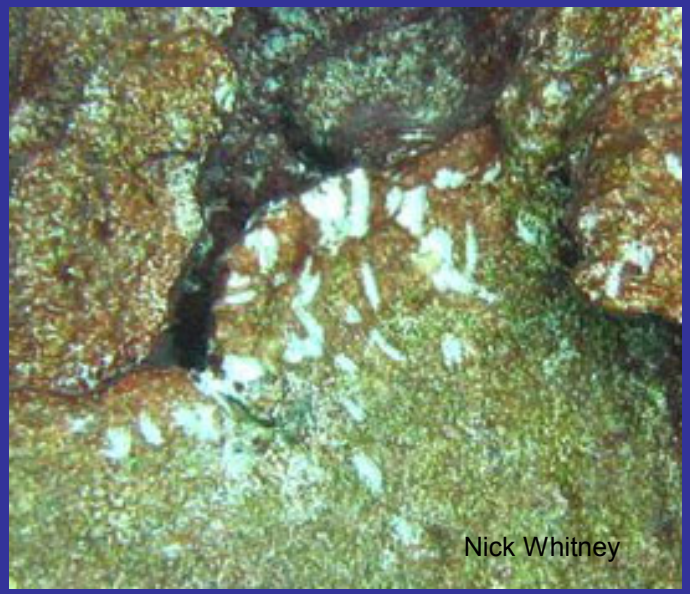
per year = bite volume X

no. bites per day X

days per year X

proportion of bites

leaving scars



25 - 34 cm
35 - 44 cm
45 - 54 cm

How much reef does a parrotfish erode in a year?

Bioerosion per fish

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no. bites per day X

days per year X

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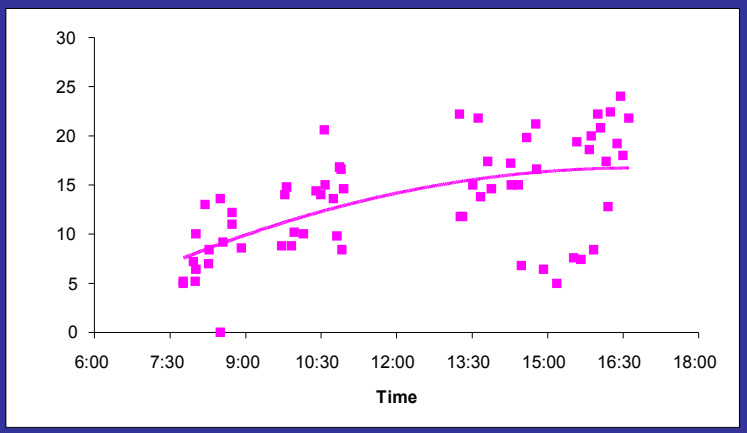
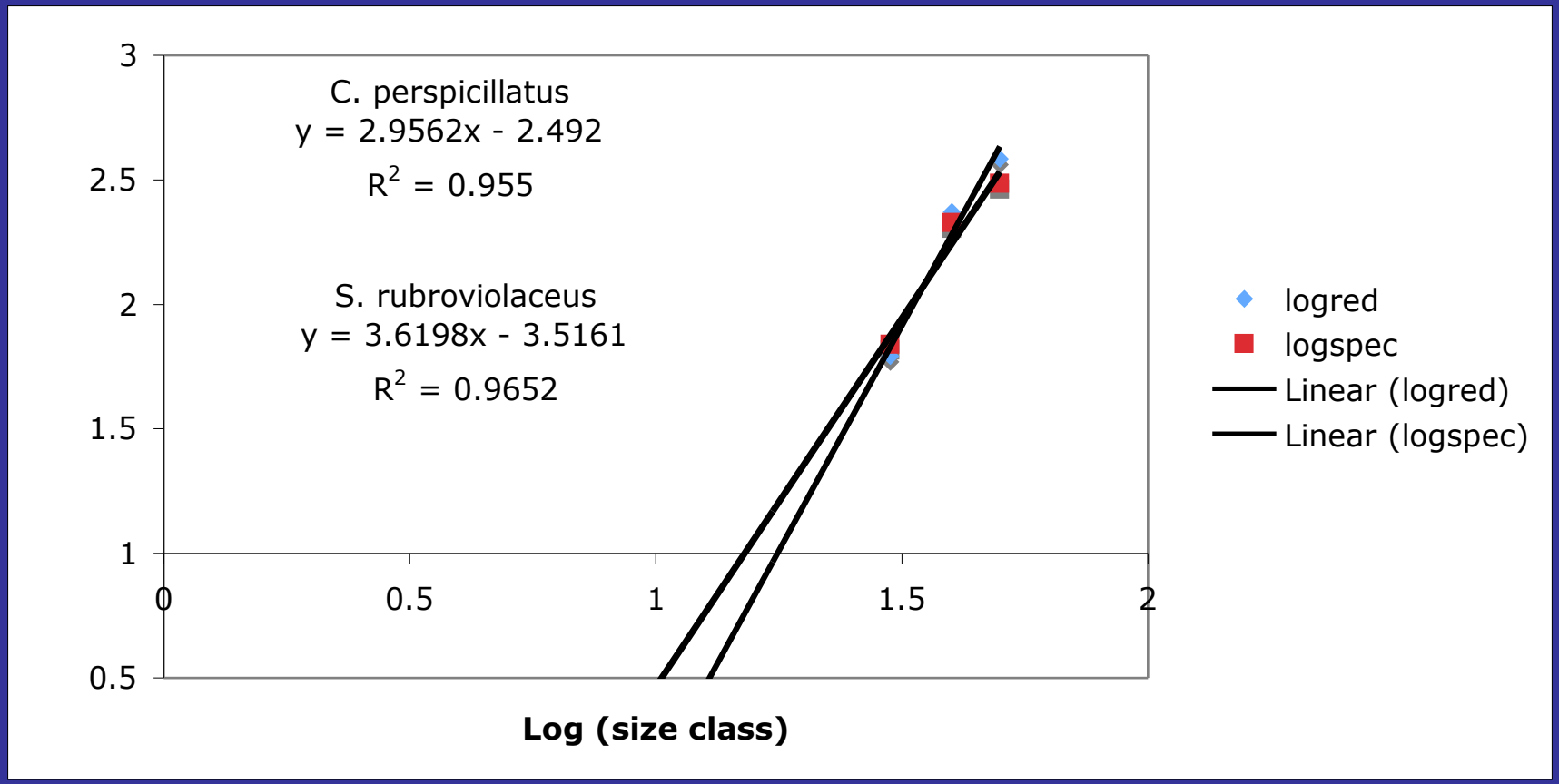
leaving scars

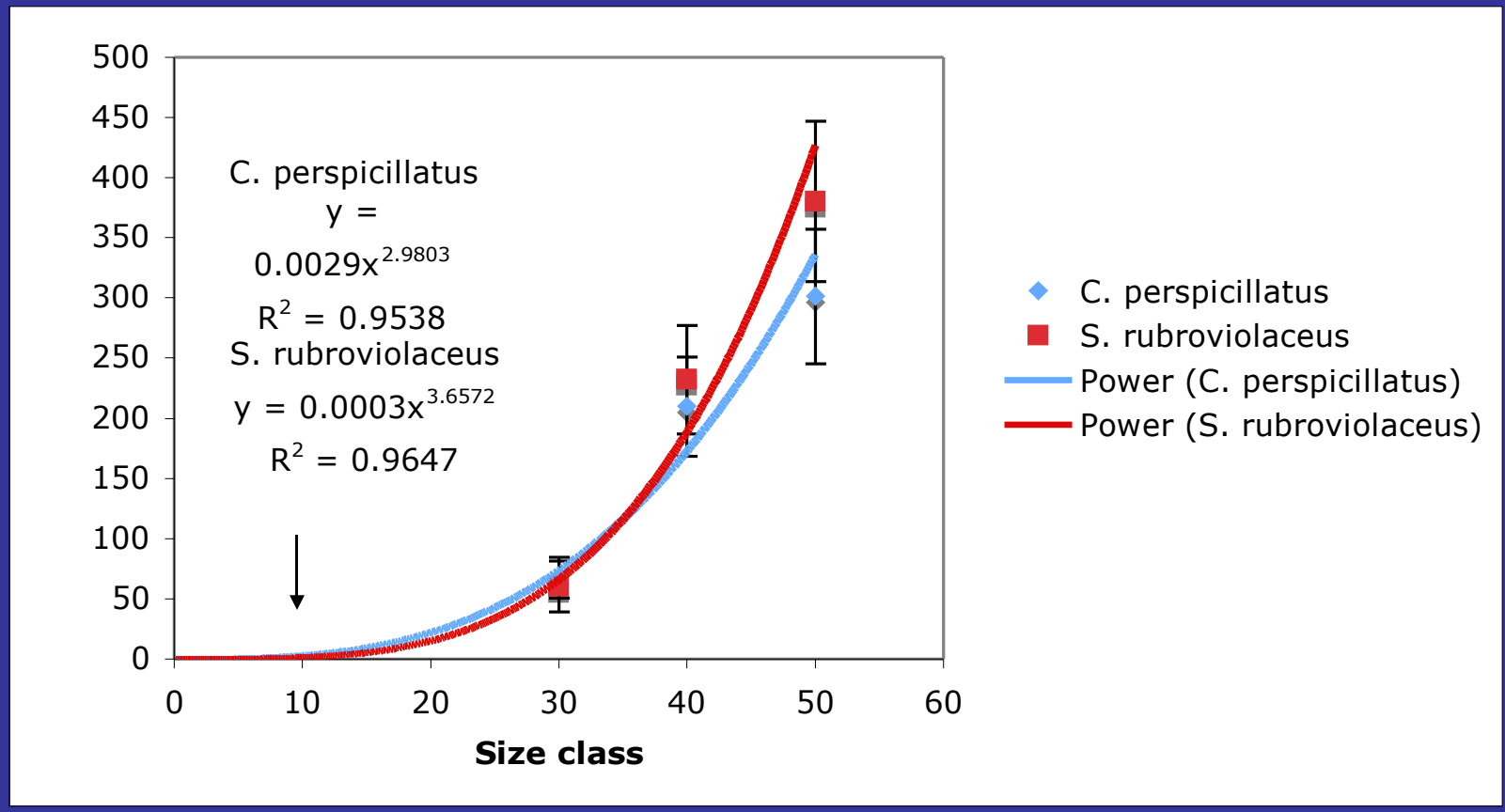


25 - 34 cm

35 - 44 cm

45 - 54 cm


C. perspicillatus
y = 2.9562x - 2.492
R2 = 0.955
S. rubroviolaceus
y = 3.6198x - 3.5161
R2 = 0.9652
3
2.5
2
1.5
1
0.5
0
0.5
1
1.5
2
Log (size class)
logred
logspec
Linear (logred)
Linear (logspec)



Ecological threshold size > 5 - 14 cm

Chlorurus sordidus
24 kg
Bellwood (1995)

20 cm

Scarus vetula
Approx 46 kg
Bruggerman et. al (1996)

40 cm

Sparisoma viridae
Approx 164 kg
Bruggerman et. al (1996)

40 cm

280 - 320 kg 45 cm

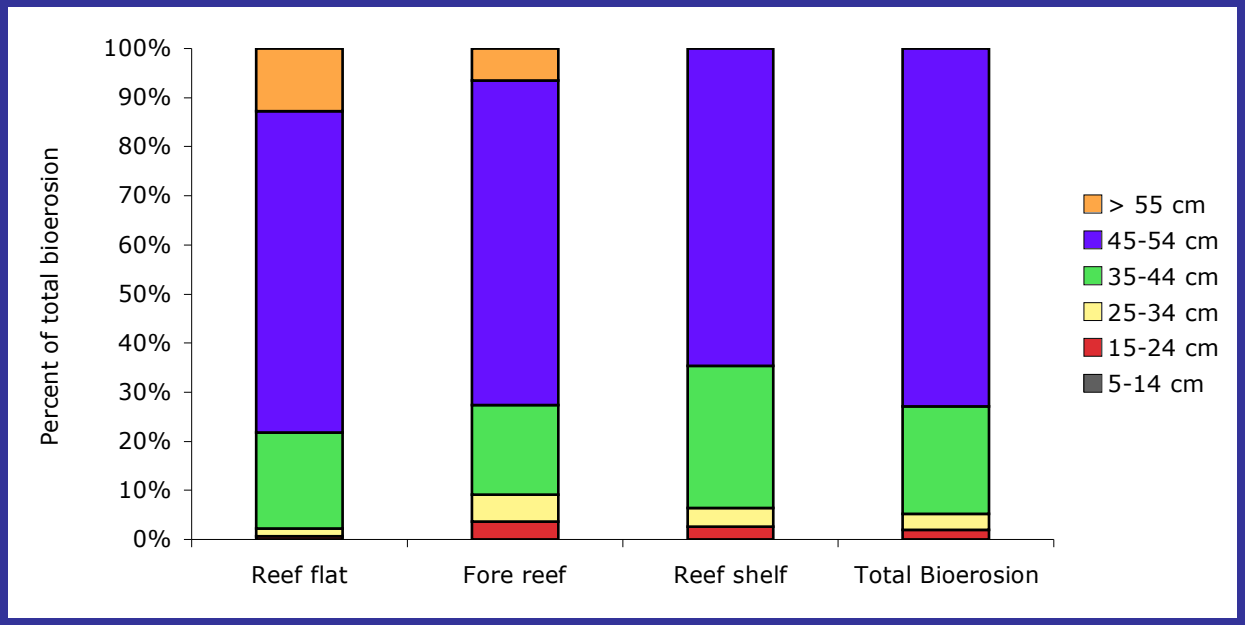
Chlorurus gibbus 44 cm
1 ton
Bellwood (1995)

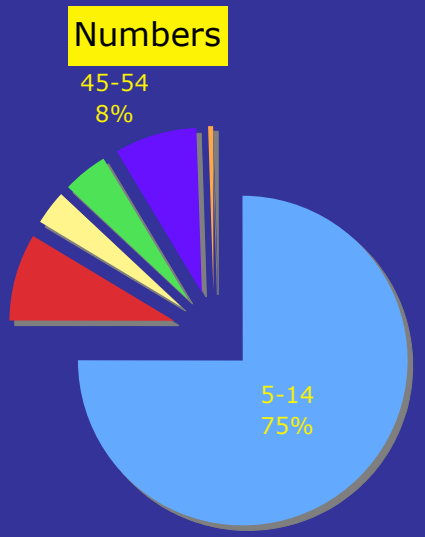
Bolbometopon muricatum
5 ton
Bellwood et. al. (2003)

100 cm

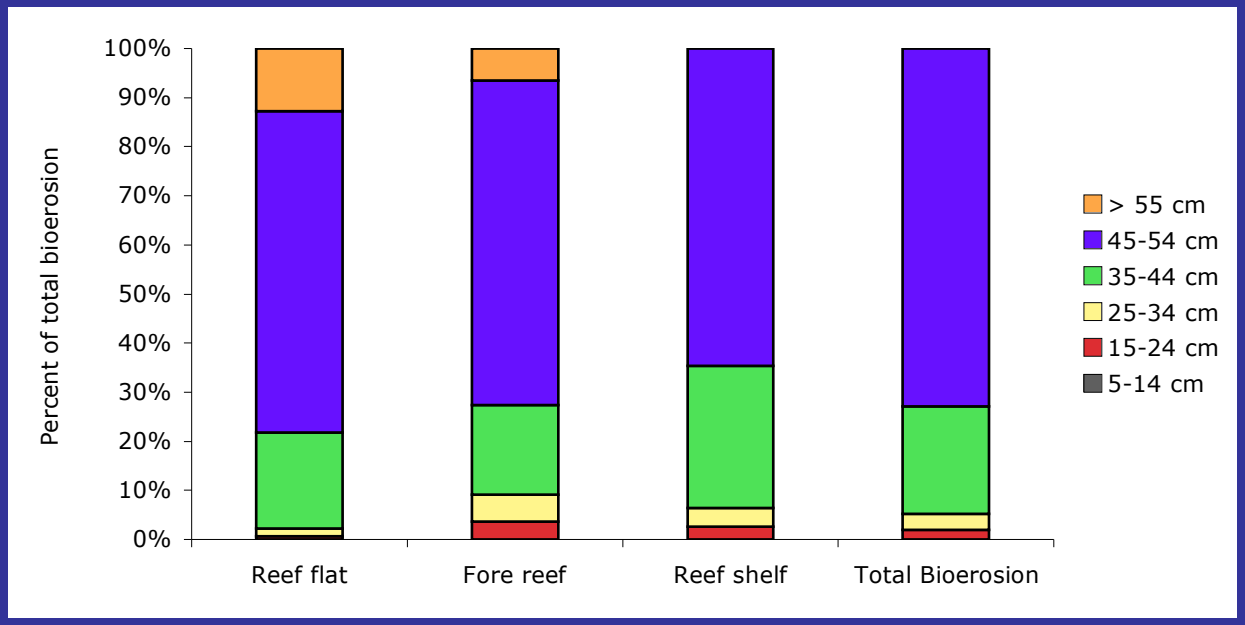
Parrotfish bioerosion/
sand production = ∑(fish density
x
bioerosion rate of size class)

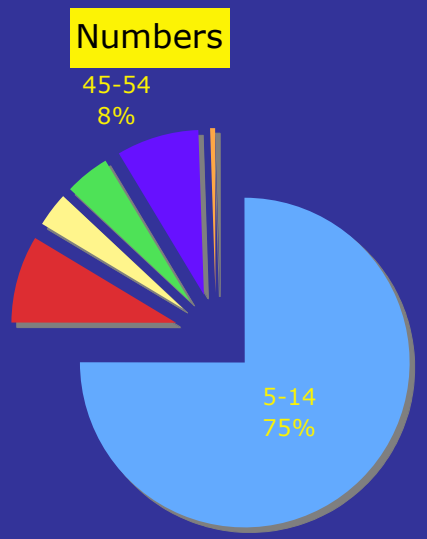
	Bioerosion rates (kg.individual^{-1}.yr^{-1})			
Size class	*Scarus rubroviolaceus*	*S. psittacus*	*Chlorurus perspicillatus*	*C.sordidus*
15-24 cm	14	14	21	21
25-34 cm	60	-	67	67
35-44 cm	232	-	210	-
45-54 cm	380	-	301	-
> 55 cm	380	-	-	-





1.98 ± 0.32 1.17 ± 0.18 0.93 ± 0.14 1.36 ± 0.21
(kg.m-2.yr-1)





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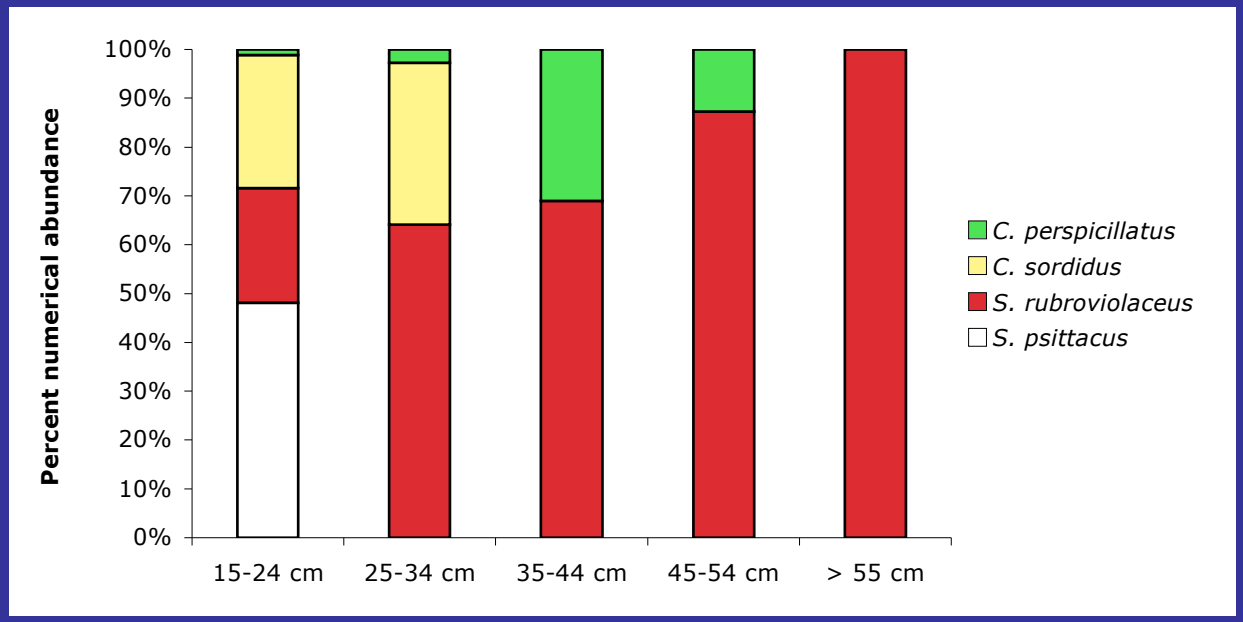
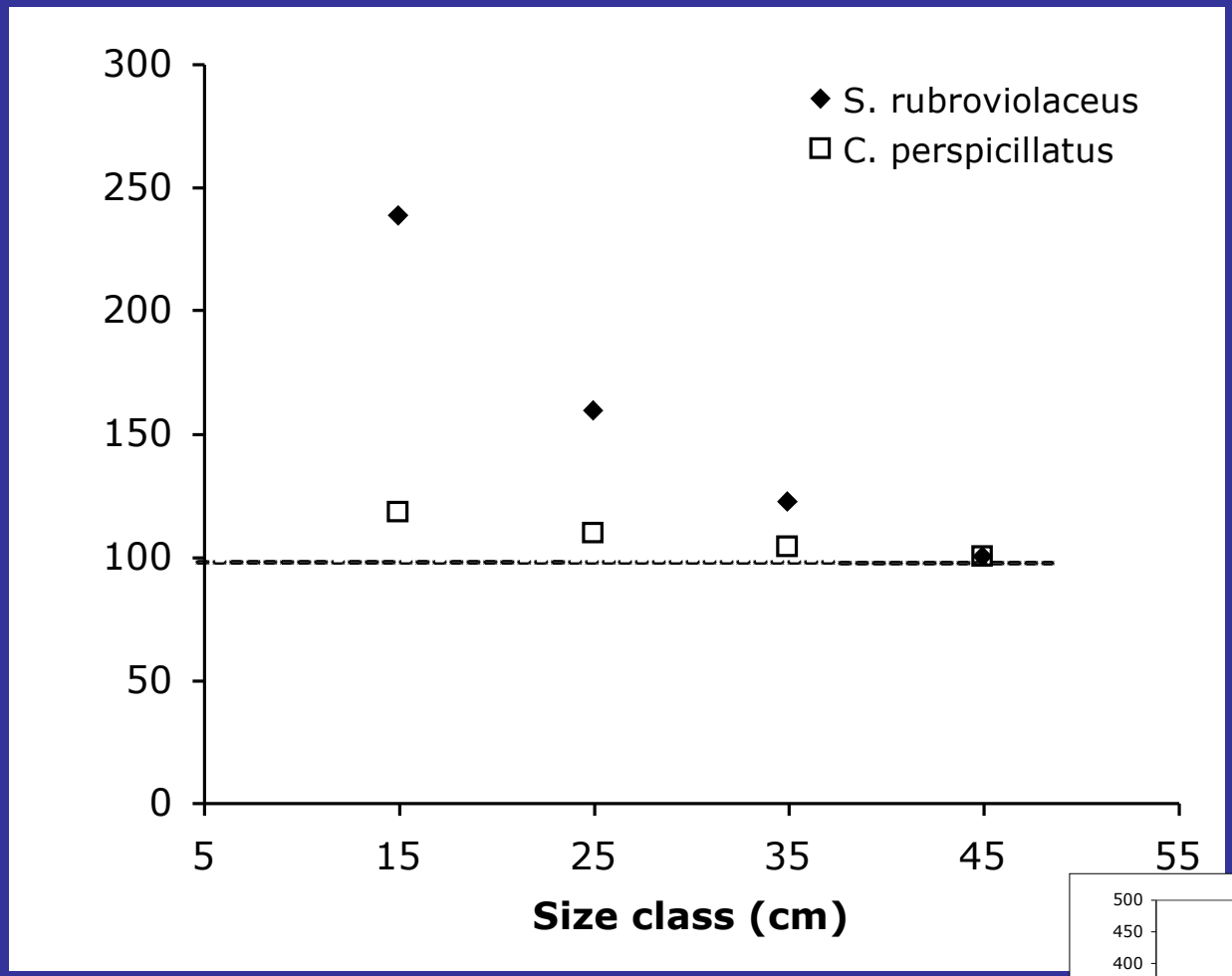
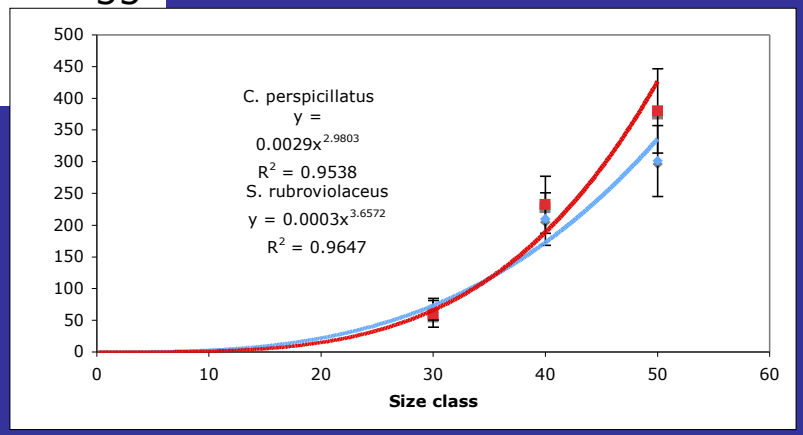



300
250
200
150
100
50
0
5
15
25
35
45
55
S. rubroviolaceus
C. perspicillatus
Size class (cm)


500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
C. perspicillatus
y = 0.0029x^2.9803
R^2 = 0.9538
S. rubroviolaceus
y = 0.0003x^3.6572
R^2 = 0.9647
Size class

Reef zone	Parrotfish bioerosion (kg.m-2.yr-1)	Gross carbonate production (kg.m-2.yr-1)	Net carbonate accretion (kg.m-2.yr-1)
Reef flat	1.98 ± 0.32	0.67 ± 0.44	-1.31 ± 0.76
Crest and Fore reef	1.17 ± 0.18	1.84 ± 0.83	0.67 ± 1.01
Reef shelf	0.93 ± 0.14	4.76 ± 1.35	3.83 ± 1.49

175 tons of sediment per year

Ecological importance

Parrotfish in Hawaii are ecologically important as bioeroders / sand producers

Larger individuals (> 45 cm) are responsible for majority of the sand production and bioerosion - larger species of parrotfishes are more important

While many species of parrotfishes may be present on a reef, only a minority of species may be contributing to sand production and bioerosion

Slot limit to protect small and large fish
Min size: L_{50} and max limit = 45 cm FL

Acknowledgements

Staff of Hanauma Bay

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Bill Claborn

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Frederique Kandel
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Craig Musburger

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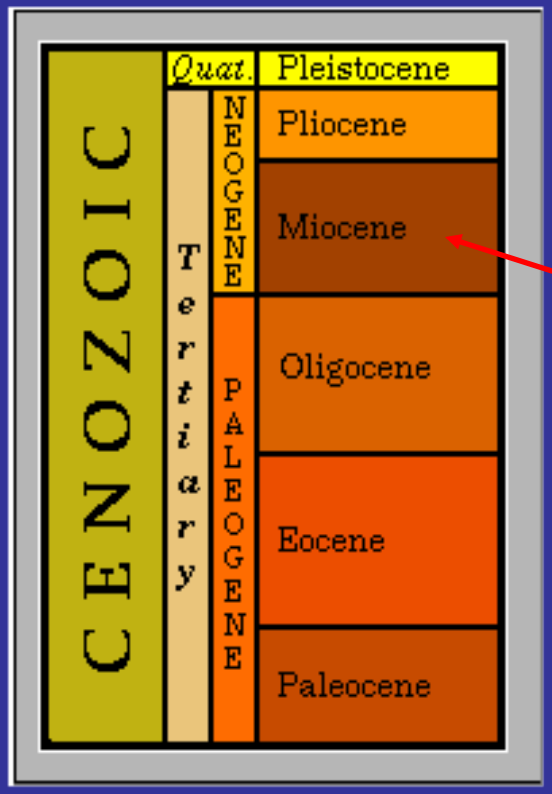
John Norris
Bruce Egborn
Andrea
Alex and Beatrice Hershey
Russel
Uchino Kanako
Tom del Mundo
Mike Quigley


Mahalo


Photo by Danielle Jayewardene

96 species in the world

- 5 genera
- More than half in genus *Scarus*

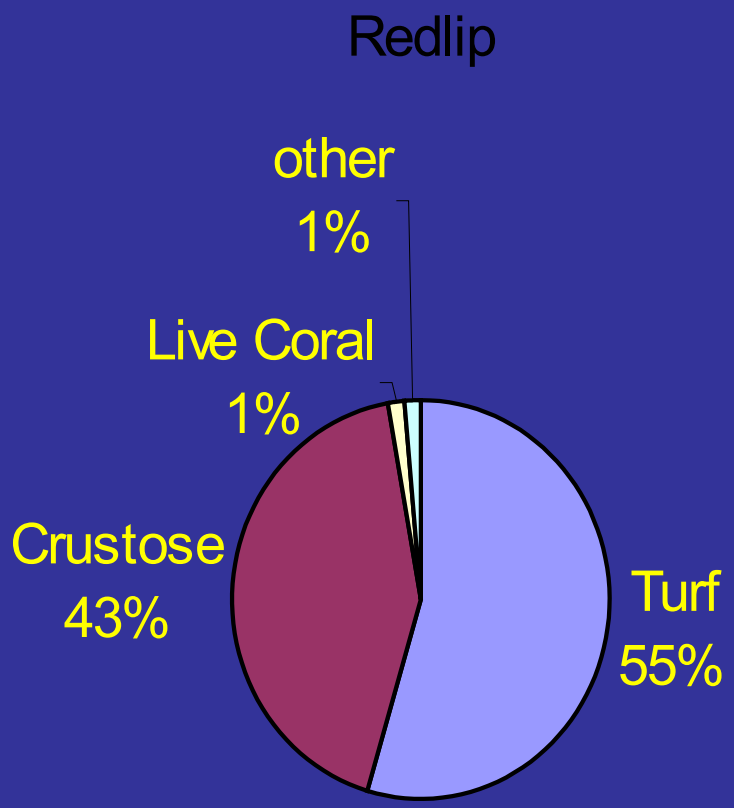


present

65 mya

Parrotfish are at least 14 million years old

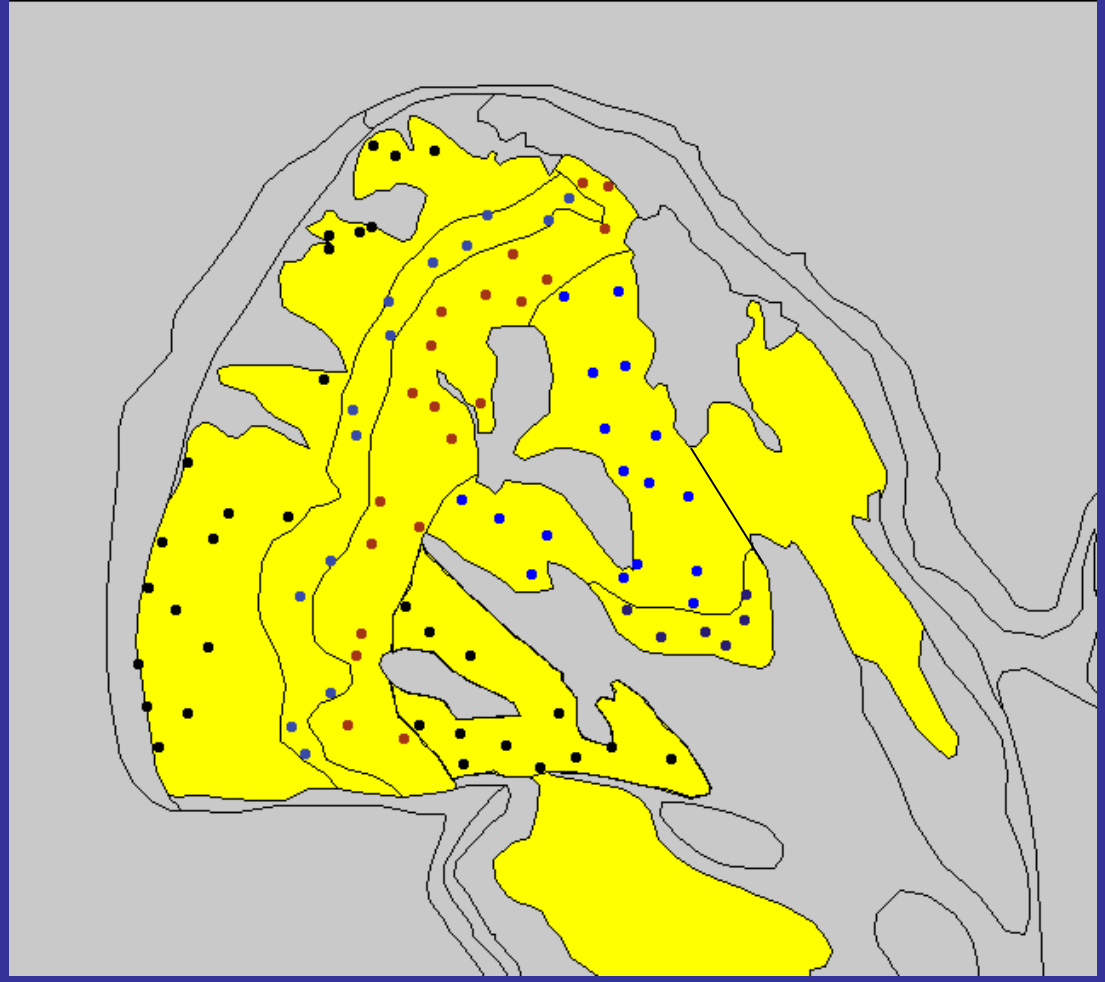
- Mid-miocene



Turf : eaten in proportion available

Crustose algae: actively selected for

Live coral and others: actively avoided



Gross carbonate production = ∑(growth rate of species

x bulk skeletal density

x percent cover)

Species	n	HR	Duration	method	location	ref
Sparisoma chrysopterum	17	180 -350 m^2	20 mins	visual	Caribbean	Mumby and Wabnitz 2002
Sparisoma cretense	16	200 - 2000 m^2	20 mins	visual	Mediterranean	De Girolamo et al 1999
Sparisoma rubripinne	17	330- 1400 m^2	20 mins	visual	Caribbean	Mumby and Wabnitz 2002
Sparisoma aurofrenatum	25	40 - 125 m^2	20 mins	visual	Caribbean	Mumby and Wabnitz 2002
Scarus iserti	25	40 -120 m^2	20 mins	visual	Caribbean	Mumby and Wabnitz
Sparisoma viride	25	80 - 300 m^2	20 mins	visual	Caribbean	Mumby and Wabnitz 2002
Cheilodactylus fuscus (Red Morwong)	7	1800 - 3600 m^2	8-12 night	telemetry	S Australia	Lowry and Sutters 1998
Caranx melampygus (Blue trevally)	5	3,000 - 6,000 m linear reef	26-120 hr	telemetry	Hawaii	Holland et al 1996
Paralabrax chlatratus	12	33 - 11200 m^2	62 - 120 hrs	telemetry	California	Lowe et al. 2003
Sarpa salpa	14	1600 - 28000 m^2	1 - 49 days	telemetry	Mediterranean	Jadot et al. 2005
Parupeneus porphyreus (White saddle goatfish)	5	9,000 - 35,000 m^2	45 - 92 hrs	telemetry	Hawaii	Meyer et al 2000
Phycodorus eques (Leafy seadrgon)	9	up to 50,000 m^2	2 - 10 days	telemetry	GBR Australis	Conolly et al 2002
Naso unicornis (Blue spined Unicorn fish)	5	300 - 57,400 m^2	12 - 72 hrs	telemetry	Hawaii	Meyer et al 2005
Dasyatis lata (Hawaiian stingray)	7	0.62 - 2.77 km^2	31 - 74 hrs	telemetry	Hawaii	Cartamill et al 2003
Carcharhinus limbatus (Blacktip shark)	74	2-13 km^2	1 -167 days	passive telemetry	Florida	Heupel et al 2004

Chlorurus sordidus

24 kg

Bellwood (1995)

20 cm

Scarus vetula

Approx 46 kg

Bruggemann et al. (1996)

40 cm

Sparisoma viridae

Approx 164 kg

Bruggemann et al. (1996)

40 cm

Chlorurus gibbus

1 ton

Bellwood (1995)

44 cm

Bolbometopon muricatum

5 tons

Bellwood et al. (2003)

100 cm

Hanauma Bay, parrotfish sediment production only

1.36 kg. $m^{-2}.yr^{-1}$

Kailua bay, no parrotfish

Total carbonate
sediment production= 0.9 kg. $m^{-2}.yr^{-1}$ (using planimetric data)

Harney and Fletcher 2003