Data requirements for length-based assessments of coral reef fish

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Stock assessment program

Assessing coral reef fish stocks

- Problems
  - Lots of species
  - Different fishing gear
  - Spatially diffuse fishing effort
  - Data-poor

Life history data / parameters

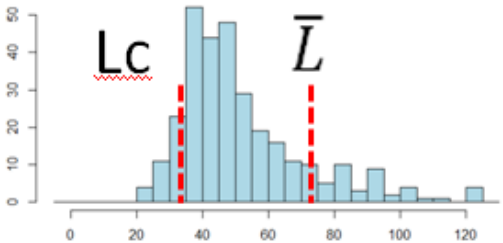
- Local studies
- Scientific literature
- Biosampling program

t_λ L_∞ K t_0

M L_m A , B

Size structure data

- Underwater visual census
- Creel, biosampling surveys
- Commercial reports



Length-based mortality model

$$Z = \frac{K(L_\infty - \bar{L})}{\bar{L} - L_c} \rightarrow F = Z - M$$

Stock simulation model

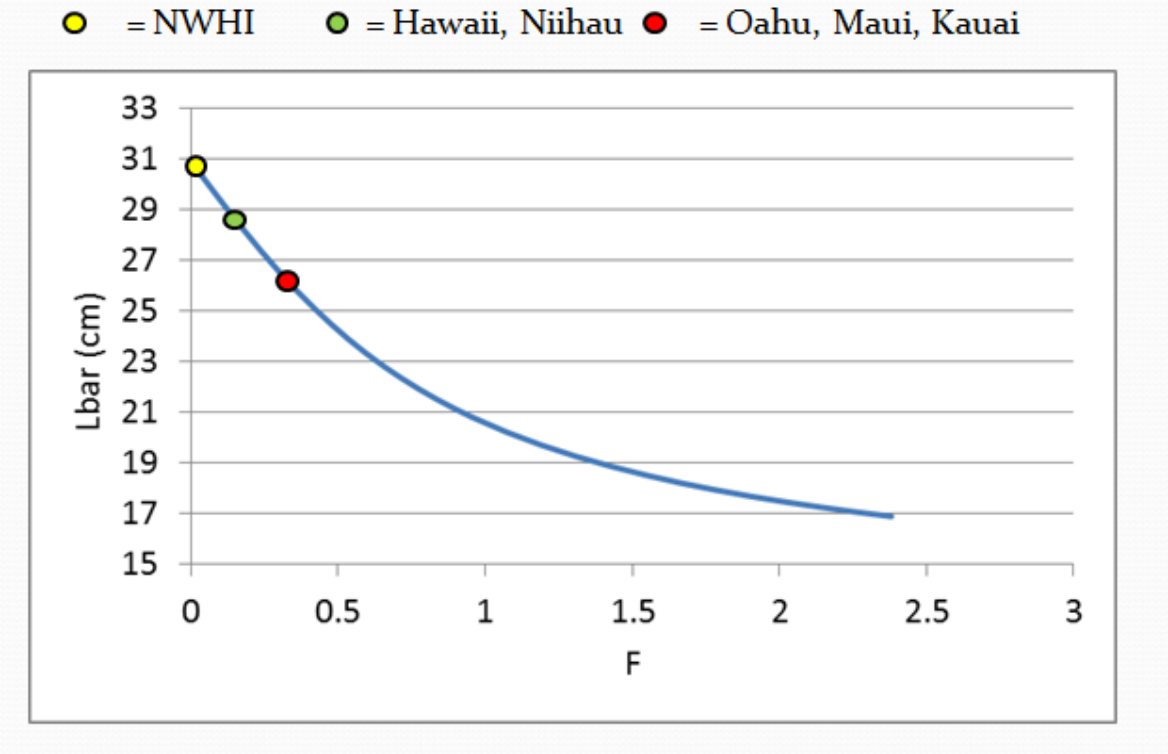
Current SPR → Optimal Lc

Current yield → Optimal F

= Data

= Model

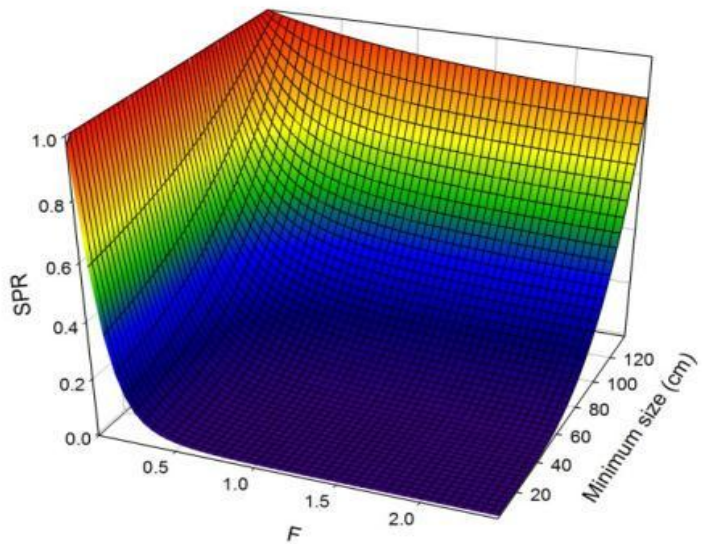
Relating average length to total mortality



$$\overline{L} = \frac{\int_{t_c}^{t_\infty} F_t \cdot L_t \cdot N_t \cdot dt}{\int_{t_c}^{t_\infty} F_t \cdot N_t \cdot dt} \rightarrow Z = \frac{K \cdot (L_\infty - \overline{L})}{(\overline{L} - L_c)}$$

Beverton and Holt (1954)

Spawning potential ratio



$$N_t = R \cdot e^{-(M+F)t}$$

$$SSB = \sum_{a=a_m}^{a_\lambda} \overline{N}_a \cdot \overline{W}_a$$

$$W = a * L^b$$

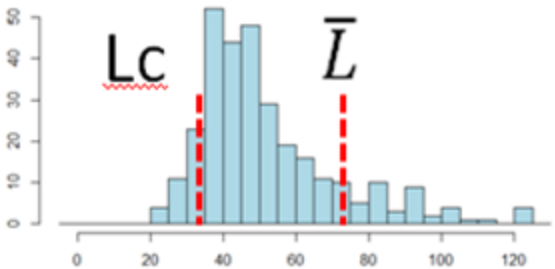
$$SPR = \frac{SSB_F}{SSB_{F=0}}$$

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

Assessing coral reef fish stocks

Population model

- Data requirements
  1. **Abundance-at-size**: fishing mortality rates (F) and size-at-first-capture (Lc)



  2. **Life history parameters**: (L-infinity, K, t0, M, a, b, longevity, maturity)

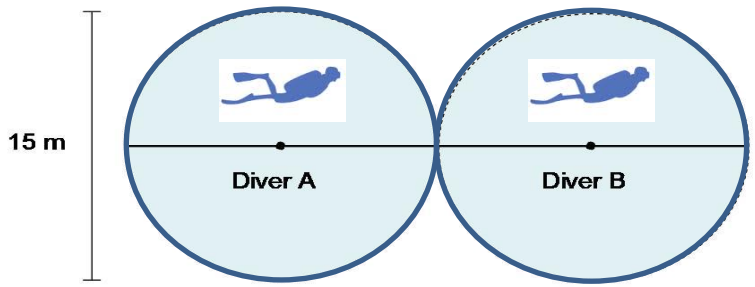
Size structure data

1. Underwater visual census (UVC)
   - Diver surveys
   - Baited Remote Underwater Vehicles (BRUVs)
   - Autonomous Underwater Vehicles (AUV)
2. Intercept surveys
   - Marine Recreational Information Program (MRIP)
   - Biosampling
3. Commercial trip report

Underwater Visual Census

- Count and size fish by species
- Density, biomass, diversity, size structure, average length

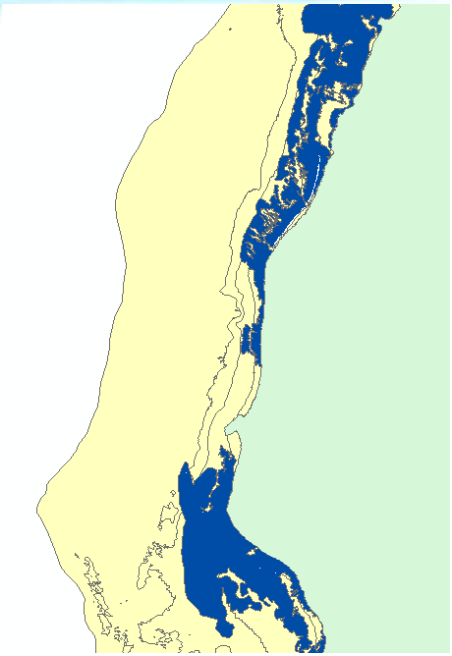
SCUBA divers



Autonomous Underwater Vehicle

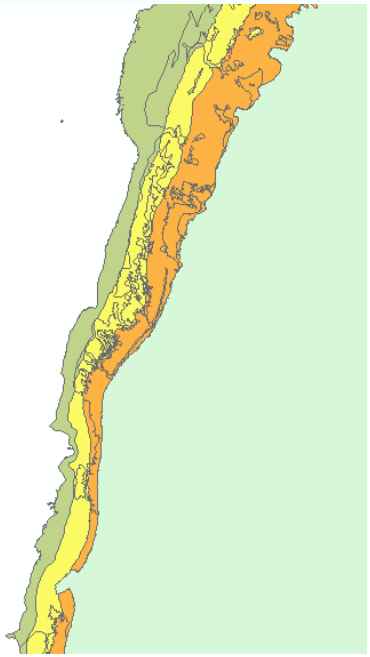
Baited Remote Underwater Video

UVC sampling design



Bottom type

+



Depth

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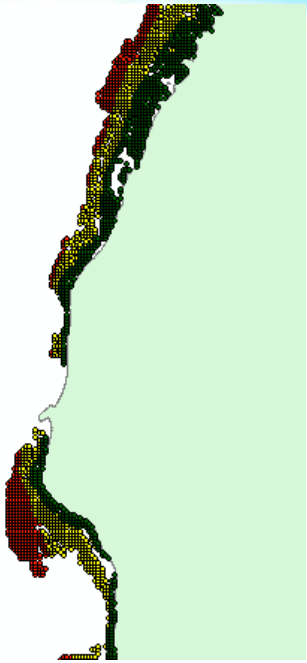
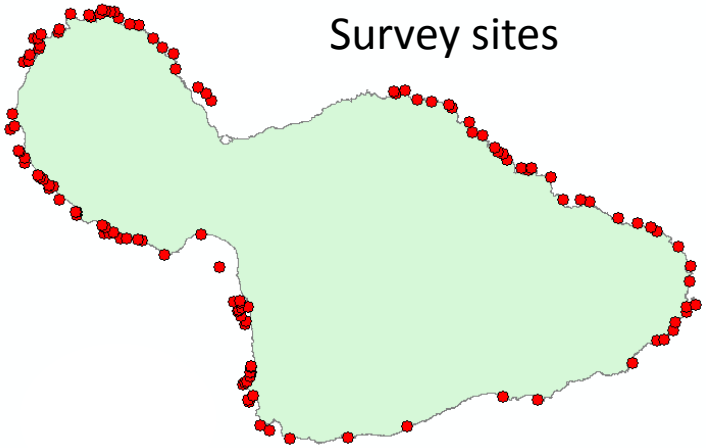


Sampling grids

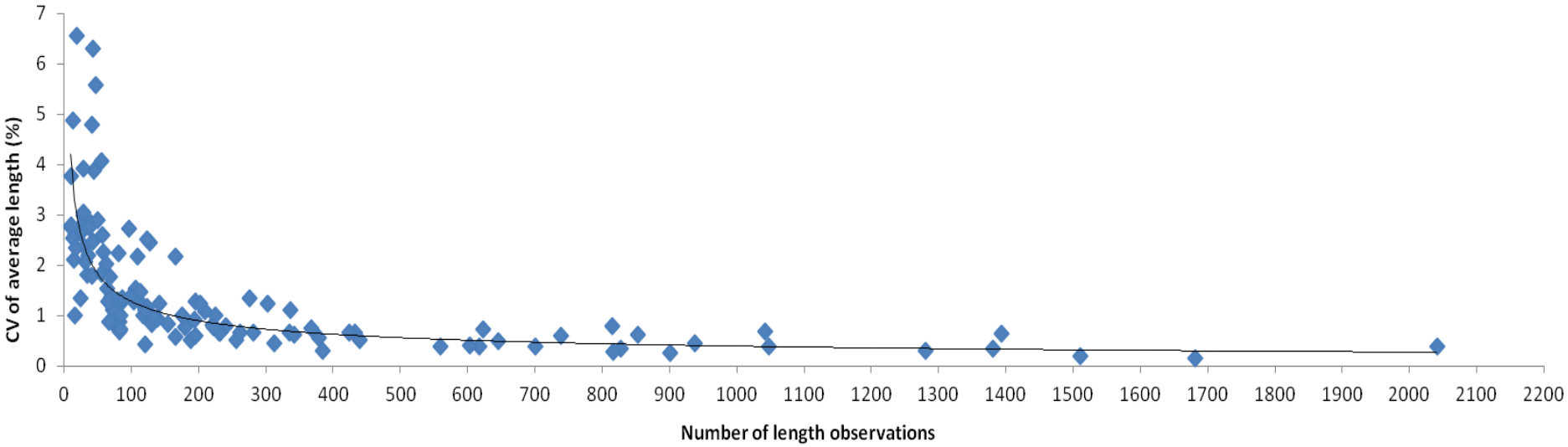
Survey sites



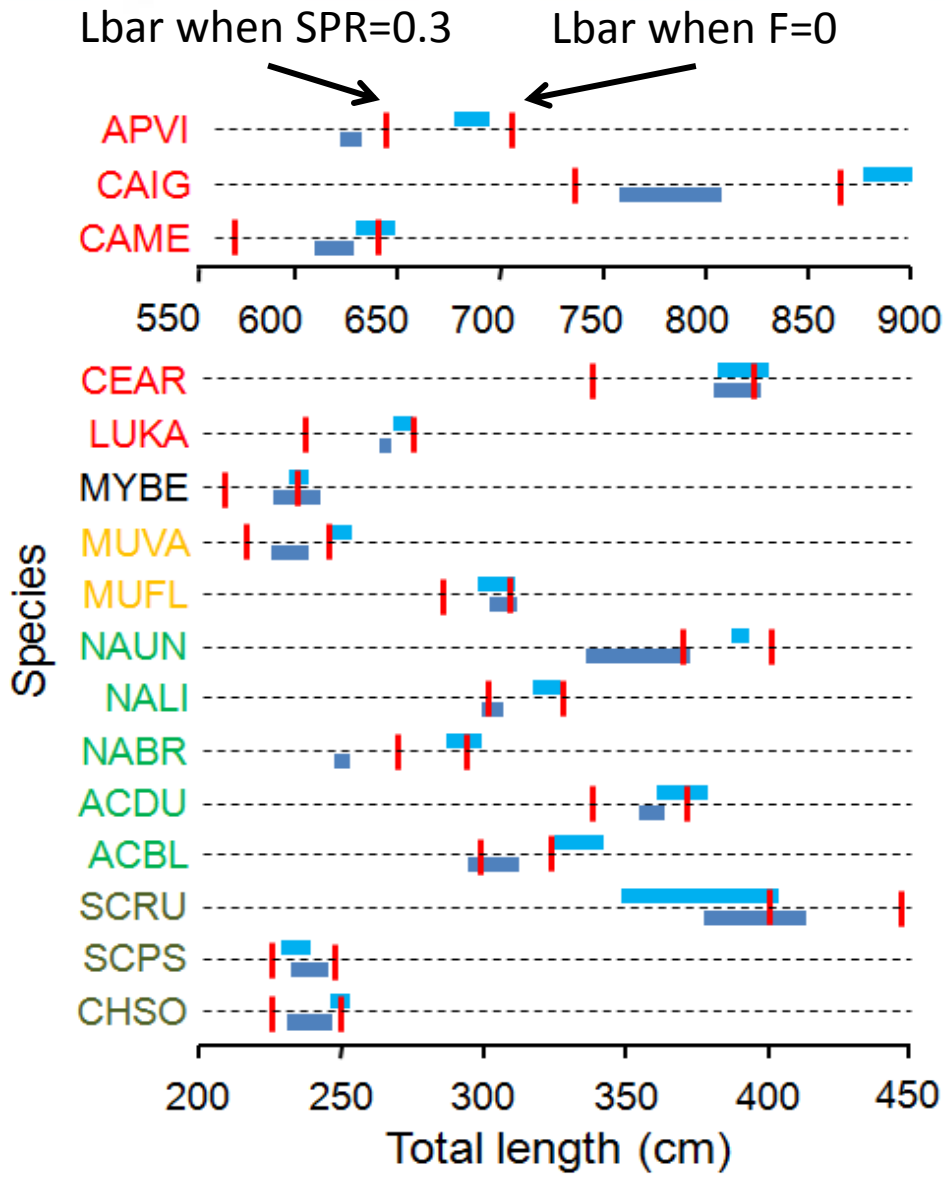
Average length from diver surveys

95% confidence intervals for different regions in Hawaii

Species	Hawaii		Maui Nui		Oahu		Kauai and Niihau		NWHI	
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
C. spilurus	81	262-285	196	235-247	-	-	-	-	853	246-253
S. psittacus	29	241-272	112	233-245	13	227-275	13	248-273	209	229-240
S. rubroviolaceus	109	360-392	165	381-415	19	339-440	97	407-453	56	347-407
A. blochii	77	302-316	64	289-308	-	-	69	290-307	203	325-340
A. dussumieri	120	348-355	71	341-352	-	-	67	344-356	76	361-379
A. virescens	-	-	44	559-652	-	-	50	563-632	1042	673-690



Average lengths in Hawaii



Intercept surveys

- Marine Recreational Information Program
  - Hawaii surveys 2004-2012

Species	Family	Count of Measured Length
Caranx melampygus	Jack	251
Iniistius pavo	Wrasse	202
Caranx ignobilis	Jack	124
Mulloidichthys flavolineatus	Goatfish	113
Selar crumenophthalmus	Jack	111
Aprion virescens	Snapper	108
Acanthurus triostegus	Surgeonfish	104
Parupeneus multifasciatus	Goatfish	100
Carangoides orthogrammus	Jack	87
Lutjanus kasmira	Snapper	68
Mulloidichthys vanicolensis	Goatfish	66
Abudefduf abdominalis	Damselfish	63
Scomberoides lysan	Jack	54
Decapterus macarellus	Jack	54
Acanthurus dussumieri	Surgeonfish	47
Lutjanus fulvus	Snapper	40

Biosampling

What Biosampling Data Are Collected:

- Name of fisherman
- Date
- Area fished
- Number of hours fishing
- Car or boat?
- How many fisherman in boat
- How much bait used (bottomfishing)
- How much fuel used
- How much ice (supplied)

Biosampling – American Samoa

- 7 DMWR staff trained to identify fish species ID of catch
- work with 10 spearfishermen, 4 bottomfishing boats, and 2 handlining fishermen.
- Measured over 90,000 fish and still counting.
- Collected almost 2,000 otoliths and gonads from 10 fish species for life-history data; and over 200 fin slips for barcode of life project.

Commercial trip report

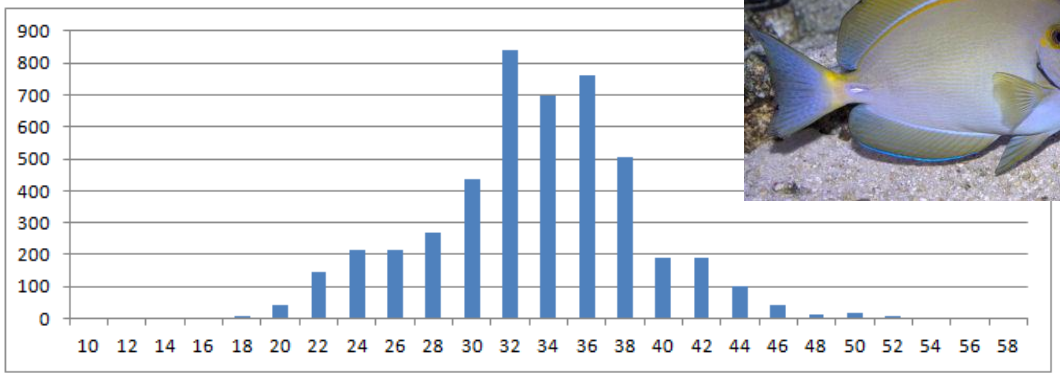
- No direct length measurements
  - Number caught per trip
  - Weight caught per trip
- Hawaii data going back to 1948, weights rounded to pounds before 2003
- High number of observations

Commercial trip reports – Hawaii 2003-2012

Species	Family	Commercial reports
Lutjanus kasmira	Snapper	8410
Acanthurus triostegus	Surgeonfish	5871
Acanthurus dussumieri	Surgeonfish	4700
Aprion virescens	Snapper	4166
Naso annulatus; brevirostris; unicornis	Surgeonfish	3862
Lutjanus fulvus	Snapper	3594
Parupeneus porphyreus	Goatfish	3539
Kyphosus bigibbus; K. cinerescens	Chub	3437
Bodianus bilunulatus	Wrasse	3069
Heteropriacanthus cruentatus	Bigeye	3052
Mulloidichthys pfluegeri	Goatfish	2432
Iniistius pavo	Wrasse	2430
Caranx melampygus	Jack	2316
Parupeneus cyclostomus	Goatfish	2269
Mulloidichthys vanicolensis	Goatfish	2065
Cephalopholis argus	Grouper	2039
Caranx ignobilis	Jack	1958
Carangoides orthogrammus	Jack	1622
Acanthurus olivaceus	Surgeonfish	1607
Mulloidichthys flavolineatus	Goatfish	1601
Ctenochaetus strigosus	Surgeonfish	1595
Monotaxis grandoculis	Emperor	1482
Acanthurus nigroris	Surgeonfish	1387
Parupeneus insularis	Goatfish	1295
Sphyraena helleri	Barracuda	1243
Acanthurus blochii; A. xanthopterus	Surgeonfish	1085
Mugil cephalus	Mullet	998
Naso lituratus	Surgeonfish	839

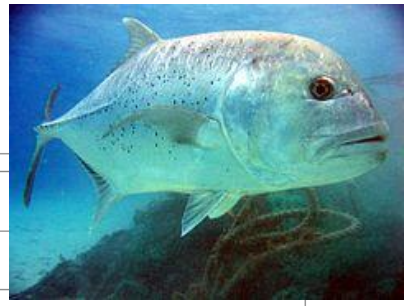
Commercial trip reports – Hawaii 2003-2012

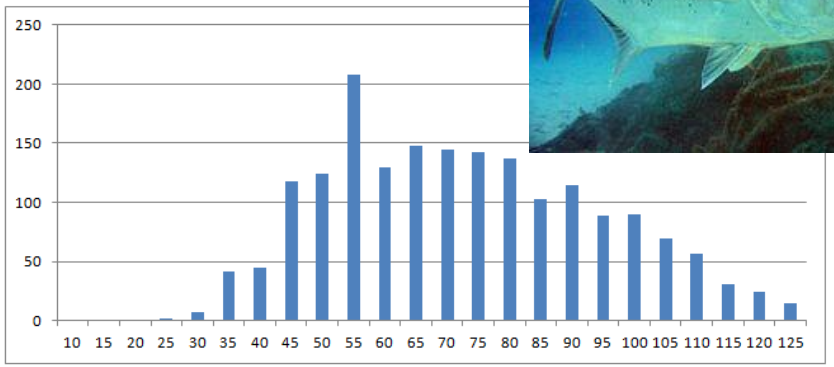
Acanthurus dussumieri



Total length (cm)

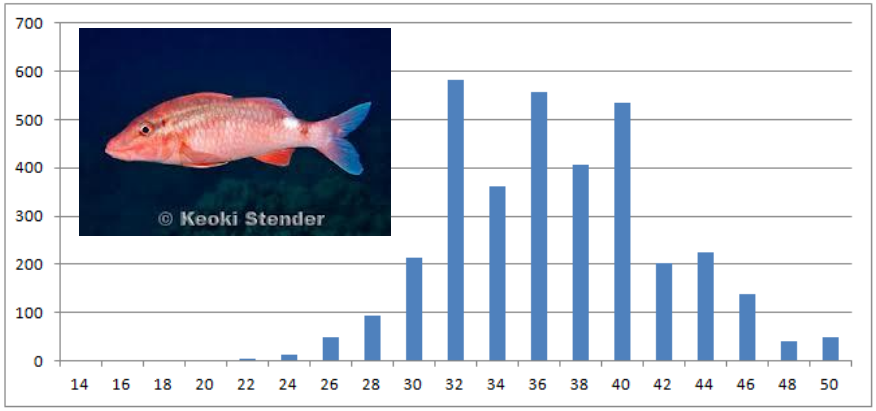
Caranx ignobilis





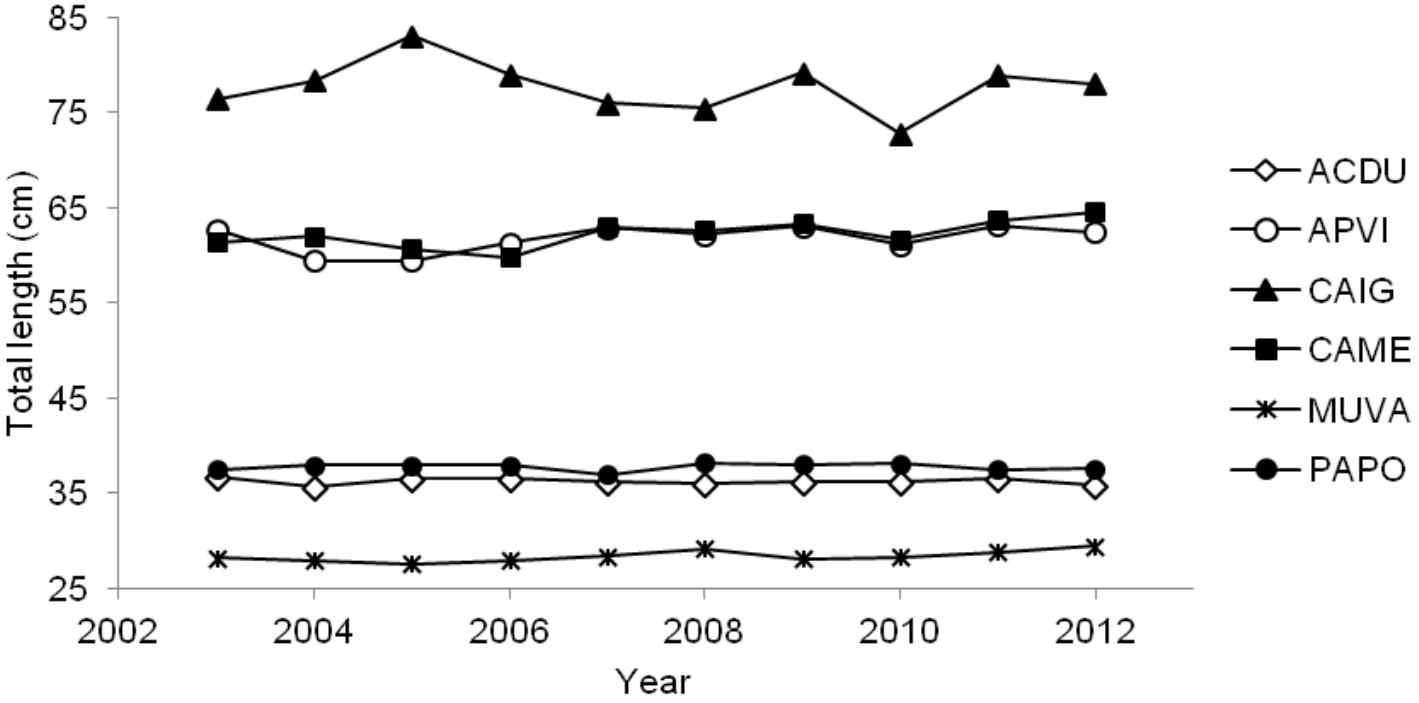
Total length (cm)

Parupeneus porphyreus

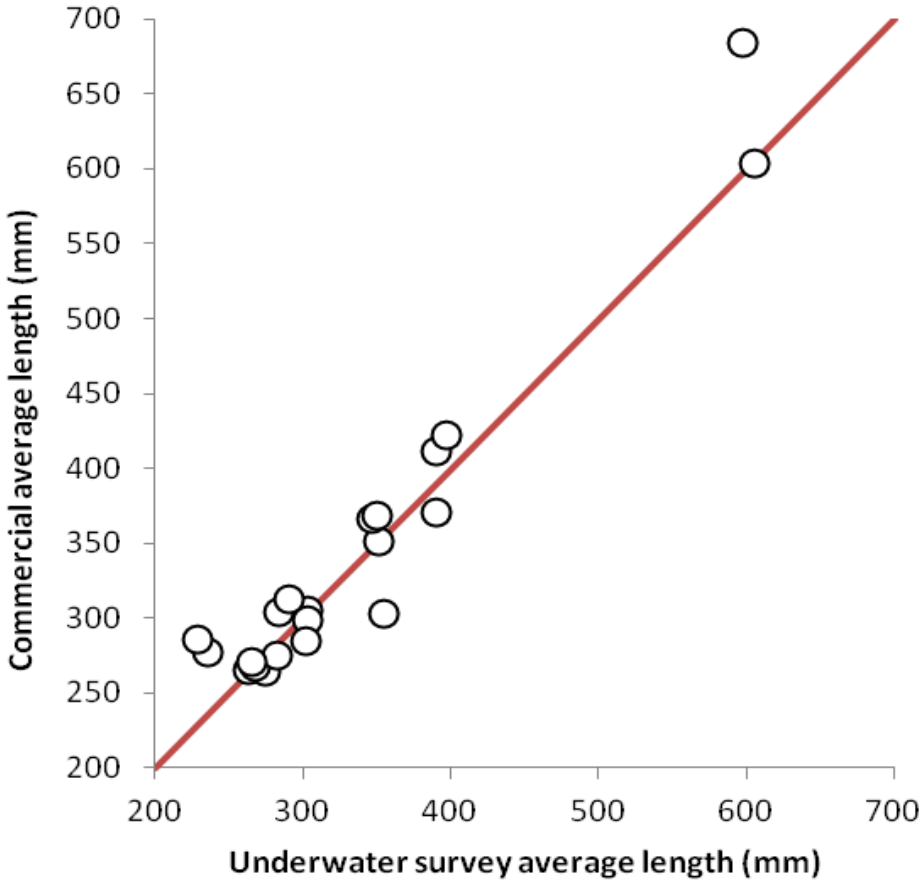


Total length (cm)

Commercial trip reports – Hawaii 2003-2012



Average lengths – UVC vs. Commercial



Summary – Size structure data 1=Best, 5=Worst

	Diver surveys	MRIP	Local creel surveys	Bio-sampling	Commercial trip report
Number of length observations	4	5	3	1	2
Quality of length measurements	4	1	1	1	5
Observations from large protected areas (i.e. model validation)	Yes	No	No	No	No
Control of sampling design	Yes	No	No	No	No
Control of spatial distribution	Yes	No	No	No	No
Depth limited	Yes	No	No	No	No
Control of selectivity pattern (gear fishing or "observation" power)	Yes	No	No	No	No
Information on minimum size	No	Yes	Yes	Yes	Yes
Information on rare, mobile species (i.e. sharks, certain jacks)	Few	Yes	Yes	Yes	Yes
Quality of species identification	1	2	3	2	5
Cost	5	2	2	2	1

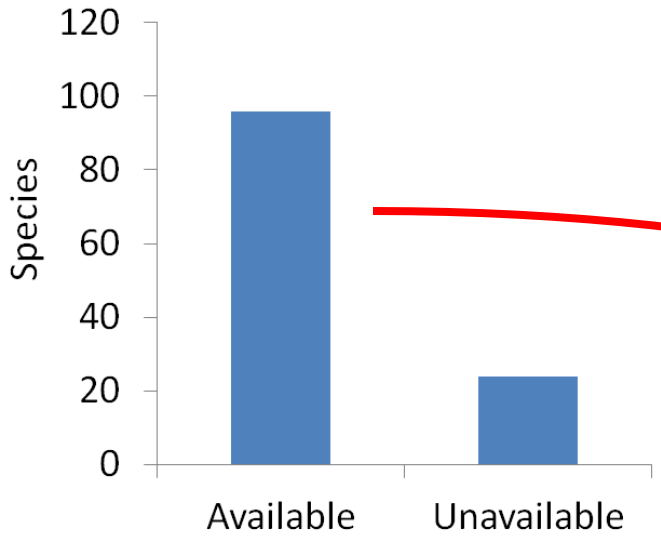
Regional summary - size structure datasets

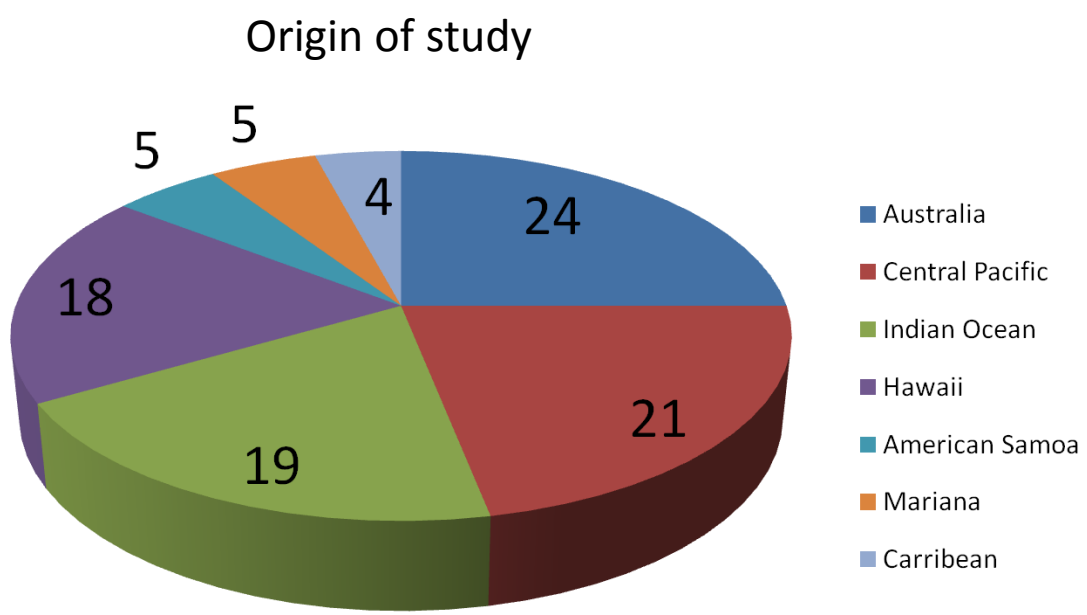
	Hawaii	American Samoa	Mariana
Diver surveys	X	X	X
Marine Recreational Information Program (MRIP)	X		
Local creel surveys		X	X
Biosampling		X	X
Commercial trip report	X	?	?

Life history parameters

- Growth: L_{inf}, K, T_0
- Longevity -> M
  - M = -ln(0.01 or 0.05) / Longevity
- Maturity: L_{50} or t_{50}
- *a* and *b* parameters of the length-weight relationship
  - Weight = a x $Length^b$

Growth studies for US Pacific coral reef fish species





Regional summary

Growth curve information for the top 20 targeted species

	Hawaii	American Samoa	Mariana
Information on growth	12 (60%)	11 (55%)	17 (85%)
Growth information from local studies	8 (40%)	3 (15%)	4 (20%)
Growth information from in-depth local studies	2 (10%)	2 (10%)	2 (10%)

Summary and recommendations

- Size structure data
  - Combination of UVCs (i.e. diver surveys) with fisheries-dependent dataset is ideal
  - Biosampling of reef fish in Hawaii would help fill a gap in recreational fishing information and avoid relying on commercial dataset for length info
- Life history parameters
  - Major bottleneck in conducting more analyses
  - Send specimens to more labs, create local capacity