The data-richness spectrum and sustainability of California fisheries

Louis W. Botsford

D. Patrick Kilduff

Department of Wildlife, Fish and Conservation Biology

University of California

Davis, CA 95616

Workshop: Managing Data-Poor Fisheries: Case Studies, Models, and Solutions
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Definition: Spectrum of data-richness

The distribution of <u>combinations</u> of data types available for each fishery

Why?

1. Overall level of certainty re: population health, risk….

2. Program for reduction in level of uncertainty.

3. Assessment at higher level than single population (ecosystem?)

Procedure:

1. Make a list of data combinations for each fishery (Table 1)

2. Analyze data combinations based on:
    a. Precautionary Approach
    b. Population Dynamics

Category	Species /Group	Landings	Effort	Size Composition	Age Composition	Stock Assessed	Life History
Nearshore Invertebrates	*Abalone*	*C-1916*	*R-1975*	*R-1975*			*X*
	Spiny Lobster	*C-1916*	*C-1973*	*X*			*X*
	Red Sea Urchin	*C-1970*	*C-1988*	*X*			*X*
	Purple Sea Urchin	*C-1983*					*X*
	Dungeness Crab	*C-1916*	*X*	*X*			*X*
	Rock Crabs (Yellow , Brown and Red)	*C-1926*					*X*
	Sheep Crab	*C-1978*					*X*
	Ocean Shrimp	*C-1950*	*X*				*X*
	Spot Prawn	*C-1928*					
	Ridgeback Prawn	*C-1973*	*C-1986*				*X*
	Red Rock Shrimp	*C-1994*	*X*				*X*
	Coonstripe Shrimp	*C-1999*					*X*
	Sea Cucumbers	*C-1978*	*C-1993*				
	Pismo Clam	*C-1916 to 1947*					*X*
	Sand Crab	*C-1963*					*X*
	Wavy Turban Snail	*C-1992*					*X*
	Rock Scallop	*R-1978*					
	Owl Limpet	*C-1980s*		*X*			*X*
	Kellet's Whelk	*C-1979*					*X*
Coastal Pelagic Species	*California Market Squid*	*C-1916*	*C-1981*				*X*
	Pacific Sardine	*C-1916*	*C-1985*	*X*	*X*	*X*	*X*
	Northern Anchovy	*C-1916*			*X*		*X*
	Pacific Mackerel	*C-1924*	*R-1935*		*X*	*X*	*X*
	Jack Mackerel	*C-1924*					*X*
Highly Migratory Species	*Albacore*	*C-1916*	*C-1966*	*R-1983*	*X*	*X*	*X*
	Swordfish	*C-1916*	*X*	*X*	*X*	*X*	*X*
	Pacific Northern Bluefin Tuna	*C-1916*	*R-1983*	*R-1983*		*X*	*X*
	Skipjack Tuna	*C-1916*	*C-1975*	*C-1975*		*X*	*X*
	Yellowfin Tuna	*C-1916*	*C-1975*	*C-1975*	*X*	*X*	*X*
	Striped Marilin	*R-1947*	*C-1950s*	*X*		*X*	*X*
	Shortfin Mako Shark	*C-1977*		*X*			*X*
	Thresher Sharks	*C-1977*		*X*			*X*
	Blue Shark	*C-1977*				*X*	*X*
	Great White Shark	*C-1979*					*X*
	Basking Shark	*C-1991*					*X*
	Salmon Shark	*C-1977*					*X*
	Opah	*C-1976*					
	Louvar	*C-1984*					
	Dolphin	*R-1973*	*R-1983*	*R-1983*			*X*

Precautionary Approach (FAO 1995)

Pre-1990s: Maximum Sustained Yield (MSY)

Post-1990s: Reference Points

Target Reference Point:

A goal such as MSY, OSY, MS Profit

Limit Reference Point:

A state to be avoided, e.g. low biomass

If breeched, take drastic, pre-agreed action

How do we determine this?

PopulationSustainability

Age structured population with density-dependent recruitment

$R_t \quad = \qquad B_t \qquad f[C_t]$

Recruitment = Egg production x Survival [density]

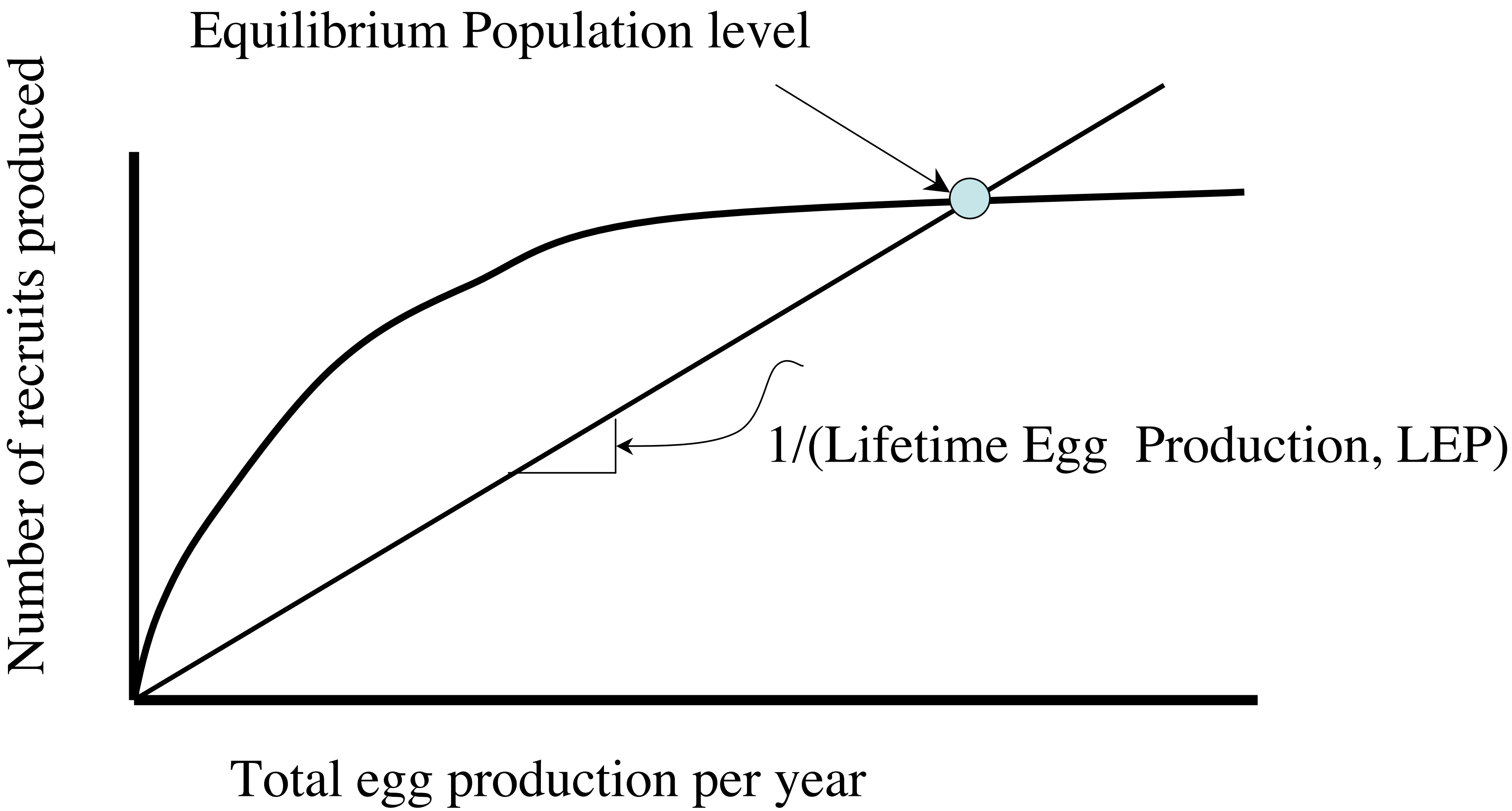
Where $B_t = \Sigma b_a\, n_{a,t}$ and $C_t = \Sigma c_a\, n_{a,t}$

Questions: Equilibrium? Collapse?

Answer: Graphical interpretation:

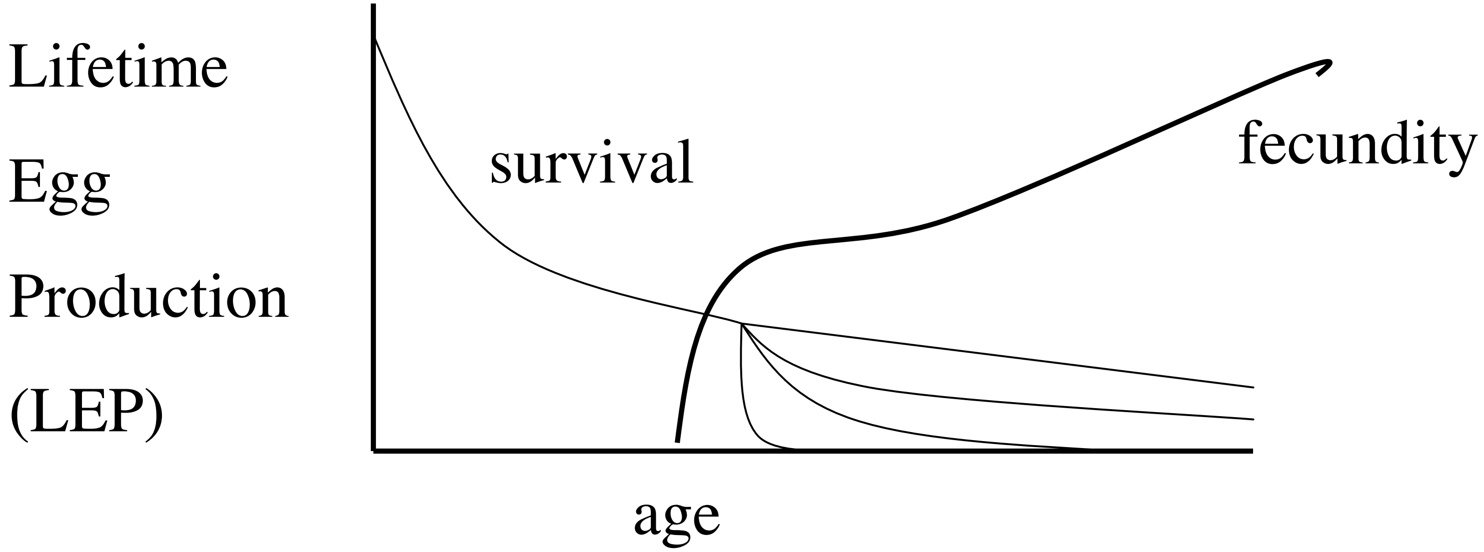
Sissenwine and Shepherd 1987

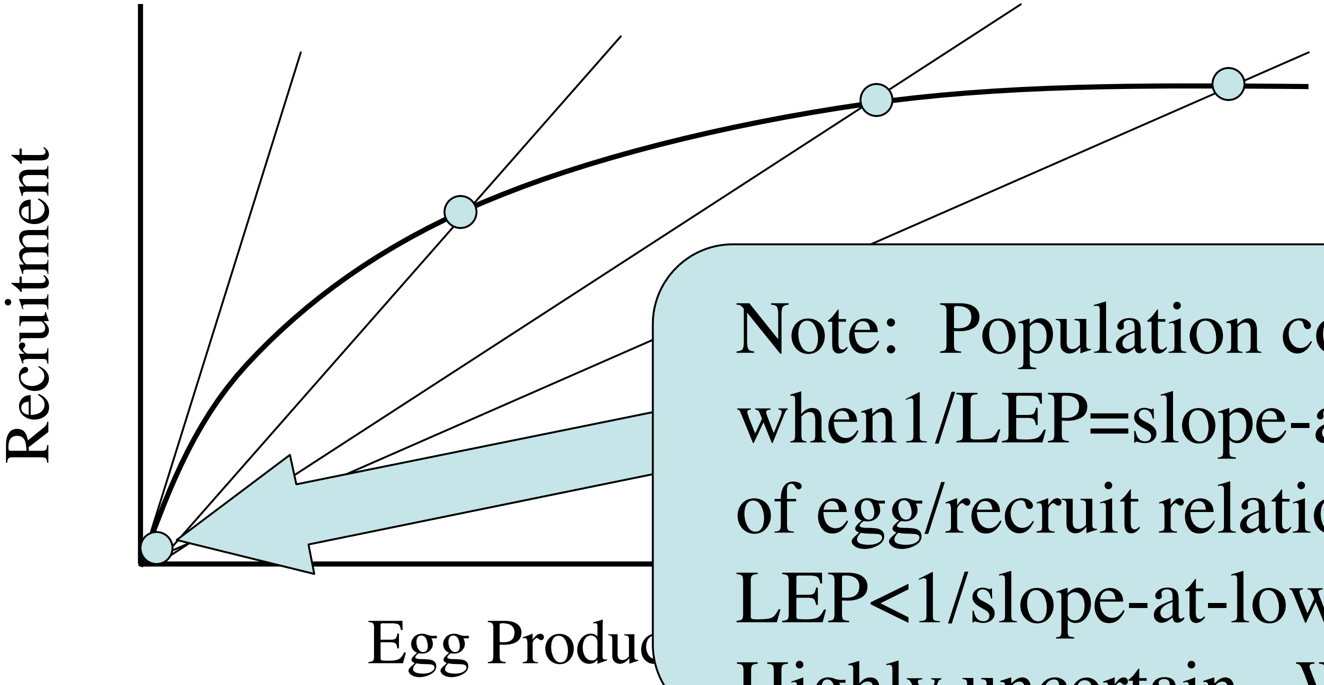
Question: what is the population equilibrium, and when does it go to zero, i.e., when does the population collapse?



Recruit = fish entering population at young age

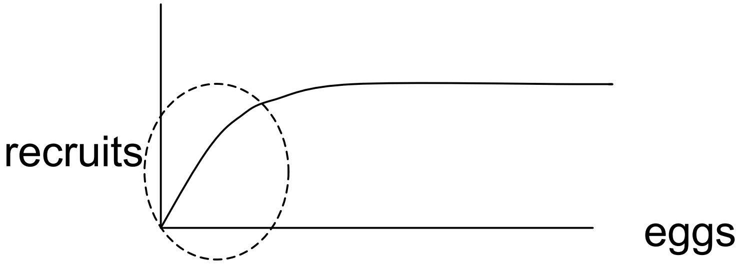
Sustainability of Populations: how hard can we fish?





Note: Population collapses when1/LEP=slope-at -the-origin of egg/recruit relationship (or LEP<1/slope-at-low-abundance) Highly uncertain. Why?

Keep track of LEP, what else?



Theory: random age structured populations, no density-dependence (Tuljapurkar refs, Lande and Orzack (1988))

Probability of N dropping below certain level N_E from

$$\ln[N_T/N_0]=\text{Gaussian}[mT, \sigma^2 T]$$

OR: $$N_T \sim N_0 e^{\mu T}$$

To keep prob[collapse] low, we should keep N_0 and growth rate from becoming too low.

In practical terms, we therefore track N or B and LEP

Current abundance, biomass

Current growth, replacement rate

How much LEP is enough?

1. We express this as a fraction of natural, unfished LEP (i.e., FLEP).

2. From examples where we have data:

35% (Clark 1991) ←

30% (Mace and Sissenwine 1993)

40% (Clark 1993, Mace 1994)

55-60% (Dorn 2002, for rockfishes)

FLEP a.k.a. Spawning Potential Ratio

How much N or B is enough?

Again choose value relative to unfished value, e.g., .4 or .5 times N_0 or B_0

Summary:

To avoid collapse, track and set limits on

1. Abundance or biomass AND 2.replacement rate

Similar to NMFS:

Control rules track

1. Spawning biomass (overfished)
2. Fishing mortality rate F (overfishing)

Set to MSY levels, B_{MSY}, F_{MSY}

In data moderate case (US west coast),

$F_{35\%}$ used as proxy for F_{MSY}

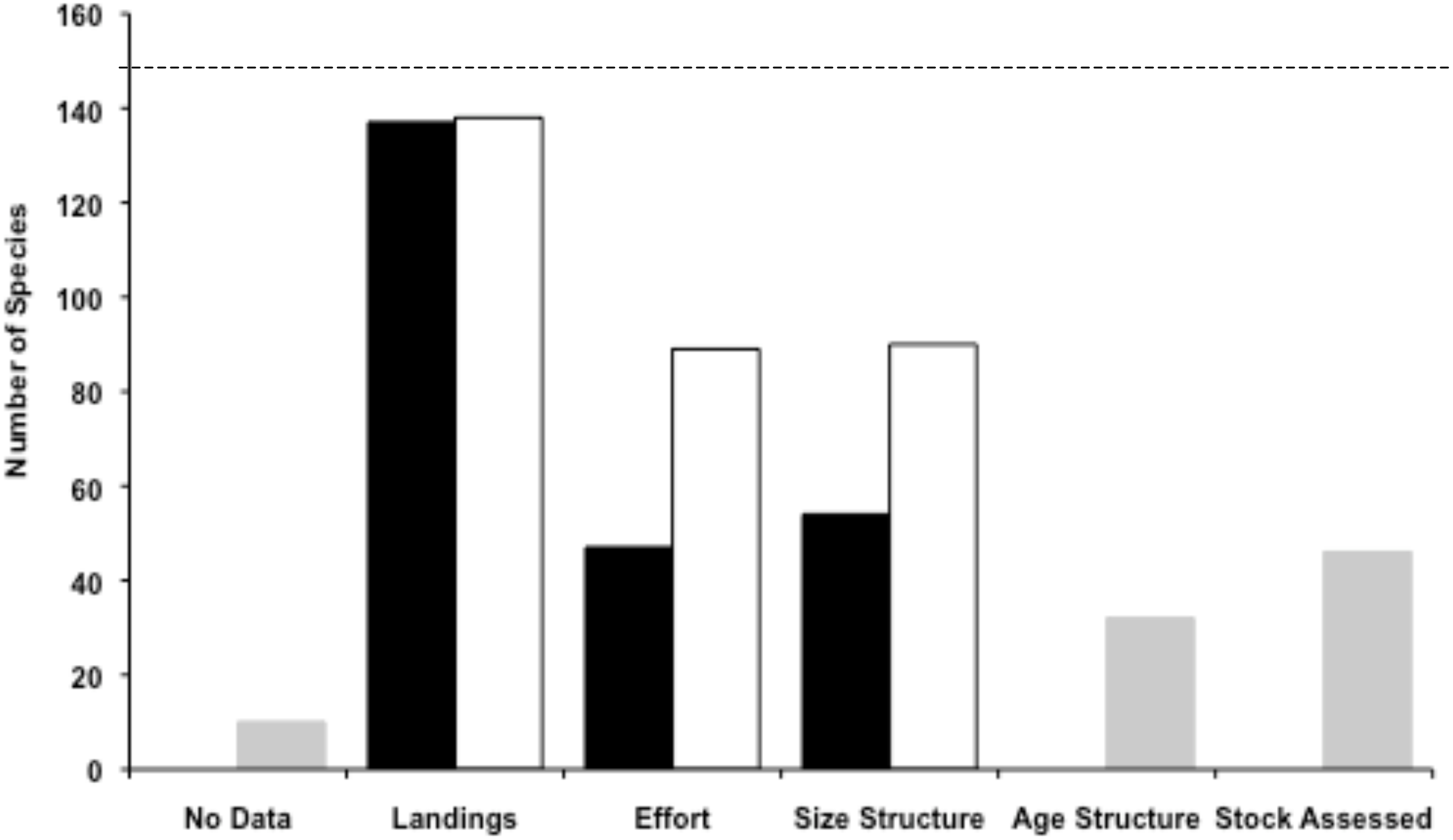
California (also similar):

"Resources are continuously replaced, taking into account fluctuations in abundance and environmental variability" (Fish & Game Code 99.5(a))

Follows federal example (Restrepo, et al. 1998)

See California’s Marine Life Management Act (1999) and Phipps, et al. (2009) this workshop

Data types in all 149 species



Question: Do the fisheries w/o assessments have sufficient data to estimate depletion of replacement?

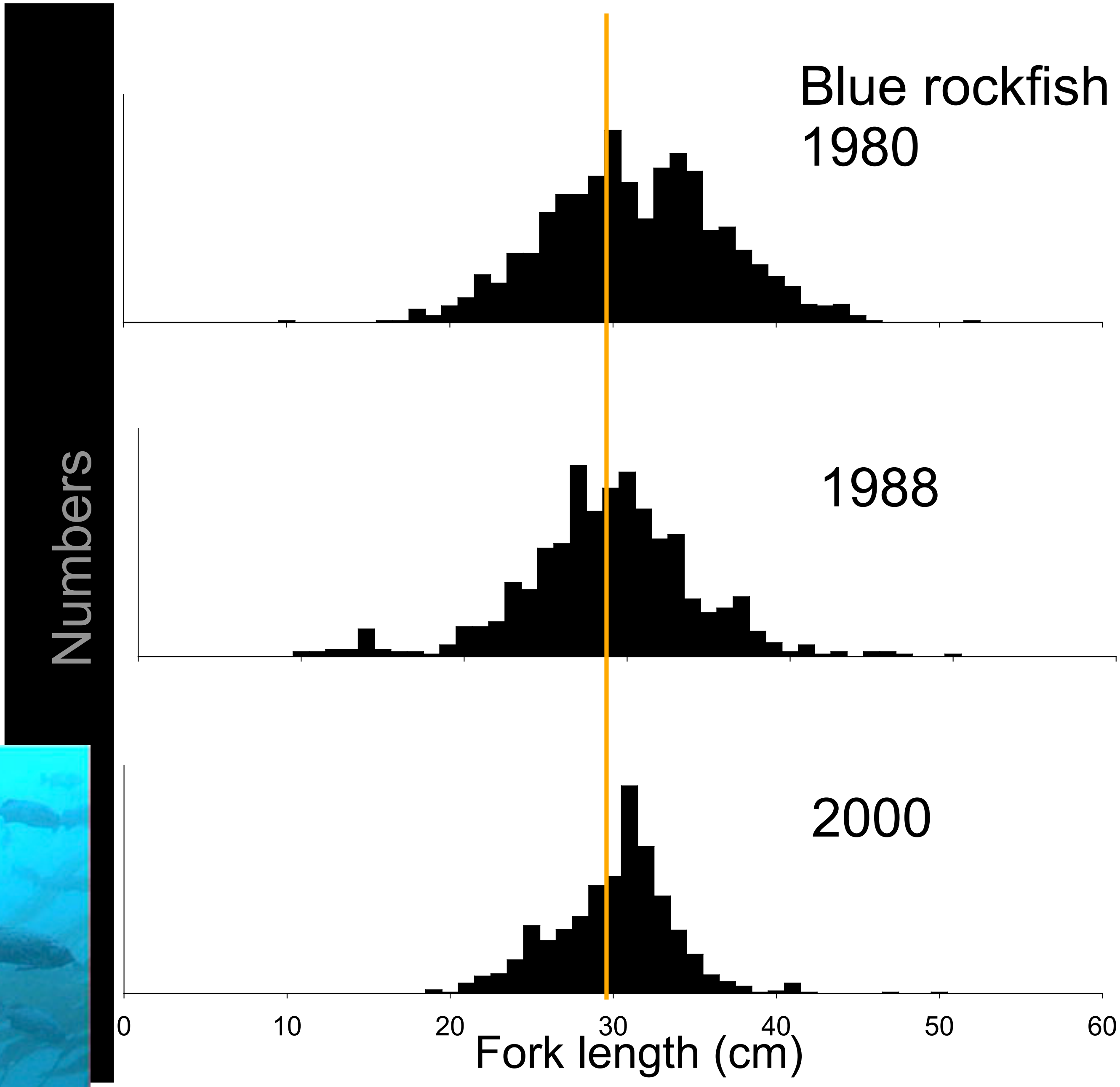
Of the 149 fished species in California,

46 (31 percent) have stock assessments

8 have a data-poor assessment of FLEP, reduction in replacement (from size distributions)

No data-poor assessments of depletion in abundance (e.g., from CPUE)

Data Poor Estimation: Size Distribution Of catch

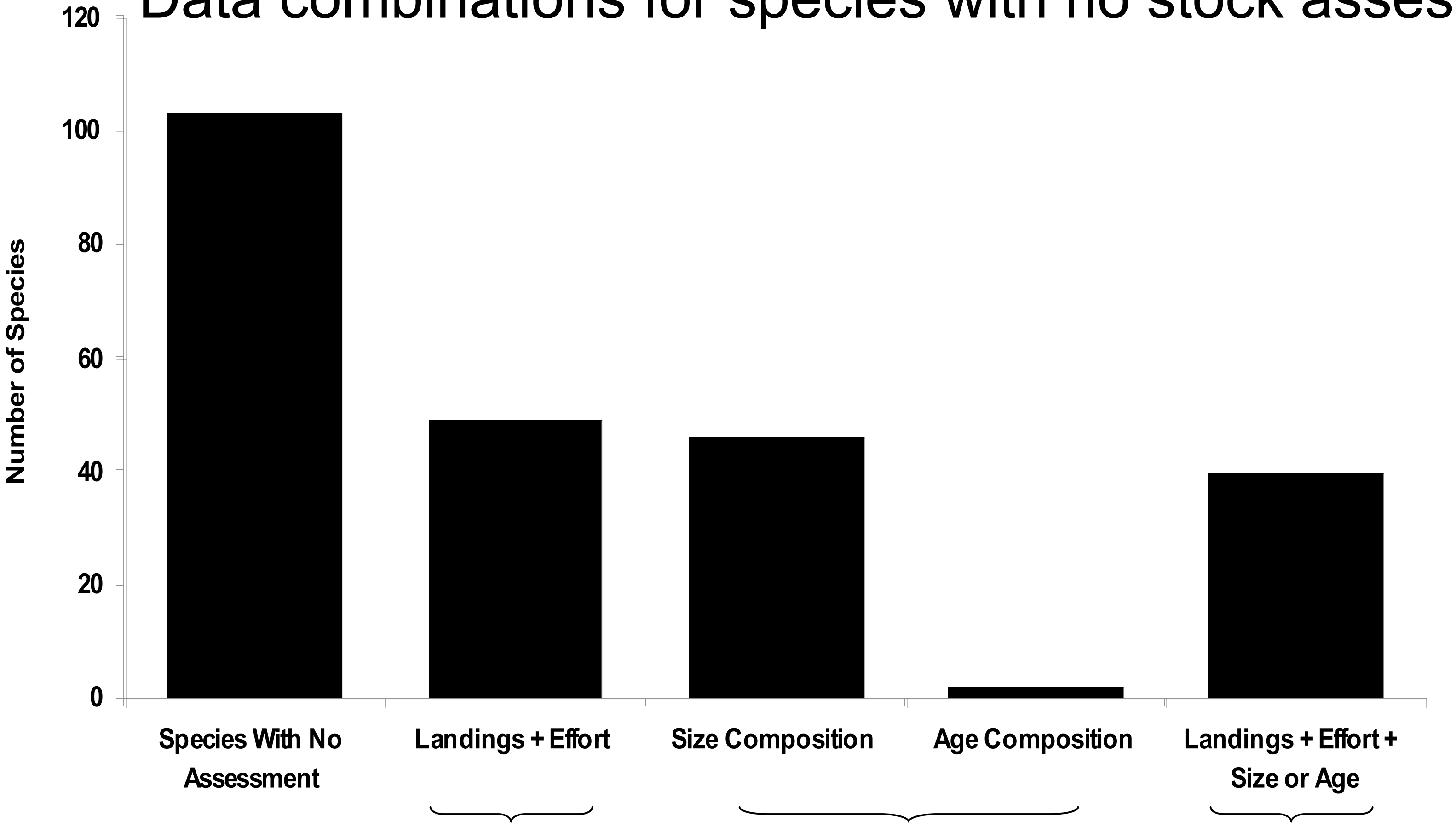


Blue rockfish

FLEP estimated for several California

Blue rockfish	32%	Concern
Black rockfish	13%	Concern
Brown rockfish	>100%	
China Rockfish*	47%	
Copper rockfish	22%	Concern
Kelp rockfish*	>100%	
Olive rockfish	20%	Concern
Sanddab*	100%	

Data combinations for species with no stock assessments



<u>Potential</u> for depletion assessment

<u>Potential</u> for replacement assessment

<u>Potential</u> for both, or stock assessment

Conclusions:

California has stock assessments for 46 of 149 species (almost a third)

Based on data presence/absence, it has the potential for assessing depletion or reduction in replacement for about another third.

We recommend they pursue these “partial, data-poor assessments “ in addition to additional data gathering and stock assessments.

THANKS

Marine
Ecosystem
Management

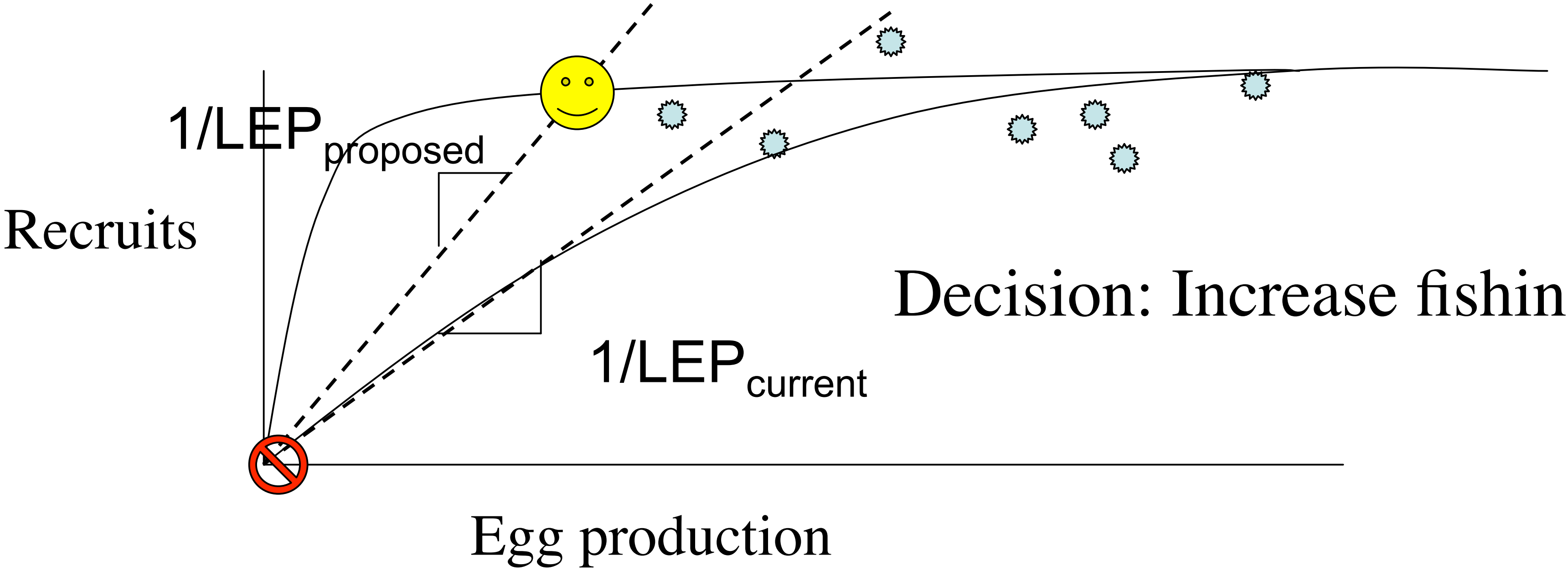
At UCDavis,
the Ag school

Fisheries Management

Initially, we don’t know the egg/recruit relationship.

Specify seasons, number of boats, size limits, etc.

As fishing increases, LEP, equilibrium decline.



Decision: Increase fishing?

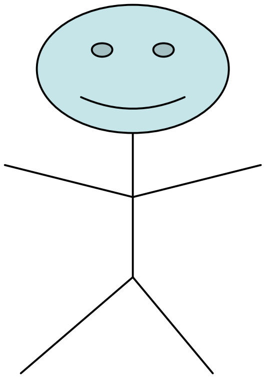
There is uncertainty in:

1. Current recruitment, egg production, i.e., effects of management
2. Where population collapses (i.e., slope-at-origin)

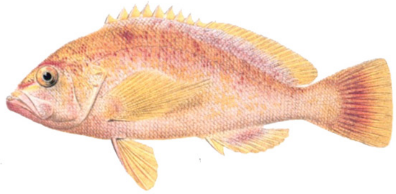
LEP, a measure of Replacement

(Here same as EPR)

Sustainability requires that individuals in a population replace themselves in their lifetime.



In humans, a couple replaces themselves with 2 babies

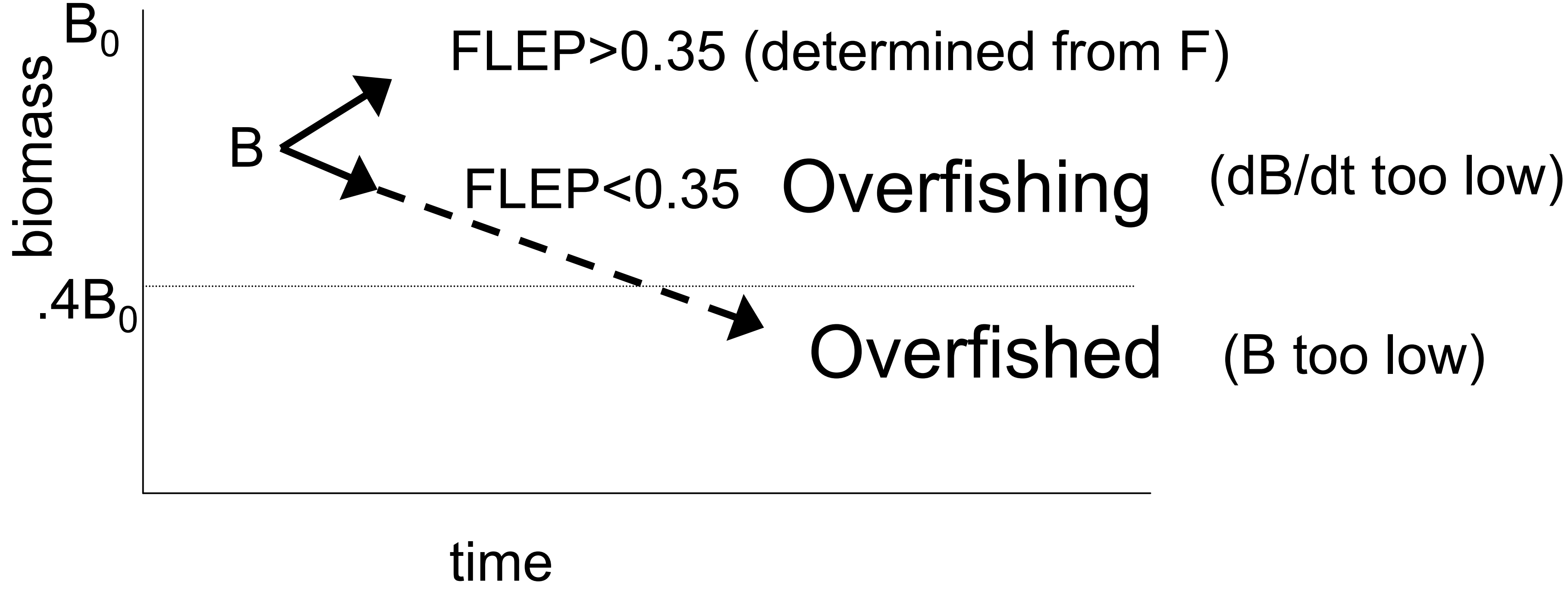


We can observe eggs. How many eggs does it take to replace one fish?

1/(slope of egg-recruit curve at low levels)

Similar to NMFS, but different rationale

Track B and F to determine Overfishing and Overfished



FLEP>0.35 (determined from F)

FLEP<0.35 Overfishing (dB/dt too low)

Overfished (B too low)

Try to keep biomass from sinking too low by taking action when estimated biomass and growth rates are low.

Results: data grouped as in Leet, et al. (2003)

Category	Total Number Species/Groups	Landings	Effort	Size Composition	Age Composition	Stock Assessed	Life History	No Fishery Data
Nearshore Invertebrates	19	18	8	5	0	0	16	1
Nearshore Finfish	68	65	46	47	10	13	54	3
Coastal Pelagic Species	5	5	3	1	3	2	5	0
Highly Migratory Species	15	15	7	9	3	7	13	0
Groundfish	19	19	16	19	12	19	18	0
Salmon	4	4	3	4	3	3	4	0
Estuarine Invertebrates	6	1	2	0	0	0	6	4
Estuarine Finfish	13	8	4	5	1	2	12	5
Total	149	135	89	90	32	46	128	13