Multi-Indicator Adaptive Assessment & Management Framework

(As applied to queen conch)

Richard Appeldoorn

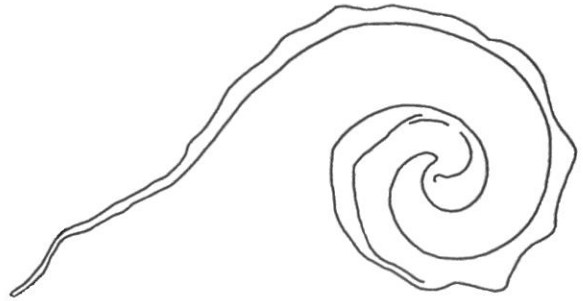
SEDAR 103

Why?

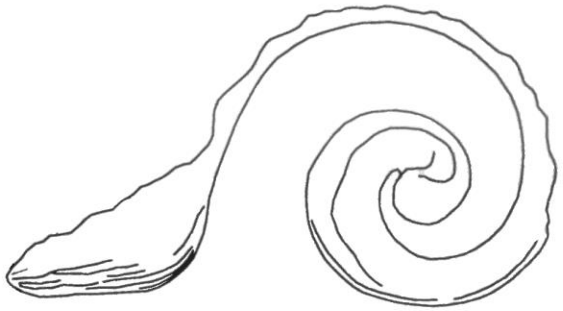
Standard population assessment models not appropriate due to:

Unique Biology

Determinate growth in shell length ~ maturation
(further shell growth by shell thickening)



- Fixes adult size, meat weight, fecundity (?)
  at size at maturation
- No single metric to assign age by size



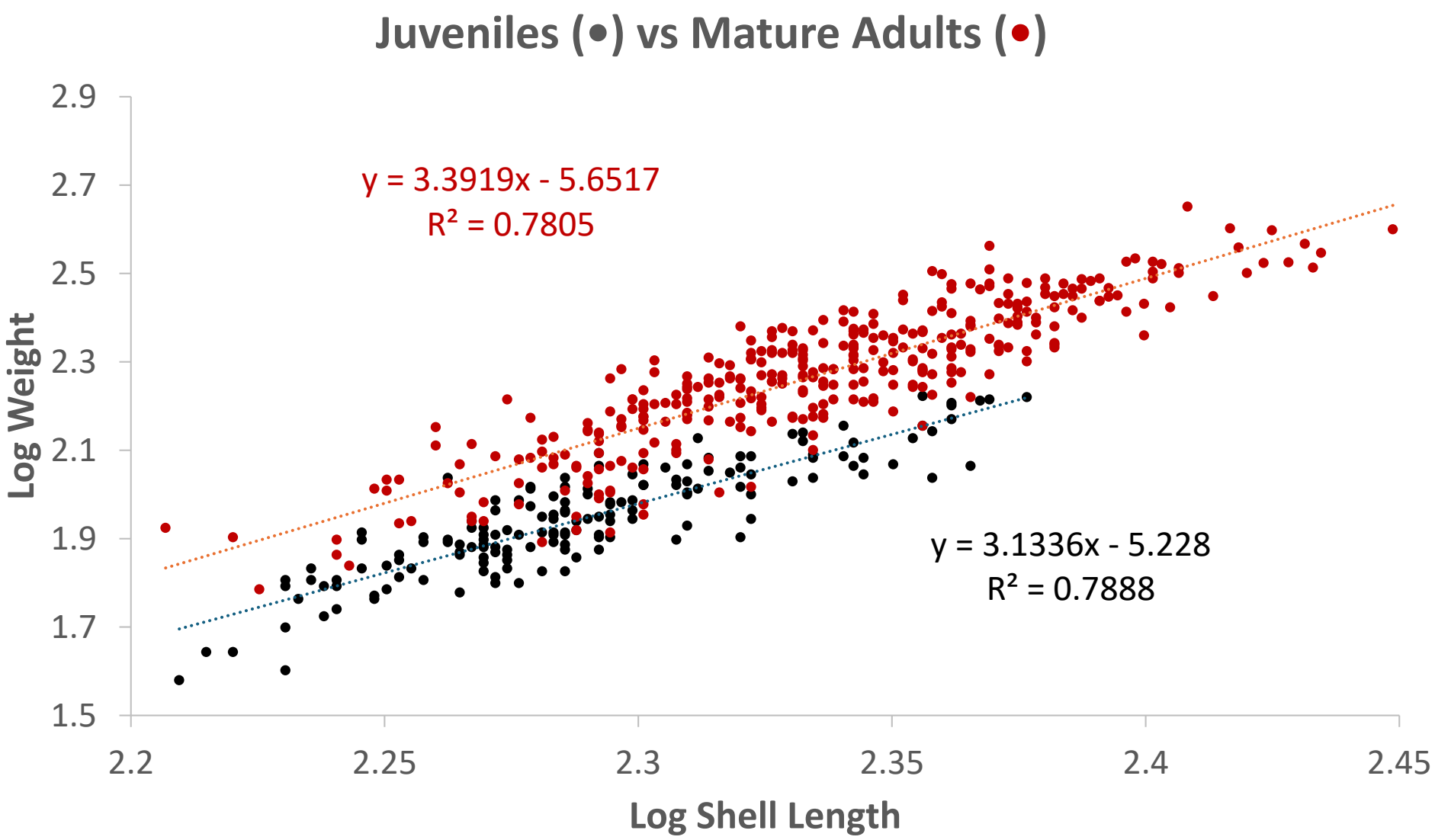
Unique Biology

High spatial variability in length at maturation, due to strong habitat influence

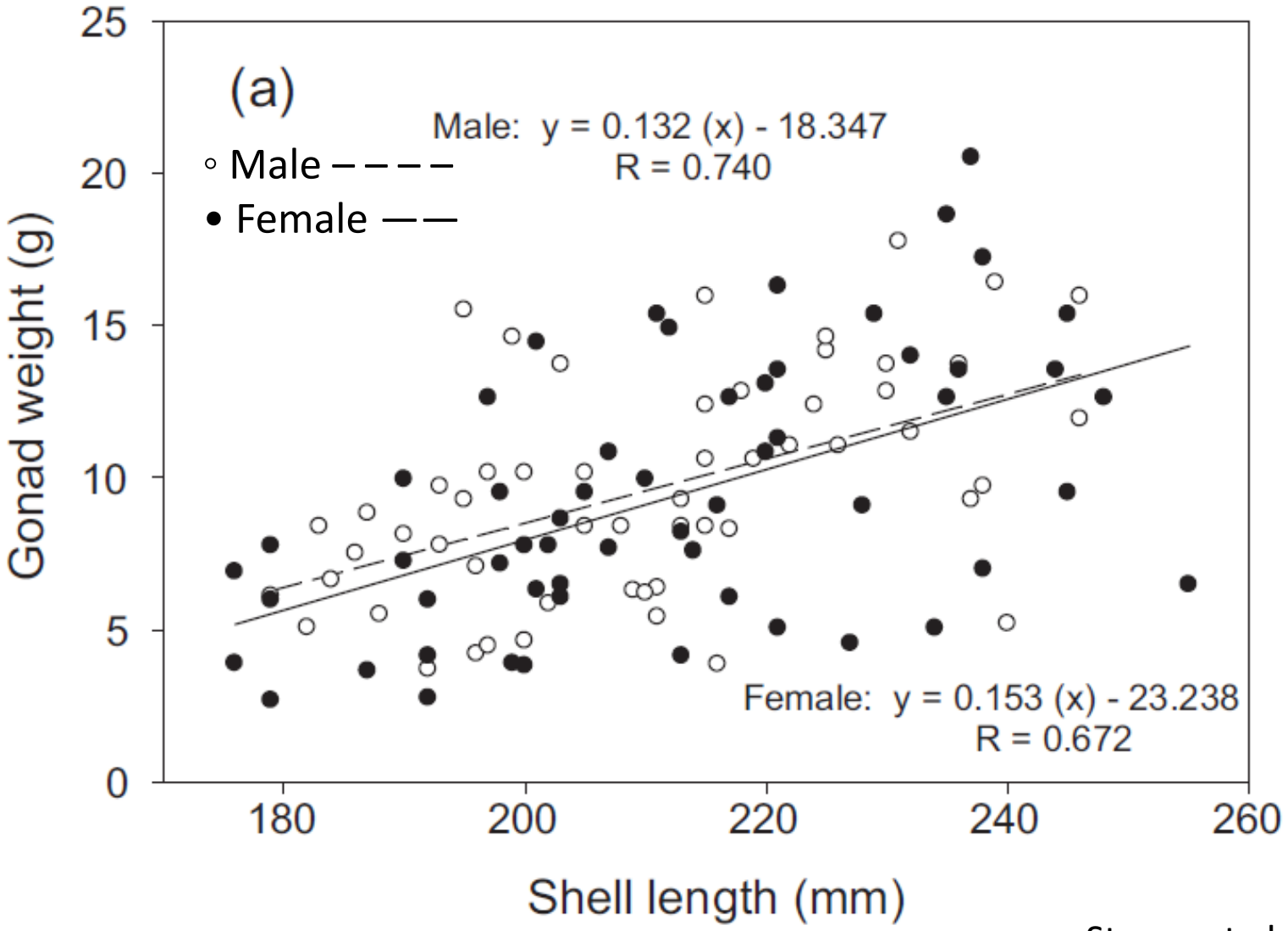
Shell length may not be a good proxy for age even for juveniles

High variability in fecundity (?)

High selection pressure for larger individuals

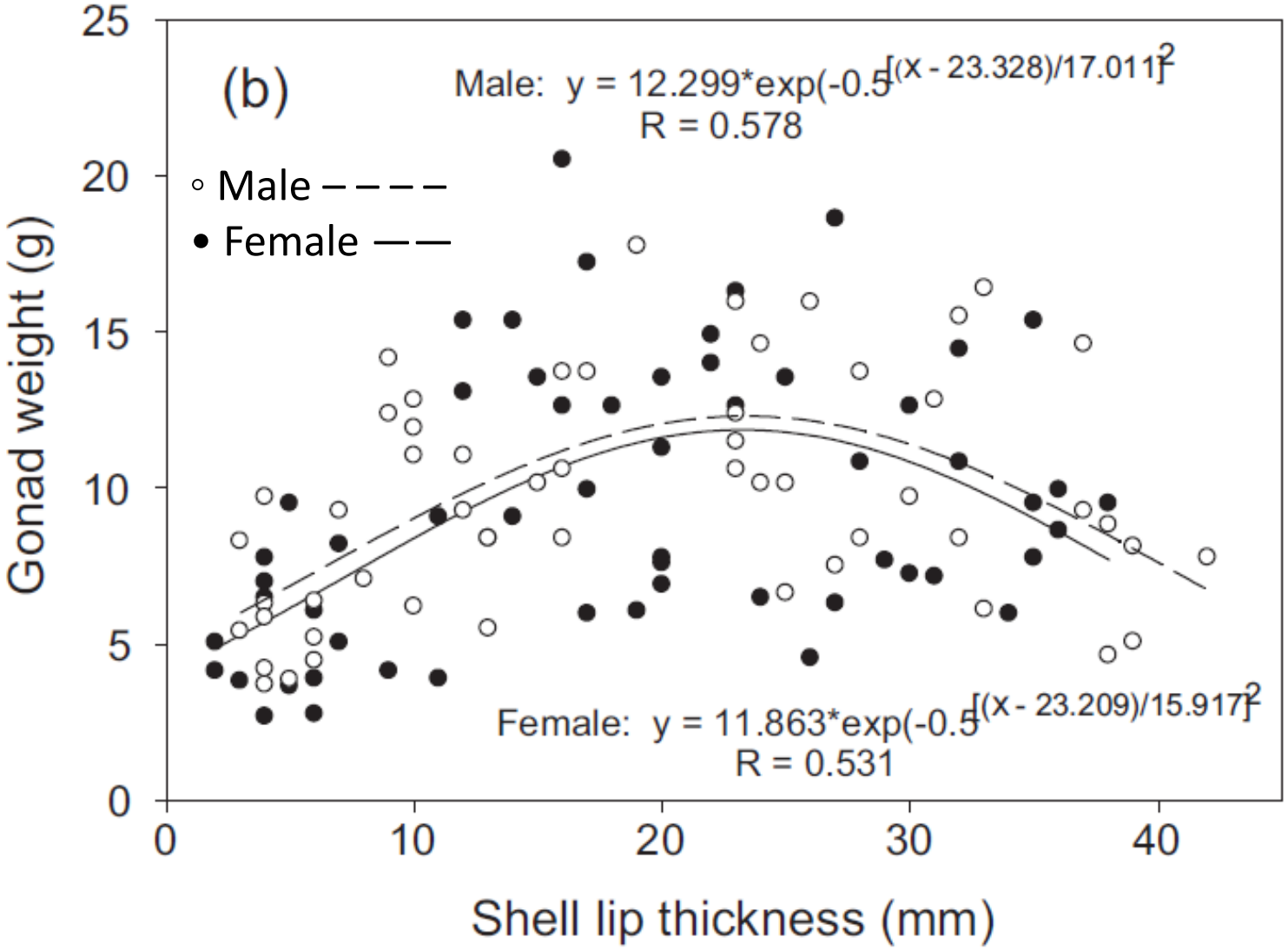

Juveniles (•) vs Mature Adults (•)
y = 3.3919x - 5.6517
R² = 0.7805
y = 3.1336x - 5.228
R² = 0.7888
Log Weight
Log Shell Length
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
2.2
2.25
2.3
2.35
2.4
2.45

High variability in fecundity (?)



Stoner et al. (2012)

BOFFF (i.e., megaspawner) conservation strategy (Froese 2004) difficult to conceptualize



Stoner et al. (2012)

Unique Biology

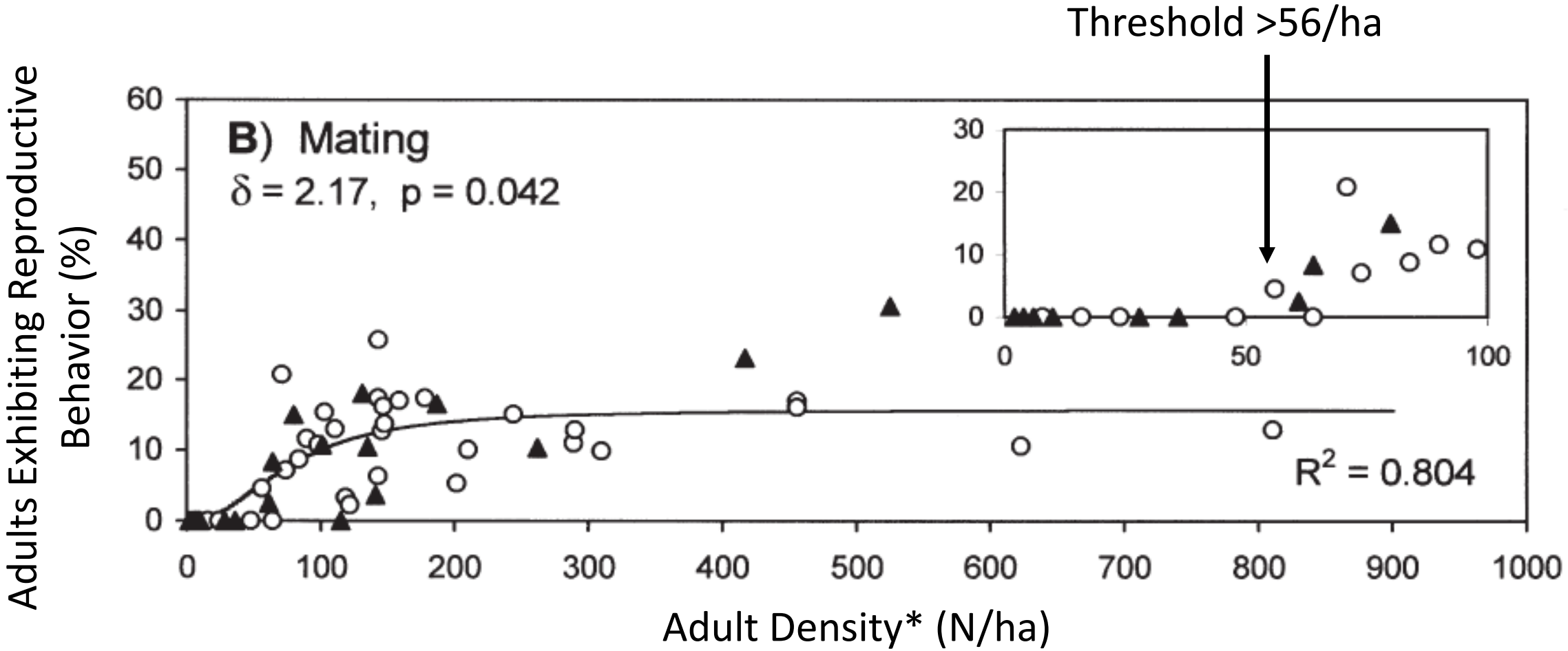
Copulation coupled with slow movement and spatially exploited population densities

Reproduction may be highly dependent on adult density

– leading to Alee effect

– Alee effect significantly impacts assumptions regarding population growth functions used in statistical biomass assessment and catch forecasting models

Allee Effect



*Density in Spawning Area, NOT = Total population density

Stoner & Ray-Culp (2000)

Unique Fishery

Commercial CPUE: not proportional to abundance (density)

PR – Use of daily boat quota, which is almost always reached
Therefore: catch/trip ≈ Constant

STX – Catch is demand based, NOT based of effort (=N trips)

Method description

Multi-Indicator Adaptive Management Framework

- Model free assessment procedure
  - Uses biological & harvest-based indicators
  - In conjunction with harvest control rules (HCRs)

- Provides guidance on future exploitation through
  - Relative adjustments to previous TACs according to HCRs
  - Management-measure Gap Analysis

Data inputs

Method is adaptable, but suggested data inputs are:

- Density
- "Size" composition
- Recruitment
- Frequency of observed reproductive behavior

— Benthic surveys

- Landings
- Number & location of trips
- Price/pound

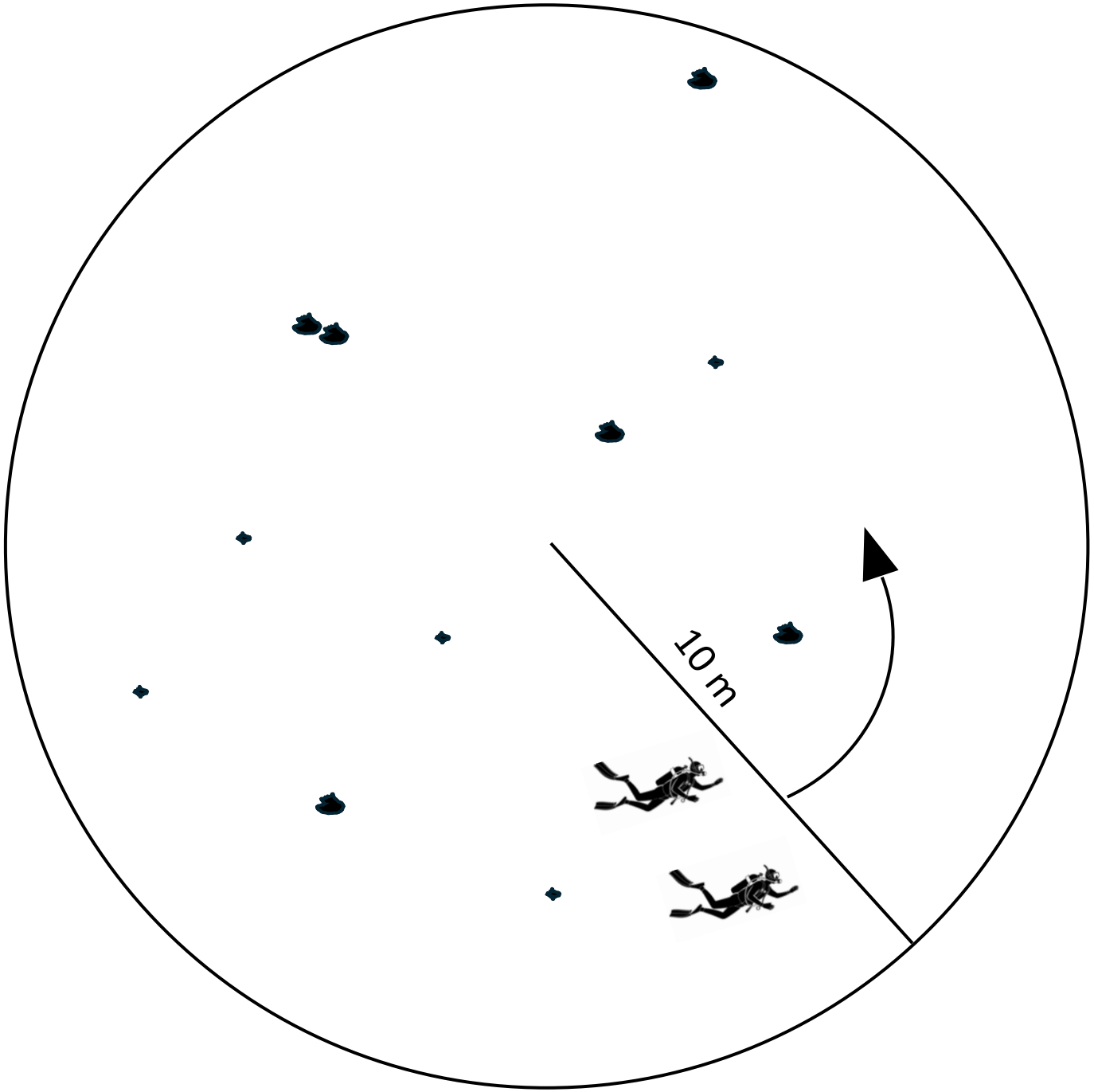
— Comm. Catch reports
Port sampling

Data Collected

- Number of individuals
- Shell length
- Shell Lip-thickness
- Reproductive Activity
- Depth
- Habitat type

Used For:

- Density
- “Size structure”
- Recruitment
- Frequency of reproduction



Analysis/data output summary

- Analysis: Comparison of indicator levels to established standards and changes over time
- Output: Ranking of indicator performance (low, medium or high risk), with overall risk determined through the combination across indicators

- Gap analysis of management measures relative to management goals

Potential Indicators and Risk Assessment*

Indicator		**Risk**	
	Low (= 2)	Medium (=1)	High (= 0)
Density	Harvestable population density > 100 conch/ha	Harvestable population density < 100 conch/ha but >50 conch/ha	Harvestable population density < 50 conch/ha
Average size of conch in the population	Average size well above minimum size. Average size increases over time	Average size significantly above minimum size. Average size is variable but no long-term trend	Average size approaches minimum size. Average size decreases over time
Size composition of population	Conch found in oldest size/age classes	Some old individuals occur	No individuals found in oldest size/age classes
Recruitment	Many conch observed in the field in the smallest size classes (age 1+)	Some conch observed in the field in the smallest size classes	Few or no conch observed in the field in the smallest size classes
Distribution of fishing effort	Spatial/depth distribution of effort is constant over time	Spatial/depth distribution of effort changes slightly over time	Spatial/depth distribution of effort changes over time to deeper depths or sites further away

*Extracted from Tables 6.2 & 8.1 in CITES Secretariat. 2026.

Potential Indicators and Risk Assessment*
(Continued)

Indicator		**Risk**	
	Low (= 2)	Medium (= 1)	High (=0)
Proportion harvested	Proportion harvested ≤ 4 % of exploitable biomass	Proportion harvested is between 4 and 8% of exploitable biomass	Proportion harvested ≥ 8% of exploitable biomass
Reproduction Frequent	Mating, copulation and spawning are frequently reported by fishers/surveyors	Mating, copulation and spawning are occasionally reported by fishers/surveyors	Mating, copulation and spawning are infrequently or not reported by fishers/surveyors
Trend in Catch	Catch is decreasing over time	Catch is steady or slowly increases over time	Catch is increasing rapidly over time
Trend in price per weight	Price per weight is decreasing over time	Price per weight is steady or slowly increases over time	Price per weight is increasing rapidly over time

*Extracted from Tables 6.2 & 8.1 in CITES Secretariat. 2026.

Density	0
Size composition	1
Recruitment	2
Freq. reproduction	1

Average score = 1 (moderate stress)

Catch trend	1
Price/lb trend	1
Number of trips	0
Spatial Distribution	1

Average score = 0.75 (moderate stress)

Can give variable weights to each indicator

Example:
Giving greater weight to population indicators

Survey based indicator average = 1 x 1.5 = 1.5

Fishery based indicator average = 0.75 x 1 = 0.75

Weighted Average = 1.125

How this method can inform management

- Determined risk level triggers management response based on harvest control rules to increase, decrease, or maintain catch levels and/or alter harvest regulations (e.g., size limits, closed season, closed areas, etc.)

- More rigorous results will come from established time series of indicators, which will allow assessments/outcomes to be fine-tuned over time.

Harvest Control Rule: A simple Example

Range of possible response: 0 to 2
Therefore, split into 3 parts:

Indicator Score	**Status**	**HCL**
>1.5	Low stress	Raise ACL by 20%
1 to 1.5	Moderate stress	Keep ACL unchanged
<1	High stress	Reduce ACL by 20%
		Review Mgt Measures

Caveats for this method

- Density and size-structure data obtained at 2-year intervals (SEAMAP-C; SEFSC)

  Therefore, minimum frequency of assessment is 2 years
  But – this is rapid by current assessment time frames

- Spatial distribution/movements not well understood in PR & St. Croix

Caveats for this method

- Process requirea consensus and formal adoption management agencies
  (1) Indicators
  (2) Definitions of low, medium and high stress
  (3) Weightings given to each indicator
  (4) Trigger values requiring mandated management response
  (5) Magnitude of management response

  Note: MSE is feasible using the model of Harford (2021)

- Adoption requires:

  Orientation
  Education ├——-⟩ Time
  Discussion

Caveats for this method

- No previous specific application to queen conch, but based on:

Harford, WJ, T Gedamke, EA Babcock, R Carcamo, G McDonald, JR Wilson. 2016. Management strategy evaluation of a multi-indicator adaptive framework for data-limited fisheries management. Bull Mar Sci. 92(4):423–445.

CITES Secretariat. 2026. CITES Non-Detriment Finding Guidance for Queen Conch.

Questions?

Pink is the shell of the queen,
in nature a hue rarely seen,
It’s so pretty some pay
for the conch in a way
that would make a flamingo turn green.