Considerations for harvest management plan for sea cucumber

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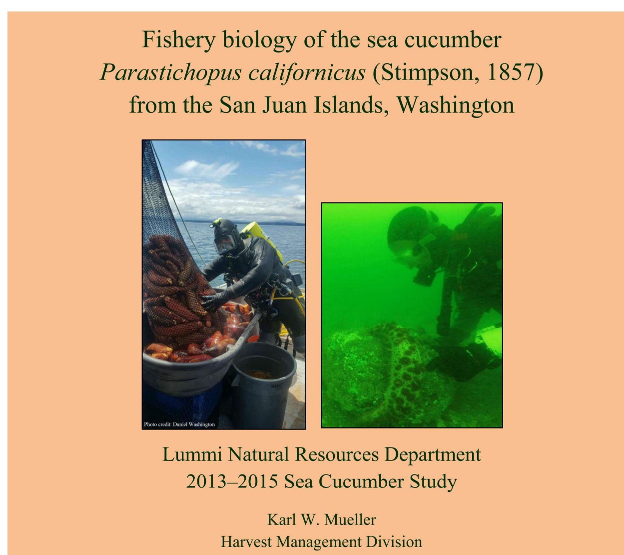
- Review 2016 LNR study
- Recommendations originally appeared in that document
- Additional data and analysis (this PowerPoint) support 2016 recommendations



Fishery biology of the sea cucumber
Parastichopus californicus (Stimpson, 1857)
from the San Juan Islands, Washington

Lummi Natural Resources Department
2013–2015 Sea Cucumber Study

Karl W. Mueller
Harvest Management Division

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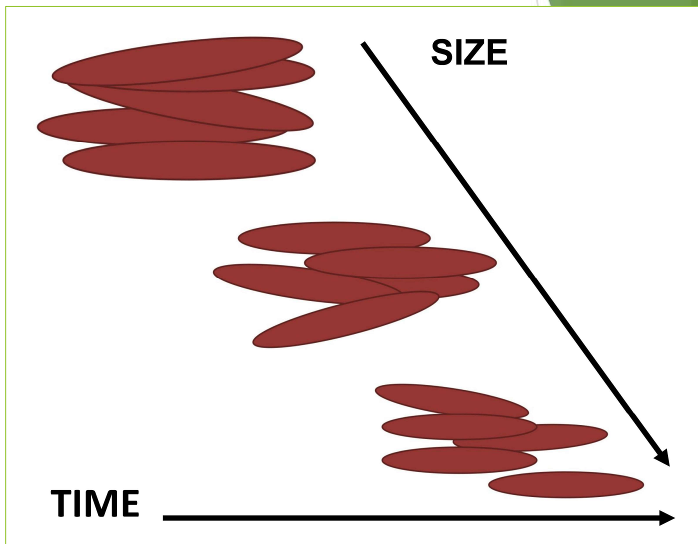
2016 LNR study revealed that size-selective harvesting is impacting stock status and reproduction

- Size-selective harvesting occurs when the largest individuals in a stock are preferentially removed leaving smaller and smaller individuals on the fishing grounds over time



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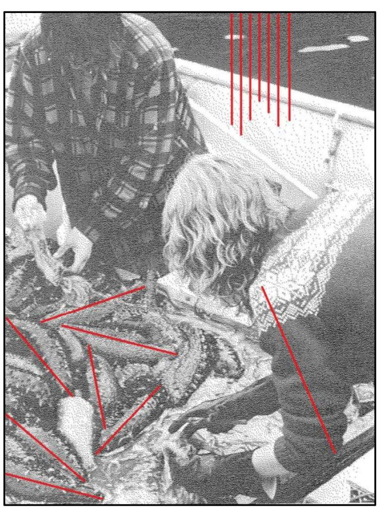

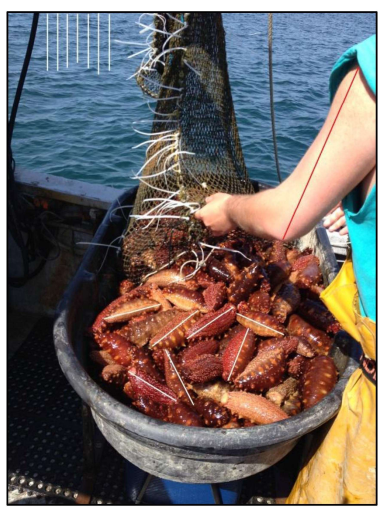

- How does size-selective harvesting impact our stock(s)?
- 2016 LNR study used several lines of evidence to indicate decrease in size of sea cucumber in Salish Sea
- For example, historical photograph analysis at left shows a 30% decrease in size of individual sea cucumber from beginning of dive fishery (1980s; left) to present day (2010s; right)

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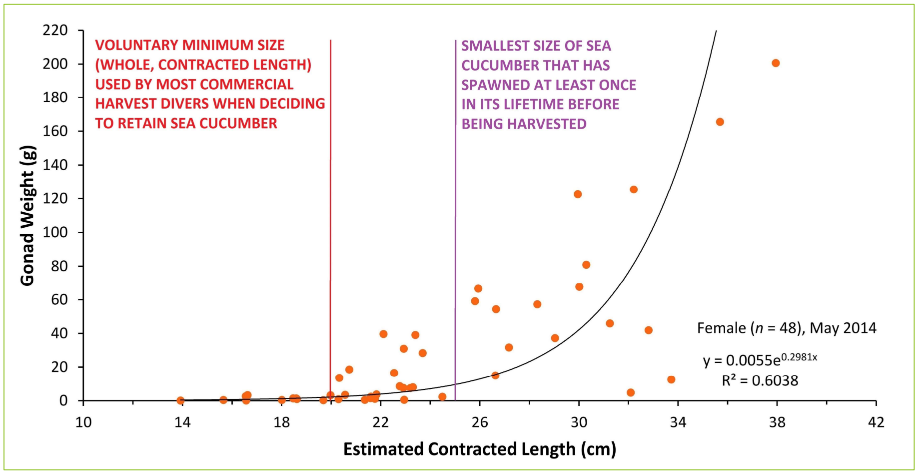

- How does size-selective harvesting impact reproduction?
- 2016 LNR study included aspects of *P. californicus* reproduction
- Above, the exponential relationship between egg mass and size of female sea cucumber. Same relationship exists in male sea cucumber
- For given length and gonad mass, it is evident that smaller sea cucumbers have considerably less reproductive potential than larger ones

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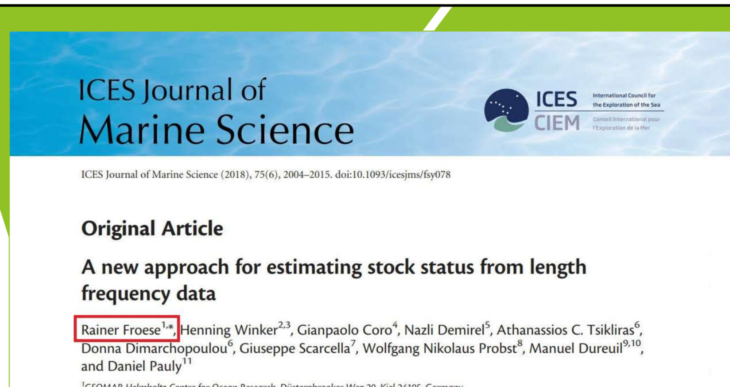
Evaluating impact of size-selective harvesting beyond the 2016 LNR study: Use of a new tool for data-poor fisheries

- Froese et al. (2018) use length frequencies (LF) from commercial catches to evaluate stock status
- Authors apply well-known, standard fisheries equations to model exploited populations
- Their length-based biomass (LBB)* estimation method determines:
  - Whether observed size structure is representative of a "healthy" stock
  - The change in relative biomass, or the rate of stock depletion, under applied fishing pressure
- LNR LF data from 2013, 2014, 2016, and 2019 (N = 768 sea cucumber) were analyzed with LBB


ICES Journal of Marine Science

ICES CIEM

ICES Journal of Marine Science (2018), 75(6), 2004–2015. doi:10.1093/icesjms/fsy078

Original Article

A new approach for estimating stock status from length frequency data

Rainer Froese[1,*], Henning Winker[2,3], Gianpaolo Coro[4], Nazli Demirel[5], Athanassios C. Tsikliras[6], Donna Dimarchopoulou[6], Giuseppe Scarcella[7], Wolfgang Nikolaus Probst[8], Manuel Dureuil[9,10], and Daniel Pauly[11]

[1]GEOMAR Helmholtz Centre for Ocean Research, Düsternbrooker Weg 20, Kiel 24105, Germany

*LBB also determines the optimal length (*L*opt) for an exploited stock such that, were the *L*opt to become the length at first capture (*L*c) in the fishery (read: minimum-length limit), impacts on size structure would be minimized, while catches and biomass would be maximized

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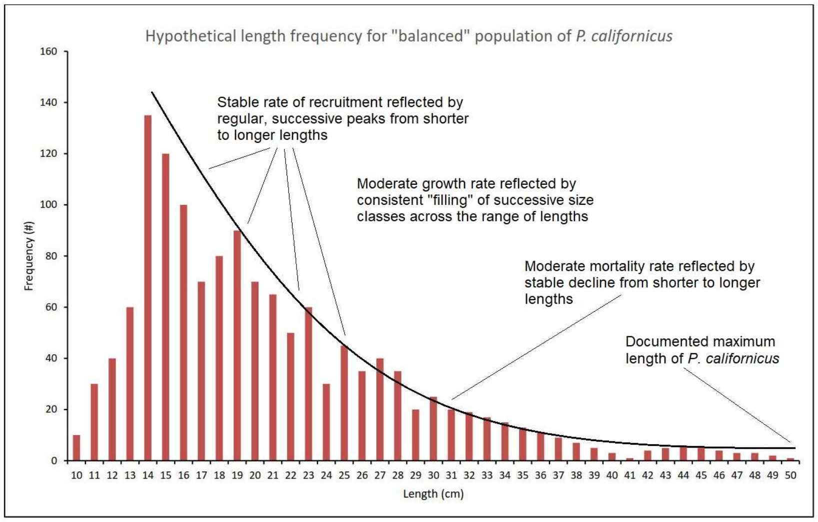
Brief review: What can we learn from length frequency (LF) data and what should a healthy stock look like? Below is an idealized LF distribution for sea cucumber. The LBB method uses information gleaned from an LF distribution such as indicators of recruitment, growth, and mortality to assess stock status



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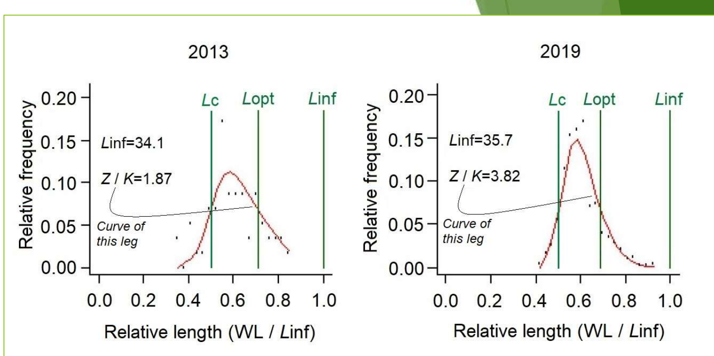
Output from applying Froese et al. (2018) to LNR LF data at beginning and end of time-series (2013 – 2019)



- WL = Sea cucumber length, cm
- *Lc* = Length at first capture in commercial fishery (= 17.5 cm)
- *Linf* = Theoretical maximum length beyond which sea cucumber cannot grow
- *Lopt* = Estimated optimal length (≥ 24 cm)
- *Z* = Total mortality (natural + fishing)
- *K* = Body growth coefficient
- *Z/K* = Relative change in stock size with length

Take aways:

- About 70% of sea cucumbers landed are below the estimated optimal length (*L*opt) for the stock
- Increasing *Z/K*, from beginning to end of time-series, suggests exponential decrease in stock size with length, i.e., increasingly higher size-selective fishing pressure over time
- Bottom-line: Too many of too small, immature sea cucumbers are being harvested

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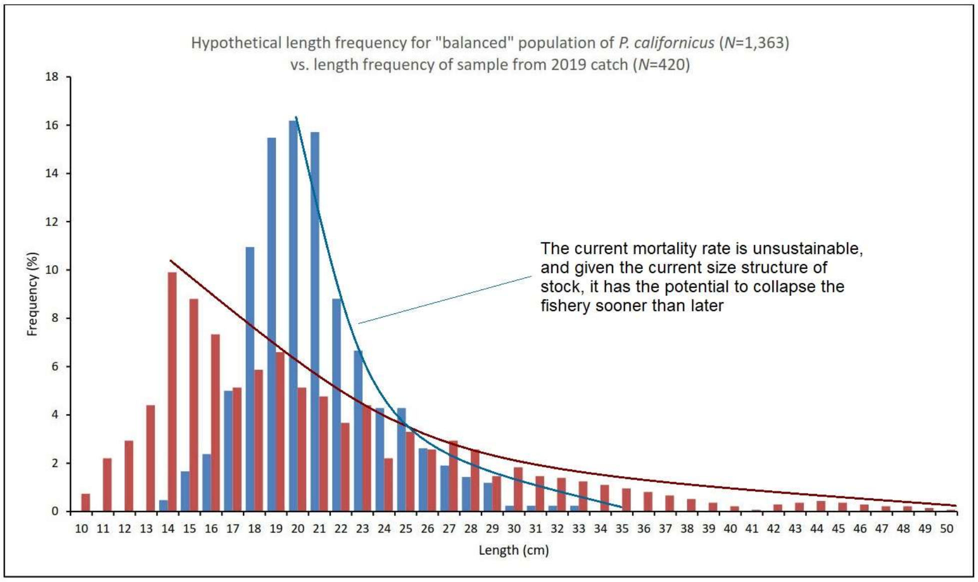

- 2019 LF data plotted over idealized LF distribution for sea cucumber to show just how far off the mark the current stock is from one having a size structure that is sustainable

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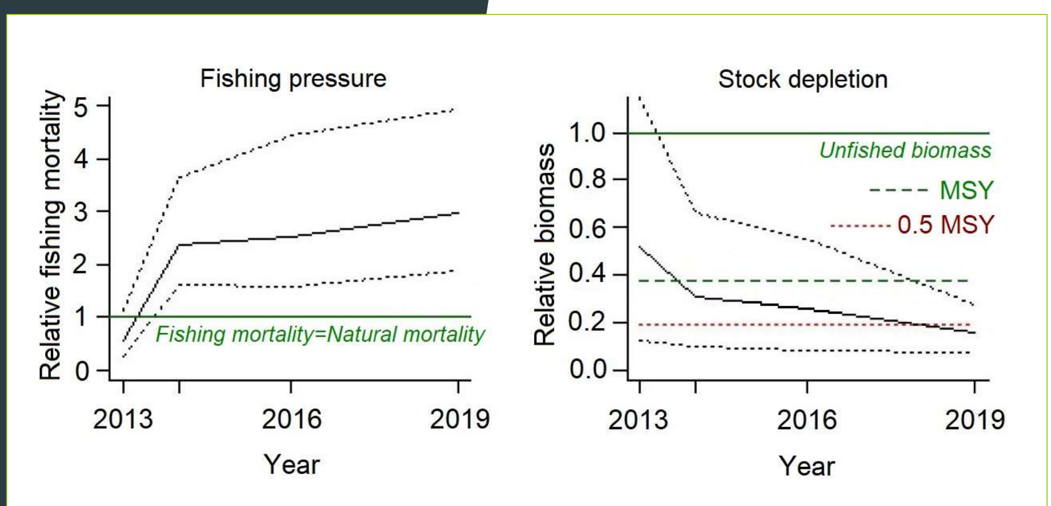
Impact of overfishing



- Fishing mortality is two- to three-fold higher than natural mortality and rising
- Without continued intervention, at the current rate of depletion, it is possible the fishery will collapse within 3 – 5 years

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Management response?

- Increase stock size (#) and size at first capture

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Increase abundance by maximizing natural production of sea cucumber

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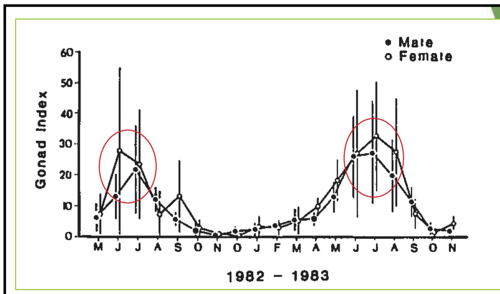
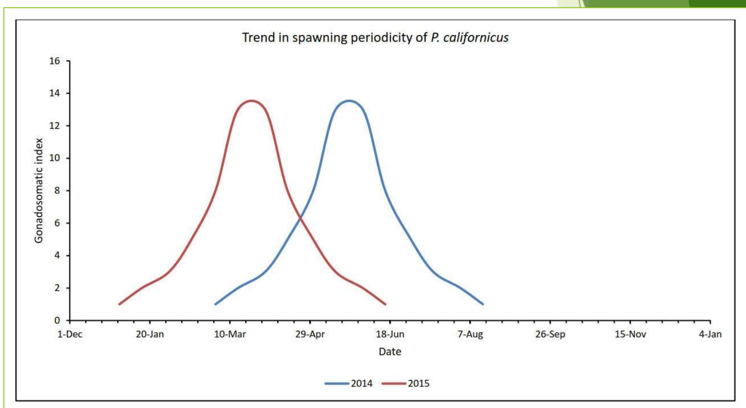


BC, Canada

SJI, WA



2016 LNR study revealed that spawning peaks vary by location and time

Action: WA co-managers adopt spawning closure (April 1-June 15) based on 2016 LNR study

Suspicion: Climate change causing spawning period to swing by days/weeks

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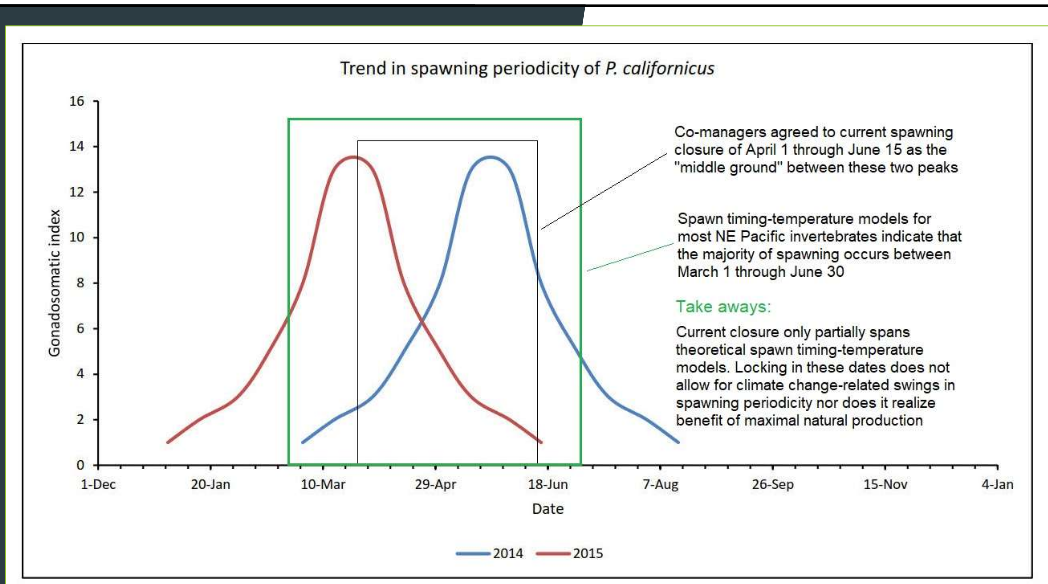

Recommendation: Expand spawning closure to March 1–June 30

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Increase size at first capture by mandating minimum-length limit

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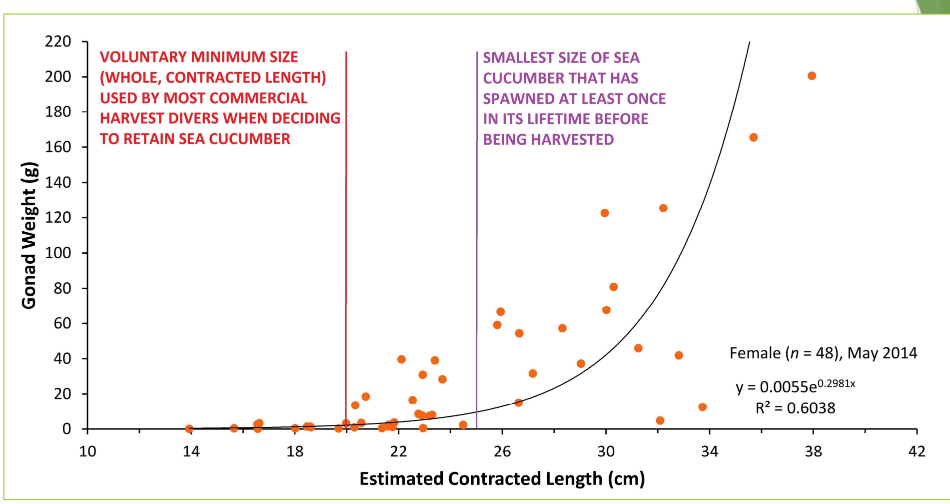

Recommendation:
25 cm minimum-length limit

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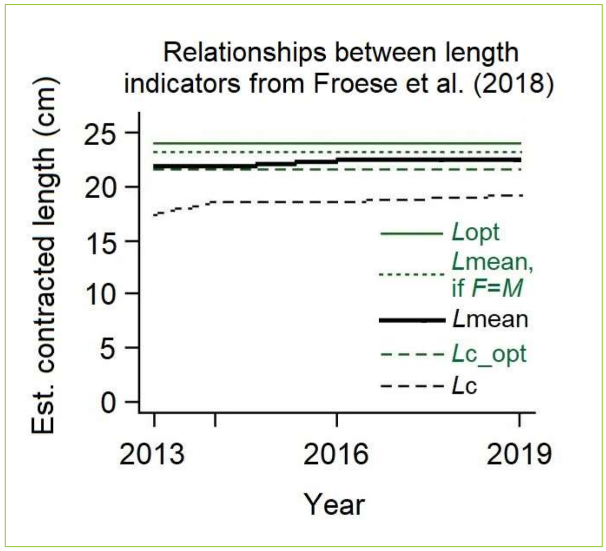
How will a 25 cm minimum-length limit measure up?

- In reviewing the LBB analysis of LNR LF data using Froese et al. (2018), with *L*c always below *L*c_opt, and with *L*mean always below *L*opt, the indicators at right reflect a "short" or unhealthy size structure for the sea cucumber stock
- The 25 cm minimum-length limit ensures that most sea cucumbers in stock will have chance to spawn at least once before being harvested
- The LBB analysis also determined the optimal length (*L*opt) for the stock such that, were the *L*opt to become the length at first capture (*L*c) in the fishery, i.e., the 25 cm minimum-length limit, impacts on size structure would be minimized, while catches and biomass would be maximized
- Conclusion: A 25 cm minimum-length limit will "raise the bar" considerably, ensuring increased reproductive capacity and harvestable biomass in the future



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When implementing the 25 cm minimum-length limit, co-managers can use weight-length conversions of Hannah et al. (2012)

North American Journal of Fisheries Management 32:167–176, 2012
American Fisheries Society 2012
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2012.663455

ARTICLE

Growth Rate of the California Sea Cucumber *Parastichopus californicus*: Measurement Accuracy and Relationships between Size and Weight Metrics

Lucie Hannah,* Nicholas Duprey, John Blackburn, Claudia M. Hand, and Christopher M. Pearce
Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, British Columbia V9T 6N7, Canada

$$\log_e(\mathbf{SWA}) = 0.104 + [0.818 \times \log_e(\mathbf{WWA})]$$

$$\log_e(\mathbf{SWA}) = -2.03 + [2.310 \times \log_e(\mathbf{WL})]$$

$$\log_e(\mathbf{WWA}) = -2.72 + [2.860 \times \log_e(\mathbf{WL})]$$

- Can measure length of sea cucumber underwater (WL)
- Can weigh whole, live wet weight of sea cucumber at surface (WWA)
- Can weigh split-and-drained weight at surface or at market (SWA)
- Can easily convert between the three metrics
- Length-weight look-up table greatly simplifies process

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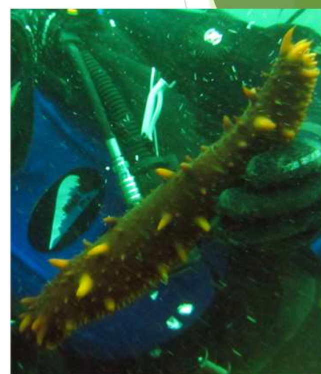
With appropriate use of gauge, divers can easily distinguish questionable-sized sea cucumbers underwater. Leaving small, immature sea cucumbers on bottom is best practice for resource.



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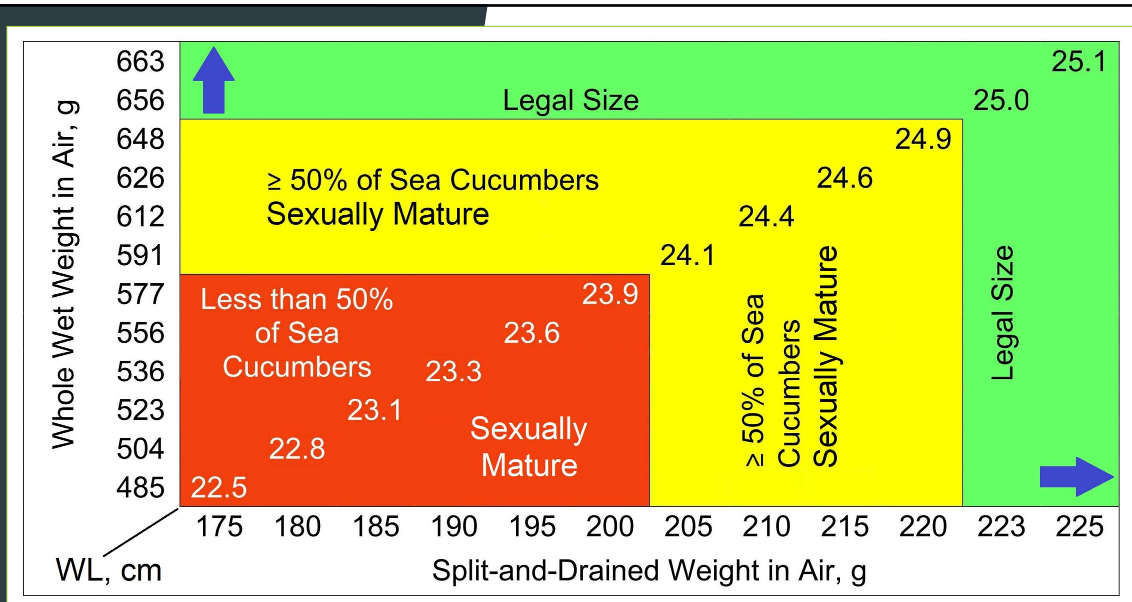

- At surface or in marketplace, a handy weight-length look-up table can be used to convert between metrics to ensure compliance

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