## Waxing nostalgic: 100+ years of pregnancies to explore population dynamics of whales

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- Scientist's name: Dani Crain
- Originally from Northern California
- Moved to Texas in August 2015 to start PhD program at Baylor University
- I study whale endocrinology











Present Your PhD



#### How did I get here?

- UCSC, Bachelor of Science
  - Graduated in 2009, not a good year!
  - Internship 2010
- Duke, Masters of Environmental Management (MEM)
  - 2010-2012
- Applied for three years for a PhD
  - 2013: Sales representative for publishing company
  - 2014: California Department of Fish and Wildlife
  - 2014-2015: College adjunct lecturer
- 2015: Accepted at Baylor

#### My future job prospects

- Lecturer/teacher (teach full-time)
- Faculty (teach part-time, research part-time)
- Work at a government agency (like National Oceanographic and Atmospheric Administration, within Department of Commerce)
  - Cetacean Health and Life History Program, Southwest Fisheries Center

## Quick intro to endocrinology!



#### Glands

• Two types of glands in our bodies:

- Exocrine glands
- Endocrine glands





### What's a hormone?

- A chemical secreted by endocrine cells that travels through the bloodstream and affects the activities of *target cells* somewhere else in the body
- An internal molecular messenger used to communicate



## Target Cells



- Each target cell has receptor proteins specific for hormones they are "sensitive" to
- Hormone 1 is referred to as the <u>ligand</u> of Target Cell "A"

## Target Cells



• Other hormones do not match to these receptor proteins & thus do not stimulate the cell.

#### Homeostasis

- <u>Homeostasis</u>: The ability of a system (the body) to maintain a stable and balanced internal environment.
- Examples:
  - Temperature
  - Acidity
  - Salt content
  - Disease
- Homeostasis requires complex feedback mechanisms

#### The Pancreas

- Located below the stomach
- Endocrine cells are called *pancreatic islets* 
  - Alpha cells produce glucagon
  - Beta cells produce insulin



#### <u>Insulin</u>

Secreted when blood glucose levels are *high*Targets most body cells
Result is to *reduce* blood glucose levels

#### **Glucagon**

Secreted when blood glucose levels are *low*Targets liver cells and skeletal muscle fibers
Result is to *increase* blood glucose levels



### How do we study hormones in humans?

• Mainly by measuring hormones in blood

#### History of endocrinology in marine mammals

- Blood
- Urine/feces



#### History of endocrinology in marine mammals

- Blood
- Urine/feces
- Blubber





#### Importance

- Many species of whales are endangered
  - MMPA 1972
  - ESA 1973
- U.S. needs to manage these populations
  - Size of population
  - Growth rate of population





https://www.hakaimagazine.com/article-long/whales-through-new-lens, Clockwise from top left) Ingo Arndt/Minden Pictures/Corbis, Tom Soucek/AlaskaStock/Corbis, Ashley Cooper/Corbis, Joe McDonald/Corbis

## Observational data

Whale ID	Sighting Date	Reproductive State	Location
539	1975	Unknown	Frederick Sound
539	1991	mother	Icy Strait
539	1997	mother	Glacier Bay
539	2002	mother	Icy Strait
539	2005	mother	Icy Strait
		Found dead, not	
539	2014	pregnant	Funter Bay

#### Lifetime Data

- Long-term observational datasets
  - i.e. killer whales, humpback whales
- Can earplugs be used to provide some of these data?
  - Used to age an individual baleen whale
  - Store chemical information
    - e.g. Hormones, contaminants
  - 6 month resolution



#### Importance

Study population dynamics to provide better science
Input into population models and allowable removals









Credit: Maya Yamamoto

## Methods

#### • Metadata:

- Year of death
- Location
- Sex
- Species
- Age



#### Methods

- Earplug delamination
- Lipid extraction
- Enzyme Linked Immunosorbent Assay (ELISA)



#### Female baleen whales

- Hormones from 11 females, 13-58 years old
- Whales lived from 1902 to 2014
- Total lamina analyzed: 727



#### Progesterone

 Progesterone is lipophilic and associated with pregnancy in many species of animals



O'Brien, J.K. and Robeck, T.R., 2012. The relationship of maternal characteristics and circulating progesterone concentrations with reproductive outcome in the bottlenose dolphin (Tursiops truncatus) after artificial insemination, with and without ovulation induction, and natural breeding. *Theriogenology*, 78(3), pp.469-482.

#### It works!

- Progesterone detected
- Normalized data to percent change in progesterone from the preceding point
- CHANGE in progesterone greatest indicator of pregnancy





#### Do other data match our data?

- Validating peaks in progesterone
- Used top 20% of these points to determine pregnancy (red circles)



#### Do other data match our data?

- Pregnancy intervals match published calving intervals
  - Except Minke whale

Spacios	Sample size	Pregnancy interval,	Calving interval,
species		earplug (yrs)	literature (yrs)
Fin whale	5	2.6 ± 0.2	$2^1 - 2.7^2$
Humpback whale	3	2.6 ± 0.2	2.78 <sup>3</sup>
Blue whale	2	2.5 ± 0.4	2-3 <sup>4</sup>
Minke whale	1	2.8 ± 0.6	1-2 <sup>5</sup>

#### References

**1.** Christensen, I.V.A.R., Haug, T. and Øien, N., 1992. A review of feeding and reproduction in large baleen whales (Mysticeti) and sperm whales Physeter macrocephalus in Norwegian and adjacent waters. *Fauna Norvegica Series A*, *13*, pp.39-48., **2**. Agler, B.A., Schooley, R.L., Frohock, S.E., Katona, S.K. and Seipt, I.E., 1993. Reproduction of photographically identified fin whales, Balaenoptera physalus, from the Gulf of Maine. *Journal of Mammalogy*, *74*(3), pp.577-587., **3**. Baker, C.S., Straley, J.M. and Perry, A., 1992. Population characteristics of individually identified humpback whales in southeastern Alaska: summer and fall 1986. *Fishery Bulletin*, *90*(3), pp.429-437., **4**. Branch, T.A., 2008. Biologically plausible rates of increase for Antarctic blue whales. *IWC document SC/60/SH8*. **5**. Reeves, R.R., Stewart, B.S., Clapham, P.J., and Powell, J.A. 2002. Guide to Marine Mammals of the World, first edition. New York, NY: Alfred A Knopf, Inc, pp.212-221.

#### Do other data match our data?

- Pregnancy rates are slightly higher than published birth rates
  - Except Minke whale

Spacios	Sample size	Pregnancy rate,	Birth rate,
species		earplug	literature
Fin whale	5	0.42 ± 0.02	0.37 <sup>1</sup>
Humpback whale	3	0.38 ± 0.01	0.37 <sup>2</sup>
Blue whale	2	0.43 ± 0.07	$0.43 \pm 0.17^3$
Minke whale	1	0.44	0.85-0.97 <sup>4</sup>

#### References

1. Agler, B.A., Schooley, R.L., Frohock, S.E., Katona, S.K. and Seipt, I.E., 1993. Reproduction of photographically identified fin whales, Balaenoptera physalus, from the Gulf of Maine. *Journal of Mammalogy*, *74*(3), pp.577-587. 2.. Zerbini, A.N., Clapham, P.J. and Wade, P.R., 2010. Assessing plausible rates of population growth in humpback whales from life-history data. *Marine Biology*, *157*(6), pp.1225-1236. 3. Branch, T.A., Matsuoka, K. & Miyashita, T. 2004. Evidence for increases in Antarctic blue whales based on Bayesian modelling. *Mar. Mamm. Sci.* 20: 726-754. 4. Christensen, I. 1981. Age determination of minke whales, Balaenoptera acutorostrata, from laminated structures in the tympanic bullae. *Rep Int Whal Comm* 31 (1981): 245-253.

# Calculating maximum rate of increase (ROI) of a population

#### Main factors needed to calculate ROI

Species	N	Pregnancy rate	AFP	Survival rate
Fin whale	5	0.42 ± 0.02	8.6 ± 0.5	0.955
Humpback whale	3	$0.42 \pm 0.01$	5.7 ± 0.2	0.984
Blue whale	2	0.43 ± 0.07	6 ± 0.5	0.975
Minke whale 1		0.44	5.5	0.852

#### From earplug

From literature

#### Maximum rate of increase (ROI)

- Calculate maximum rate of increase (ROI) of the population
- In order to calculate this, we need:
  - Survival rate (literature)
  - Sex ratio at birth (assume 1:1)
  - Age at first parturition (our data)
  - Birth rate (our data subbing in pregnancy rate)

Species	ROI
Humpback	
(Zerbini et al 2010)	8.6%

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Species	ROI
Humpback (Zerbini et al 2010)	8.6%
Humpback whale	7.2-9.3%

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Species	ROI
Humpback (Zerbini et al 2010)	8.6%
Humpback whale	7.2-9.3%
Fin whale	4.2-4.9%
Blue whale	7.5-10.1%
Minke whale	-4.6%

#### ROI in baleen whales

- Never before has ROI been calculated for fin whales, Atlantic blue whales, or minke whales
- The data simply hasn't been available!
  - True value of earplugs
- But this model assumes whales are reproducing at the same rate over their entire lives!
  - Is this true?

#### Reproductive senescence?



#### Reproductive senescence?



#### To incorporate reproductive senescence...

- Need age for onset of reproductive senescence (RS)
- For fin whales RS occurs at 59 years old
- Now can project into the future what might this mean for a population of fin whales in the Atlantic Ocean?



#### Conclusion

- This is HUGE 50% difference in population between these two models, has large implications for population models and allowable removal calculations
  - Must use RS model for fin whales for most accurate ROI for inclusion in models
- No RS model for humpbacks appears to be appropriate
  - Only have data up to 45 years of age

# What are some other questions that you think we can ask with this special tissue?

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