



'MSM4PCOD' – MARINE SPECIES MONITORING FOR THE POPULATION CONSEQUENCES OF DISTURBANCE

- SCOPING REVIEW MEETING – 19TH MAY 2020

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CREEM

Centre for Research into Ecological
and Environmental Modelling

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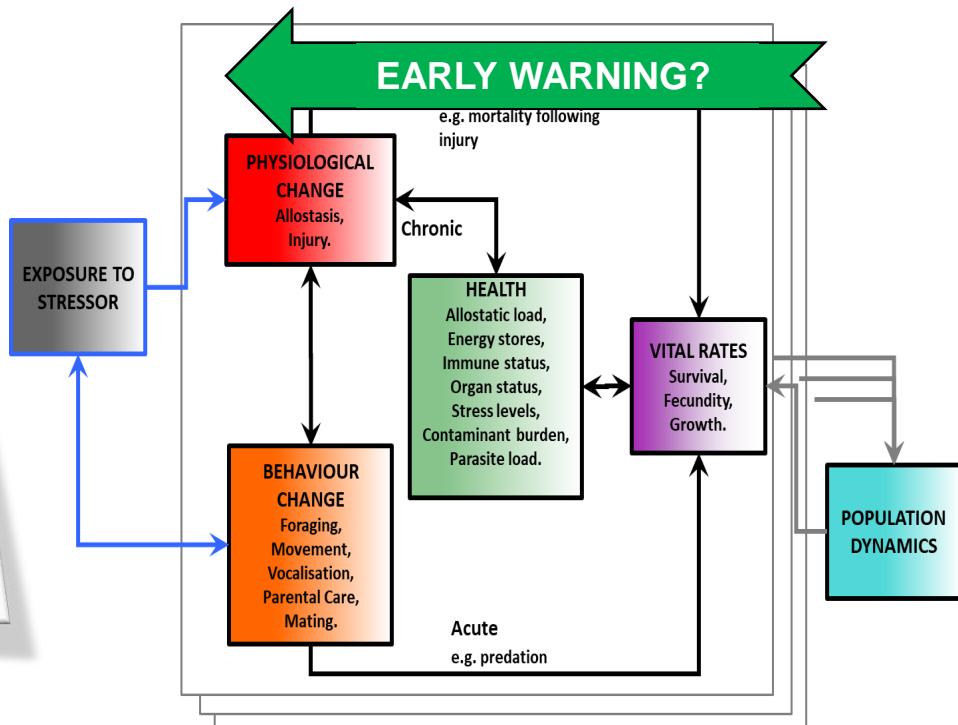
MEETING OBJECTIVES

- **Objectives:**

- Review the updated Scope of the MSM4PCoD project
- Feedback/Discuss additional information needs/issues ahead

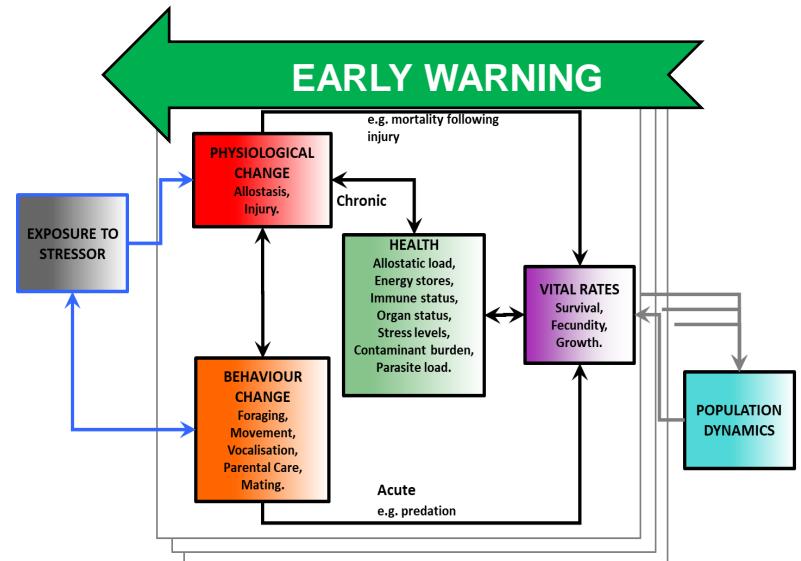


The screenshot shows the homepage of the US Navy Marine Species Monitoring Program. The header features the "US Navy" logo and the title "MARINE SPECIES MONITORING". Below the header is a large image of a blue whale's head above water. The main content area includes a "LATEST NEWS" section with two items: "Atlantic Fleet Training & Testing LOA for 2023-2025" (Posted on January 14, 2020) and "LMR News: Fall 2019 Issue" (Posted on December 22, 2019). At the bottom, there is a link to "New publication on North Atlantic". The footer contains a welcome message, information about monitoring projects, and links to various reports and RSS feeds.



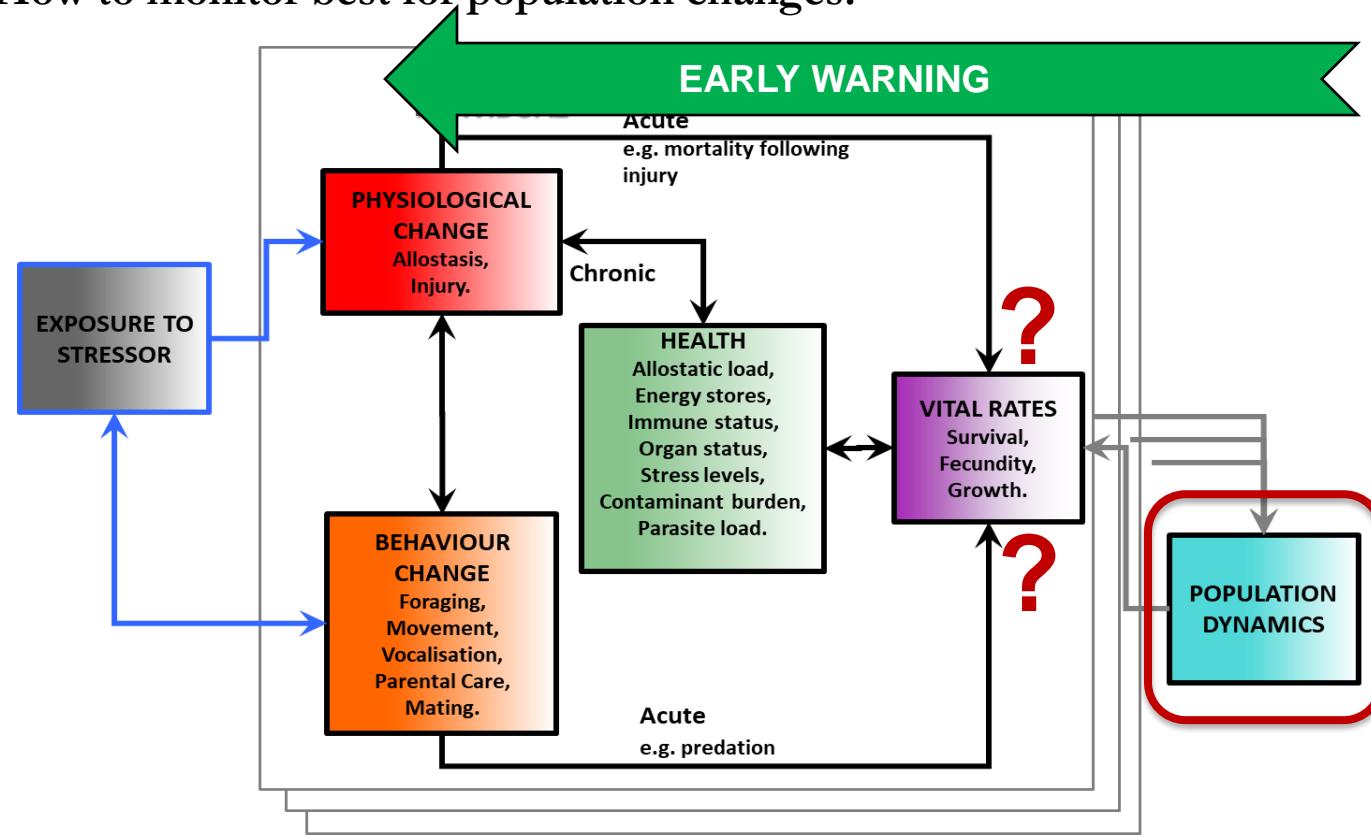
AGENDA

- Presentations
 - Intro to MSM4PCoD (brief reminder)
 - Project Scope
 - Task 1 - Review plan (Cormac)
 - Task 2 - Metrics for power analyses (John Harwood)
 - Task 3 - Power analyses (Len Thomas/Eiren Jacobson)
 - Scope of MSM4PCoD - Discussions (ALL).
- Timeline and milestones for MSM feedback
- Logistics of MSM4PCoD Options
 - Points of Contact for data access
 - Data sharing agreements
- Next steps:
 - Key final feedback re: MSM4PCoD scope
 - Workshop report etc.
- Any Other Business.



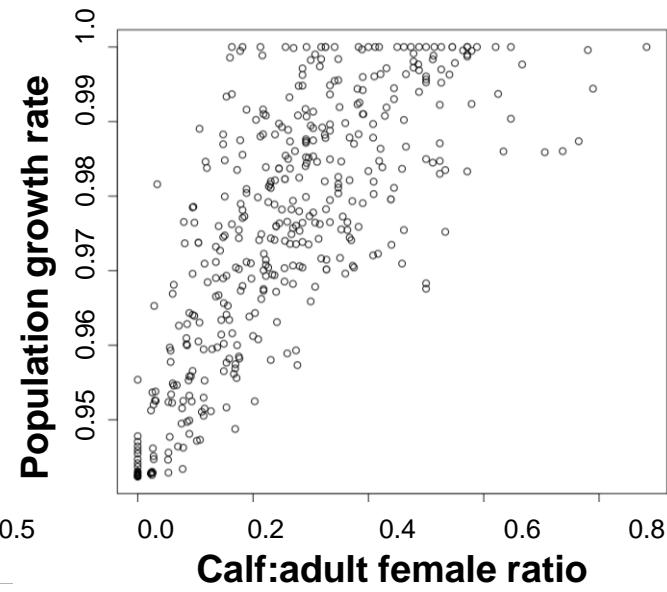
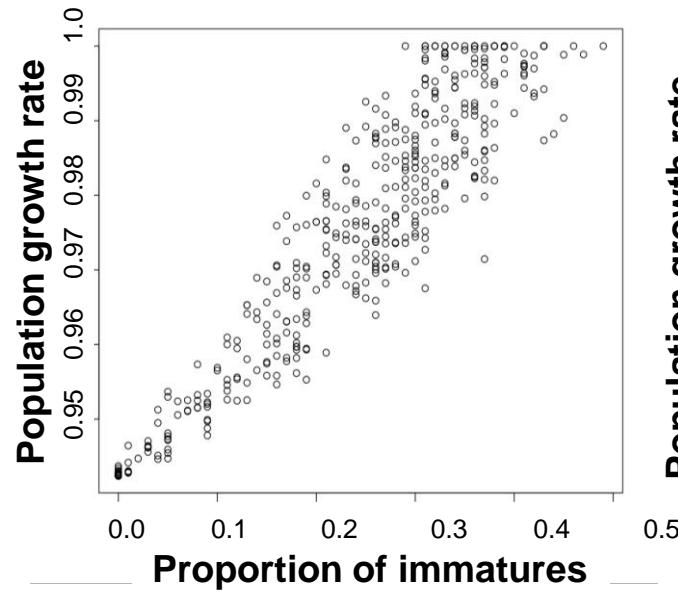
BACKGROUND

- Population Consequences of Disturbance Framework (Pirotta, et al 2018)
 - Efforts builds on over a decade of ONR funded PCoD research
 - How to monitor best for population changes?**



BACKGROUND

- Identifying monitoring priorities for PCoD – Booth et al., 2020 (Frontiers in Marine Science)
- Demographic characteristics are strongly correlated with population growth rate
 - Changes in these characteristics can provide an early warning of future changes in abundance.
 - Probability of failing to detect a large change may be high if only one characteristic is monitored



- To know what methods could feasibly be added to existing Navy monitoring we **needed a basic understanding** of current and recent monitoring methods.
- Conducted a **exploratory** look at what methods have been/are used
 - *Approaches*
 - *Platforms of research*
 - *Species/populations*
- Was never intended to be a comprehensive summary of all monitoring



The screenshot shows the homepage of the US Navy Marine Species Monitoring website. The header features the US Navy logo and the text "MARINE SPECIES MONITORING". Below the header is a navigation bar with links: Home, About, Projects, Reporting, Data Access, Reading Room, News, Blog, Media, and Contact Us. The main content area is titled "Project Profiles" and contains a message: "Not all project profiles are currently complete, but will be added as they become available." Below this message is a list of four project profiles, each with a small icon and a link: "Behavioral Response of Humpback Whales to Vessel Traffic", "Characterizing the distribution of ESA listed salmonids", "Mid-Atlantic Humpback Whale Catalog", and "Atlantic Behavioral Response Study".

Report: tiny.cc/MonPCOD

Publication: tinyurl.com/uuy7bfx

Explored projects between 2012 and 2016

Region	Species Group					Method			Platform								
	Deep diving cetaceans	Baleen whales	Coastal dolphins & porpoise	Oceanic dolphins	Land-breeding pinnipeds	Ice-breeding pinnipeds	Hands-on assessment	Remote Tissue Sampling	Visual surveys	Acoustic surveys	Capture-recapture	Photogrammetry	Individual Tracking	Land	Aerial	Vessel	PAM
Virginia Capes (VACAPES)	X	X	X	X	X			X	X	X	X		X	X	X	X	X
Cherry Point (CHPT)	X	X	X	X				X	X	X	X				X	X	X
Jacksonville (JAX)		X	X	X				X	X	X	X		X		X	X	X
Narragansett Complex					X				X					X			
Chesapeake Bay (NAS PAX)			X						X	X					X		X
Atlantic Undersea Test and Evaluation Centre (AUTEC)	X		X	X					X	X	X		X				X
Naval Surface Warfare Centre, Panama City Division (NSWC PCD)			X	X					X	X		X				X	
Northwest (NWTT)	X	X	X		X			X	X	X	X		X	X	X	X	X
Mariana Islands (MITT)	X	X	X	X				X	X	X	X		X	X	X	X	X
Hawaii-Southern California Training & Testing (SOCAL/SOAR/HRC/PMRF)	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
Gulf of Alaska (GOA TMAA)	X	X							X						X		X

- High level summary info
- Key monitoring types used:
Visual
Acoustic
- Primarily used for:
occurrence, density, abundance
- Aim:
Understand Navy monitoring program better.

Report: tiny.cc/MonPCOD

Publication: tinyurl.com/uuy7bfy

Potential methods to inform PCoD from a vessel survey



Visual

Species ID

Group size

Stage structure

Sex ratio



PhotoID

Survival rates

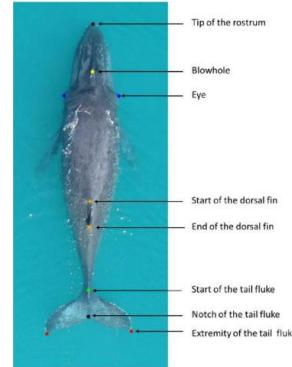
Birth rate

Age at maturity

Rake marks

Lesions

Parasite load



Photogrammetry

Morphometrics

Body condition

Mass at birth

Mass at weaning

Mass post lactation

Remote sampling

Reproductive hormones

Lipid concentration

Stress hormones

Stable isotopes

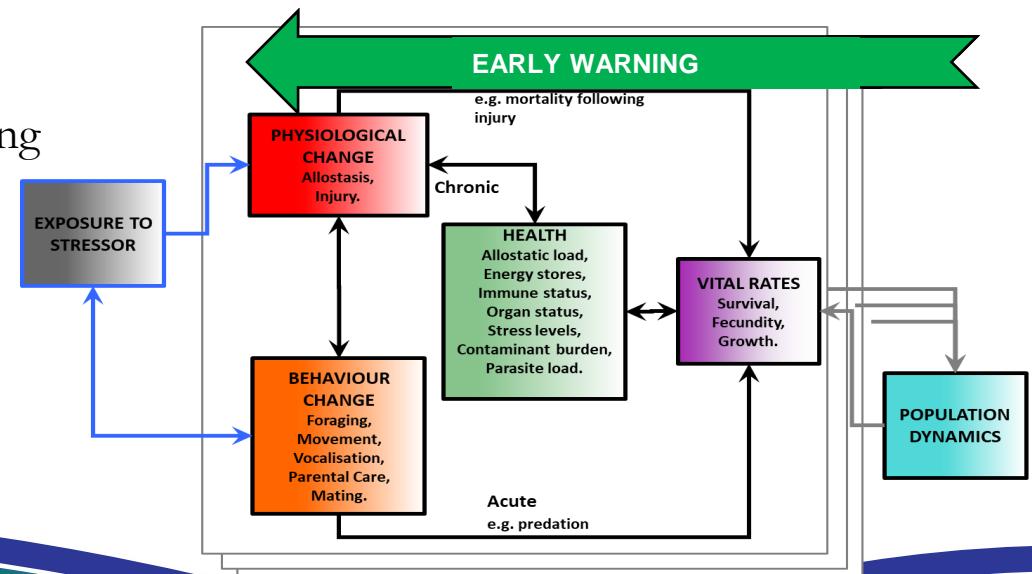
"MSM4PCoD": INTRODUCTION

MAIN OBJECTIVES

- Explore how the Navy Marine Species Monitoring (MSM) program efforts could inform future Population Consequences of Disturbance (PCoD) analyses.
 - “what kind of data Navy MSM program already collect that may be useful to PCoD analysis”
 - “what recommendations could be made to begin making incremental changes in the future that would enable Navy to gather even more pertinent data”
- Two strands:
 - Early warning detection
 - Improved precision monitoring

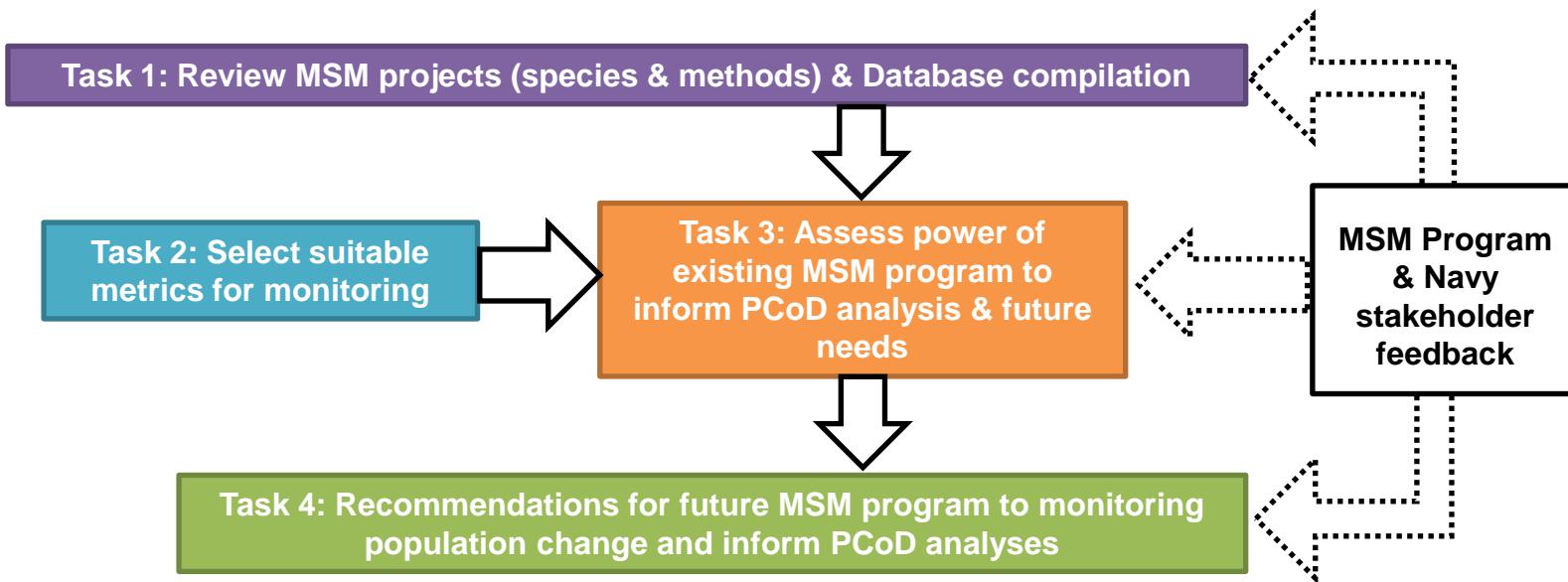
PROJECT TIMELINE

- Base effort: 2019 – 2020**
 - Scoping workshop
- Full project: 2020-2023



'MSM4PCoD' TECHNICAL APPROACH

- 'MSM4PCoD' review workflow
 - Proposed structure:



TASK 1: REVIEW DATABASE

- Objective:**

- Collate information on each project - for Task 3 - power analyses:
 - Effort**
 - Sample sizes**
 - (both may differ by method/species)

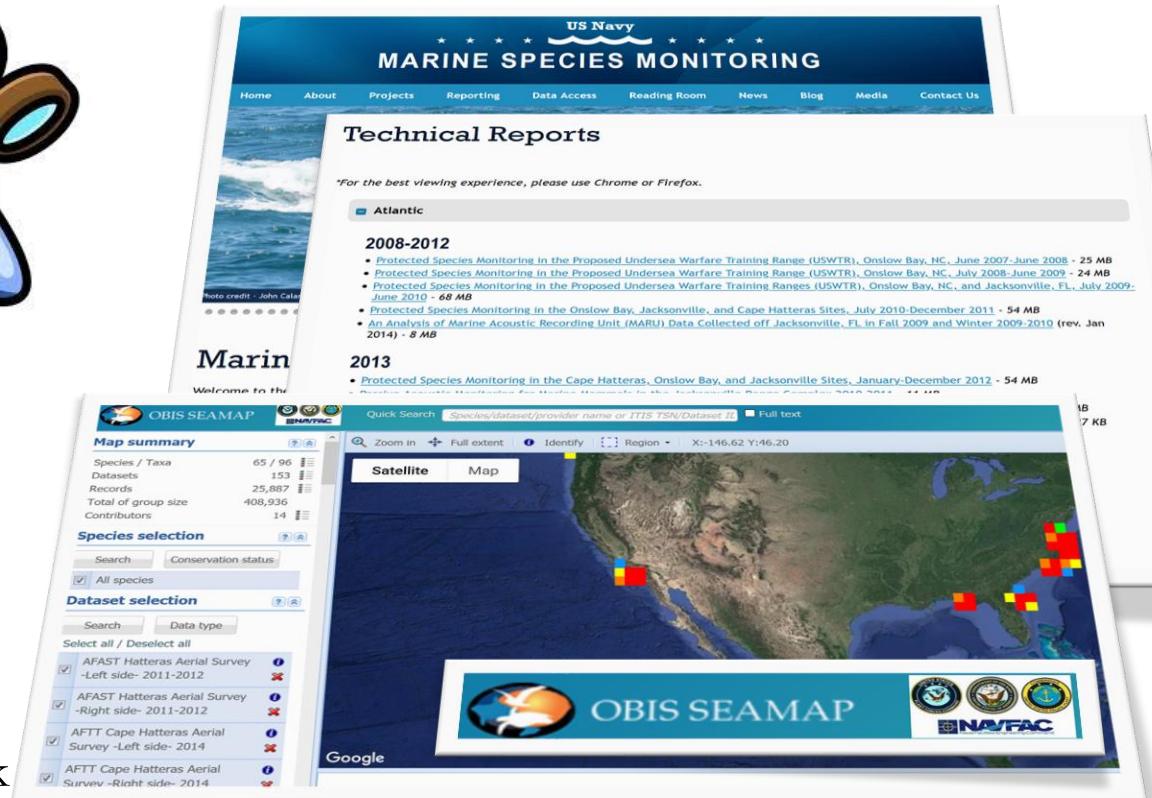
MSM4PCoD: Review of Navy MSM projects - Species and Methods

At-Sea Compliance Study Area	Complex/OPAREA(s)	Year(s)	Species name	Is this a priority species at this site?	Method Category	Method Detail	Non-priority species	Data POC	Data POC Email	Report/Publication Link
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Fin whale	Yes - Sensitive	Visual surveys	The survey vessel often followed pre-determined tr.	N.A.	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Humpback Whale	Yes - Abundant	Visual surveys	The survey vessel often followed pre-determined tr.	N.A.	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Sei whale	Yes - Abundant	Visual surveys	The survey vessel often followed pre-determined tr.	N.A.	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Short-finned Pilot Whale	Yes - Sensitive	Visual surveys	The survey vessel often followed pre-determined tr.	N.A.	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Sperm Whale	Yes - Sensitive	Visual surveys	The survey vessel often followed pre-determined tr.	N.A.	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Unidentified	No	Visual surveys	The survey vessel often followed pre-determined tr.	Unidentified Mesoplodont	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Unidentified	No	Visual surveys	The survey vessel often followed pre-determined tr.	Unidentified pilot whale	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Other - Non priority species	Not a priority species	Visual surveys	The survey vessel often followed pre-determined tr.	Other	Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Fin whale	Yes - Sensitive	Capture-recapture	Photo-ID, photo-ID Images of the individual(s) using N.A.		Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Humpback Whale	Yes - Abundant	Capture-recapture	Photo-ID, photo-ID Images of the individual(s) using N.A.		Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Other - Non priority species	Not a priority species	Capture-recapture	Photo-ID, photo-ID Images of the individual(s) using minke whale		Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2017	Sperm Whale	Yes - Sensitive	Capture-recapture	Photo-ID, photo-ID Images of the individual(s) using N.A.		Amy Engelhaupt	amyengelhaupt@gmail.com	VACAPES Outer Continental Shelf Cetacea 2017 Annual Progress Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2018	Cuvier's Beaked Whale	Yes - Sensitive & Abundant	Individual tracking	location and depth SPLASH10 tags (produced by W.N.A.)		Robin W. Baird	rwbaird@cascadiaresearch.org	Spatial Use of Cuvier's Beaked Whales and Satellite Tagged off Cape Hatteras, North Carolina Report
Atlantic Fleet Test and Training (AFTT)	VACAPES Complex	2018	Short-finned Pilot Whale	Yes - Sensitive & Abundant	Individual tracking	location and depth SPLASH10 tags (produced by W.N.A.)		Robin W. Baird	rwbaird@cascadiaresearch.org	Spatial Use of Cuvier's Beaked Whales and Satellite Tagged off Cape Hatteras, North Carolina Report
Hawaii-Southern California Training and Testing (HSTT)	HRC	2008-2012	Other - Non priority species	Not a priority species	Visual surveys	"ship-follow" aerial surveys. Elliptical orbits in front	focal follow on spinner dolphins	Joseph R. Mobley, Jr.	Joseph.Mobley@hdrinc.com	Aerial Survey Monitoring for Marine Mammals Hawaii Range Complex in Conjunction with the HSTT
Hawaii-Southern California Training and Testing (HSTT)	HRC	2008-2012	Humpback Whale	Yes - Sensitive	Visual surveys	"ship-follow" aerial surveys. Elliptical orbits in front	N.A.	Joseph R. Mobley, Jr.	Joseph.Mobley@hdrinc.com	Aerial Survey Monitoring for Marine Mammals Hawaii Range Complex in Conjunction with the HSTT
Hawaii-Southern California Training and Testing (HSTT)	HRC	2008-2012	False Killer Whale	Yes - Abundant	Visual surveys	"ship-follow" aerial surveys. Elliptical orbits in front	N.A.	Joseph R. Mobley, Jr.	Joseph.Mobley@hdrinc.com	Aerial Survey Monitoring for Marine Mammals Hawaii Range Complex in Conjunction with the HSTT

TASK 1: REVIEW DATABASE



- Data collation process:
 1. MSM website
 1. Summaries
 2. Reports
 2. OBIS-SEAMAP data
 - A. ATN & MoveBank
 3. Contact Project Leads



US NAVY MARINE SPECIES MONITORING

Technical Reports

*For the best viewing experience, please use Chrome or Firefox.

Atlantic

2008-2012

- Protected Species Monitoring in the Proposed Undersea Warfare Training Range (USWTR), Onslow Bay, NC, June 2007-June 2008 - 25 MB
- Protected Species Monitoring in the Proposed Undersea Warfare Training Range (USWTR), Onslow Bay, NC, July 2008-June 2009 - 24 MB
- Protected Species Monitoring in the Proposed Undersea Warfare Training Ranges (USWTR), Onslow Bay, NC, and Jacksonville, FL, July 2009 - June 2010 - 68 MB
- Protected Species Monitoring in the Onslow Bay, Jacksonville, and Cape Hatteras Sites, July 2010-December 2011 - 54 MB
- An Analysis of Marine Acoustic Recording Unit (MARU) Data Collected off Jacksonville, FL in Fall 2009 and Winter 2009-2010 (rev. Jan 2014) - 8 MB

2013

- Protected Species Monitoring in the Cape Hatteras, Onslow Bay, and Jacksonville Sites, January-December 2012 - 54 MB

OBIS SEAMAP

Welcome to the OBIS SEAMAP

Map summary

Species / Taxa	65 / 96
Datasets	153
Records	25,887
Total group size	408,936
Contributors	14

Species selection

Dataset selection

OBIS SEAMAP

NAVFAC



PRIORITIES - ATLANTIC MINI-REVIEW

PRIORITIES: PACIFIC MINI-REVIEW

PACIFIC MSM - ISO

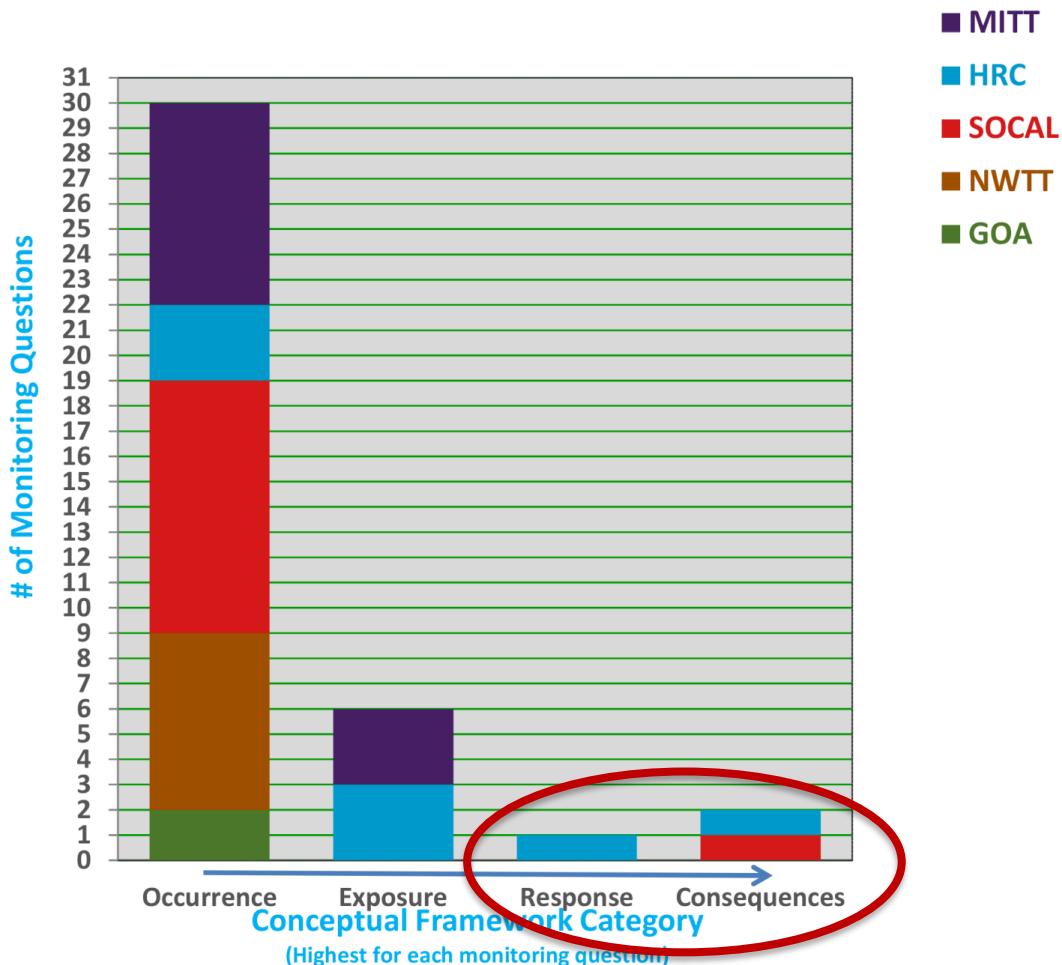


Figure 2. Numbers of monitoring questions and goals in all Pacific range complexes that address the four progressive Conceptual Framework Categories for monitoring knowledge outlined by the Scientific Advisory Group. Additional Navy-funded effort under *Response* (not represented here) has been conducted in SOCAL under the ONR Marine Mammal and Biology and Living Marine Resource programs.

2018 Monitoring Goals in All Pacific Range Complexes		
Intermediate Scientific Objectives	Monitoring Goals	Projects
1 Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, their ranges, and in specific nearshore and offshore areas of the MITT study area?	Question: What species of marine mammals occur in the nearshore (within small-boat survey range) and offshore areas of the MITT study area? Question: What is the habitat use of cetaceans in the nearshore and offshore areas of the MITT study area?	

Question: What, if any, are the short-term behavioral responses of 'blackfish,' humpback, minke, sperm and Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF?

Question: What are the long-term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's beaked whale) at PMRF?

(H2) Long-term PAM of Cetaceans at PMRF (ISO 1, 8, 9, 12, 13)

Question: Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)?

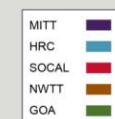
(S2) Cuvier's Beaked Whale Impact Assessment at SOAR (ISO 2, 3, 6, 7, 8, 9, 11, 12, 13)

Question: What are the baseline population demographics, vital rates, and movement patterns for a designated key species?

(S3) Beaked Whale Occurrence In SOCAL From Towed Array (ISO 1, 3)

Question: What are the movement patterns

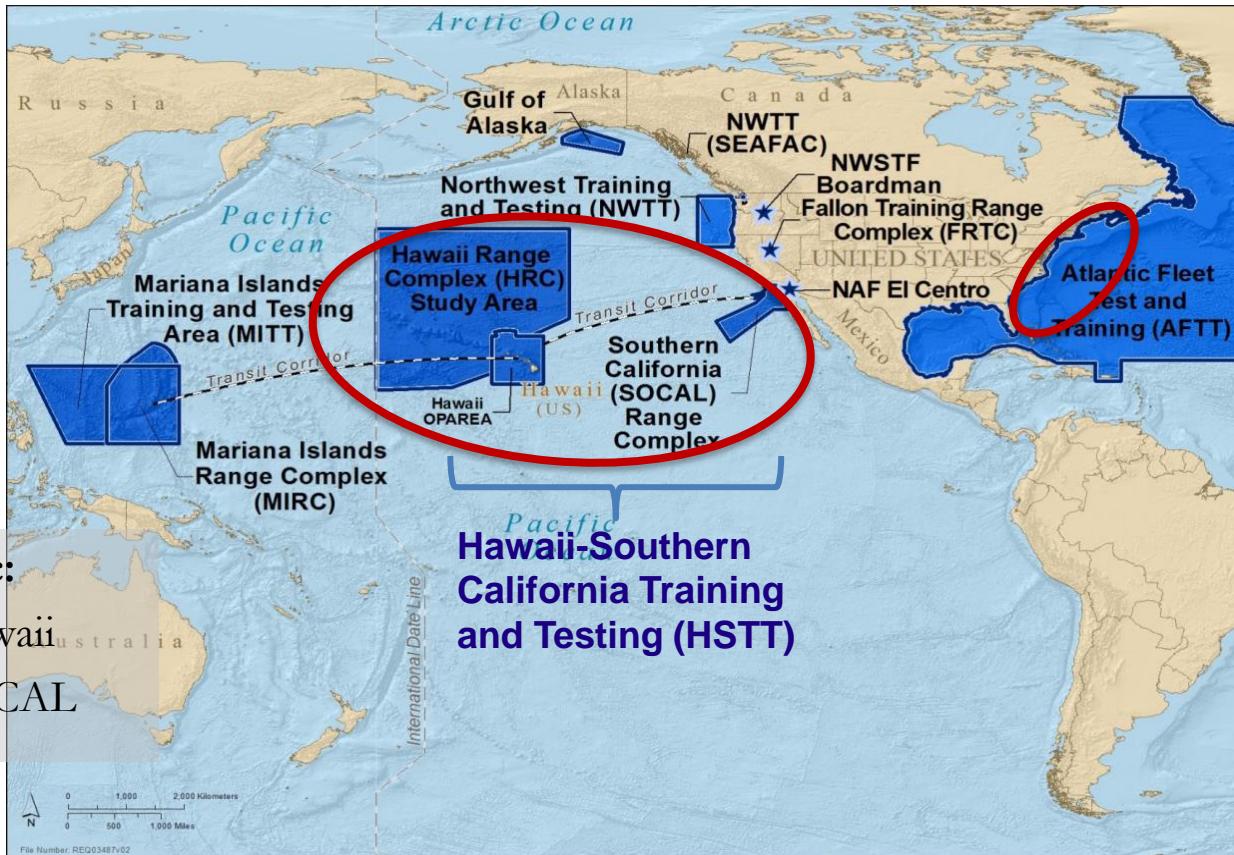
- 11 Evaluate behavioral responses of marine mammals to Navy training and testing activities to support behavioral development and application
Question: Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)?
- 12 Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to Navy training and testing activities
Question: What are the baseline population demographics, vital rates, and movement patterns for a designated key species?
- 13 Leverage existing data with newly developed analysis tools and techniques
Question: What are the residency patterns of blue whales within NMFS-designated Biologically Important Areas (BIA) for this species along the U.S. West Coast?
- Question: Are there geographic, annual oceanographic conditions (e.g. sea surface temperature, frontal zones, etc.), and/or climatic and ocean variations (e.g. Global Currents, El Niño Southern Oscillation, Pacific Decadal Oscillation (PDO), El NIÑO/Niña events, etc.) that can help explain blue and fin whale affinity for any specific areas of high residency along the U.S. West Coast?
- Question: What is the ambient and anthropogenic soundscape in SOCAL?
- Question: What is the at-sea distribution of Guadalupe fur seals as they travel through the offshore waters of the California Current Range Complex and Northwest Training and Testing area?
- Question: What are the occurrence, movement patterns, and residency patterns of Humpback whales within the North Pacific Ocean at-sea ranges (SOCAL, HRC, NWTT, GOA)?
- Question: What is the occurrence, spatial and temporal distribution of populations of salmonids in proximity to NAVFAC facilities?
- Question: What are the seasonal and annual occurrence patterns of Southern Resident killer whales relative to offshore Navy training ranges?
- Question: What is the occurrence of marine mammals and anthropogenic noise in the Gulf of Alaska?
- (S4/N3) SOCAL Blue and Fin Whale Tagging and Genetics (ISO 1, 3, 4, 5)
- (S2) Cuvier's Beaked Whale Impact Assessment at SOAR (ISO 2, 3, 6, 7, 8, 9, 11, 12, 13)
- (S3) Beaked Whale Occurrence In SOCAL From Towed Array (ISO 1, 3)
- (S5) SOCAL Soundscape (ISO 9, 13)
- (S6/N4) Guadalupe Fur Seal Satellite Tracking (ISO 1, 3, 5)
- (S7/N1/H6/G2) Humpback Whale Tagging (ISO 1, 3, 4)
- (N2) Characterizing the Distribution of ESA Listed Salmonids in the Pacific Northwest (ISO 1, 2, 3)
- (N5) Modeling the Offshore Distribution of Southern Resident Killer Whales in the Pacific Northwest (ISO 1, 2, 3, 4, 6)
- (G1) PAM for Marine Mammals in GOA (ISO 1, 2, 6)



Occurrence Exposure Response Consequences
Conceptual Framework Category

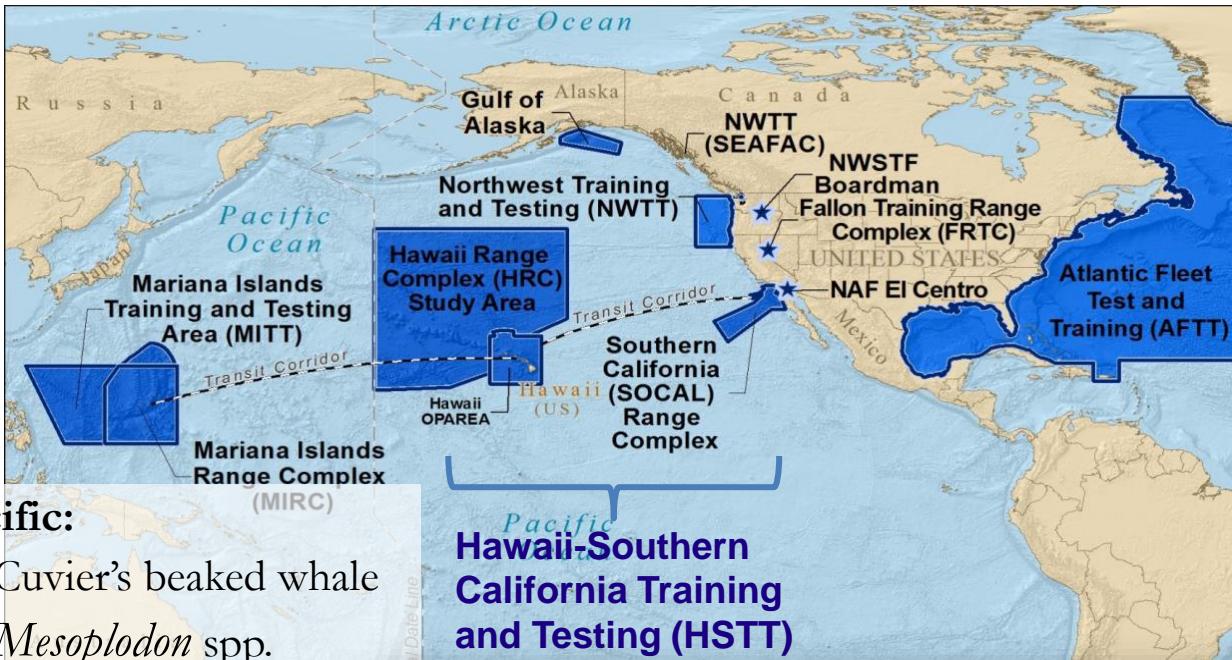
PRIORITIES: PACIFIC MINI-REVIEW

PRIORITIES – SUMMARY - REGIONS



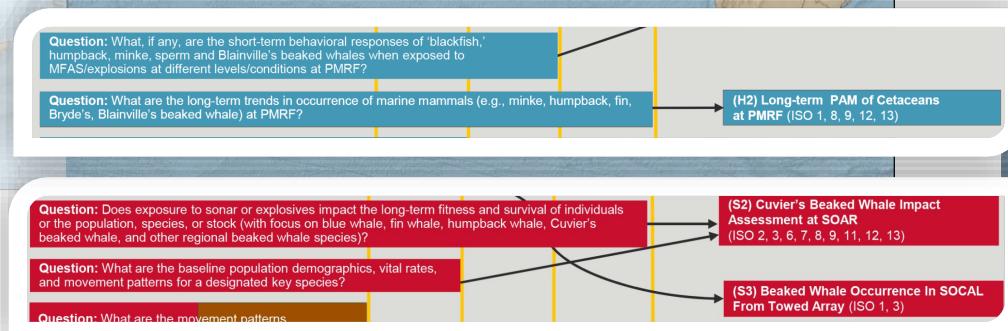
- If time allows, can consider any value in collating information from projects from NWTT / MITT / GOA (later in the project)

PRIORITIES – SUMMARY - SPECIES



Pacific:

- Cuvier's beaked whale
- *Mesoplodon* spp.
- Humpback whale
- Blackfish species
- SF pilot whale
- *Pseudorca*
- PMRF PAM
- Minke, Bryde's whale



Atlantic:

- Cuvier's beaked whale
- SF pilot whale
- Sperm whale
- Humpback whale
- Fin whale
- NA Right whale



FEEDBACK - OTHER PROGRAMS?

- Transition of R&D (ONR) and DEMVAL (LMR) new technologies to applied monitoring
 - LMR projects
 - ONR projects
- Would provide an overview of potential 'pipeline' of methods/metrics coming online in the future?
- NMFS surveys?



- **Review of data**
 - Website
 - Reports
 - OBIS-SEAMAP
 - Data POC
 - Any restrictions on use of data?
 - Need Data Sharing Agreements?

- **Best format for spreadsheet**
 - Excel?
 - Access?
 - Other





'MSM4PCOD' – Task 2: **Selecting suitable metrics** for monitoring populations of deep diving odontocetes and large baleen whales using PCoD models that already exist or are currently in development.

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- Monitoring abundance, via density, is probably the gold standard for confirming negligible impact of a set of behavioral takes.
- However, the relatively low precision of most estimates of marine mammal density make it difficult to detect even large (<50% over 15 years) declines.
- More on this from Len next.

MARINE MAMMAL SCIENCE, 23(1): 157–175 (January 2007)
© 2006 by the Society for Marine Mammalogy
No claim to original US government works
DOI: 10.1111/j.1748-7692.2006.00092.x

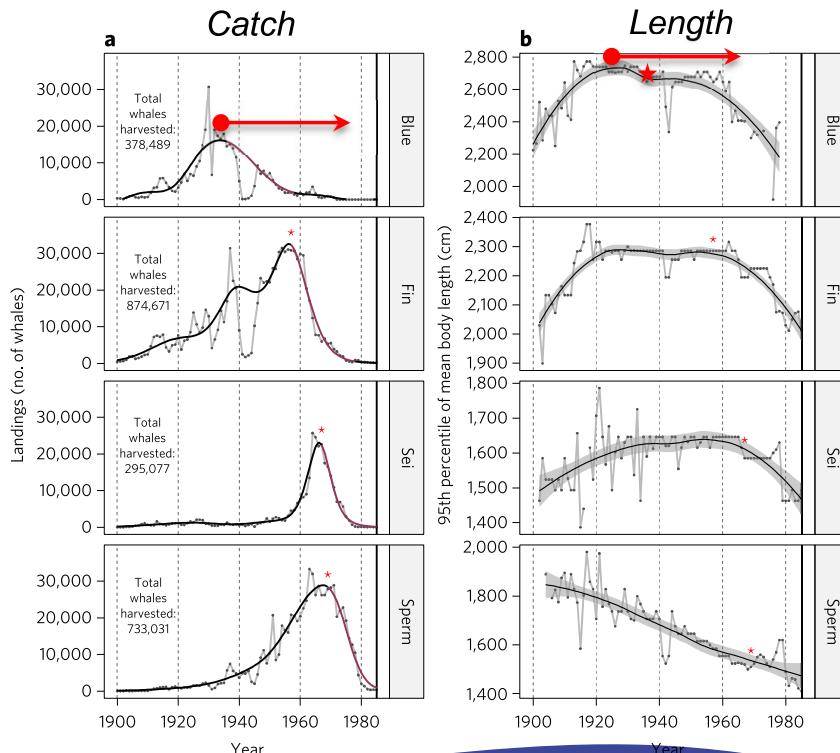
LESSONS FROM MONITORING TRENDS IN ABUNDANCE OF MARINE MAMMALS

BARBARA L. TAYLOR
MELISSA MARTINEZ
TIM GERRODETTE
JAY BARLOW



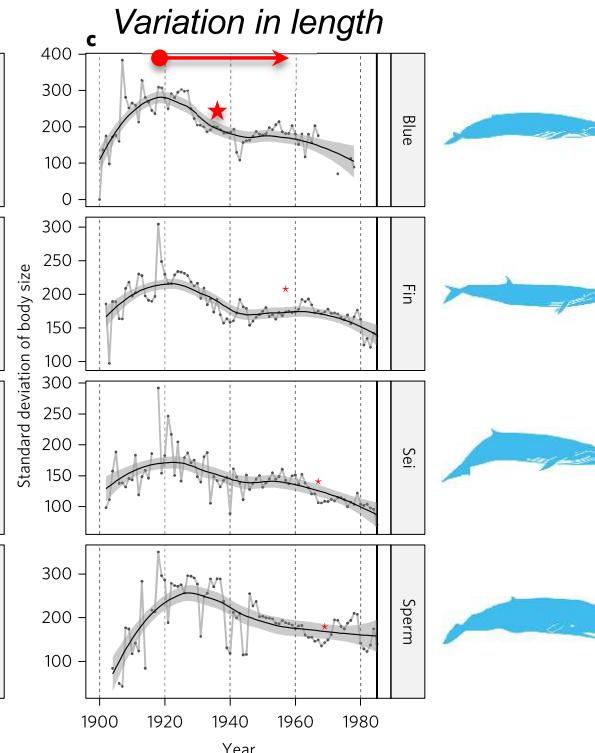
ARE THERE ADVANTAGES TO MONITORING OTHER POPULATION CHARACTERISTICS?

- Clements et al. 2017: Including information on phenotypic traits such as body size improves the accuracy of predictions of population collapse: whales in the Southern Hemisphere.



Body size shifts and early warning signals precede the historic collapse of whale stocks

Christopher F. Clements^{1*}, Julia L. Blanchard^{2,3}, Kirsty L. Nash^{2,3}, Mark A. Hindell^{2,4} and Arpat Ozgul¹



ARE THERE ADVANTAGES TO MONITORING OTHER POPULATION CHARACTERISTICS?

- Baruah et al 2019: Theoretical modelling and experimental manipulation (admittedly of protozoa!) indicate these traits can be used as an **early warning signal** of an impending population decline, provided the rate of change in the environment (e.g. prey availability) is relatively slow or the environmental change is relatively predictable.

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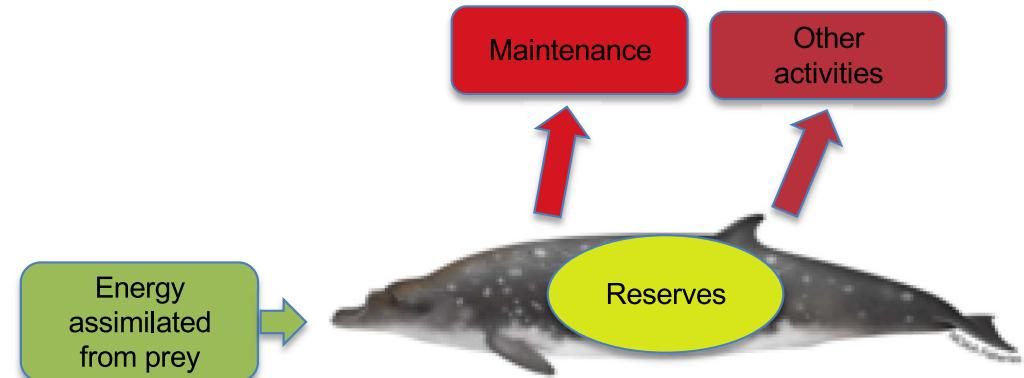
When Do Shifts in Trait Dynamics Precede Population Declines?

Gaurav Baruah,^{1,*} Christopher F. Clements,^{1,2} Frédéric Guillaume,¹ and Arpat Ozgul¹



USING BIOENERGETICS MODELS TO IDENTIFY SUITABLE TRAITS

- Bioenergetic models can provide insights into the potential population consequences of disturbance that reduces energy intake or increases energy expenditure.
- Energetics-based PCoD models have been, or are being, developed for:
 - Blue whale
 - Minke whale
 - Gray whale
 - North Atlantic right whale
 - Humpback whale
 - Bottlenose dolphin
 - Long-finned pilot whale
 - Harbor porpoise
 - Blainville's beaked whale
 - Cuvier's beaked whale
 - Sperm whale
 - as well as a number of pinniped species



USING BIOENERGETICS MODELS TO IDENTIFY SUITABLE TRAITS

- Pregnant and lactating females have highest energy requirements and are therefore likely to be most vulnerable to energy-related effects of disturbance
- For deep-diving species, females require 10% more energy during early pregnancy
- and up to 30% at the end of pregnancy
- Energy needs are much higher in pregnant baleen whales because they are accumulating reserves
- For deep-diving species, females require >30% more energy during first months of lactation.
- Body condition of all species is predicted to decline markedly during this period.





MONITORING SIZE AND CONDITION

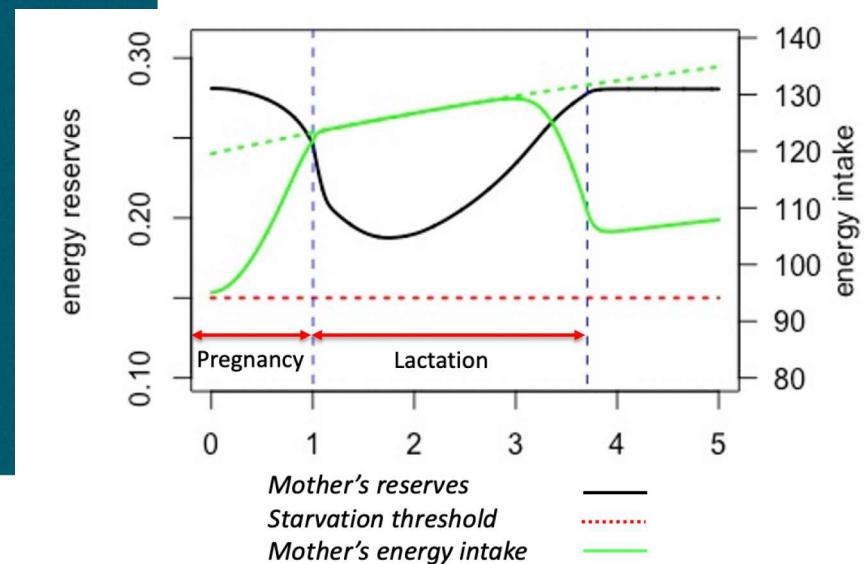
Body size can be monitored remotely using a combination of photo-ID and photogrammetry

MONITORING SIZE AND CONDITION



John Durban – National Marine Fisheries Service

However, the body size of adult females can change dramatically as a result of normal life history events



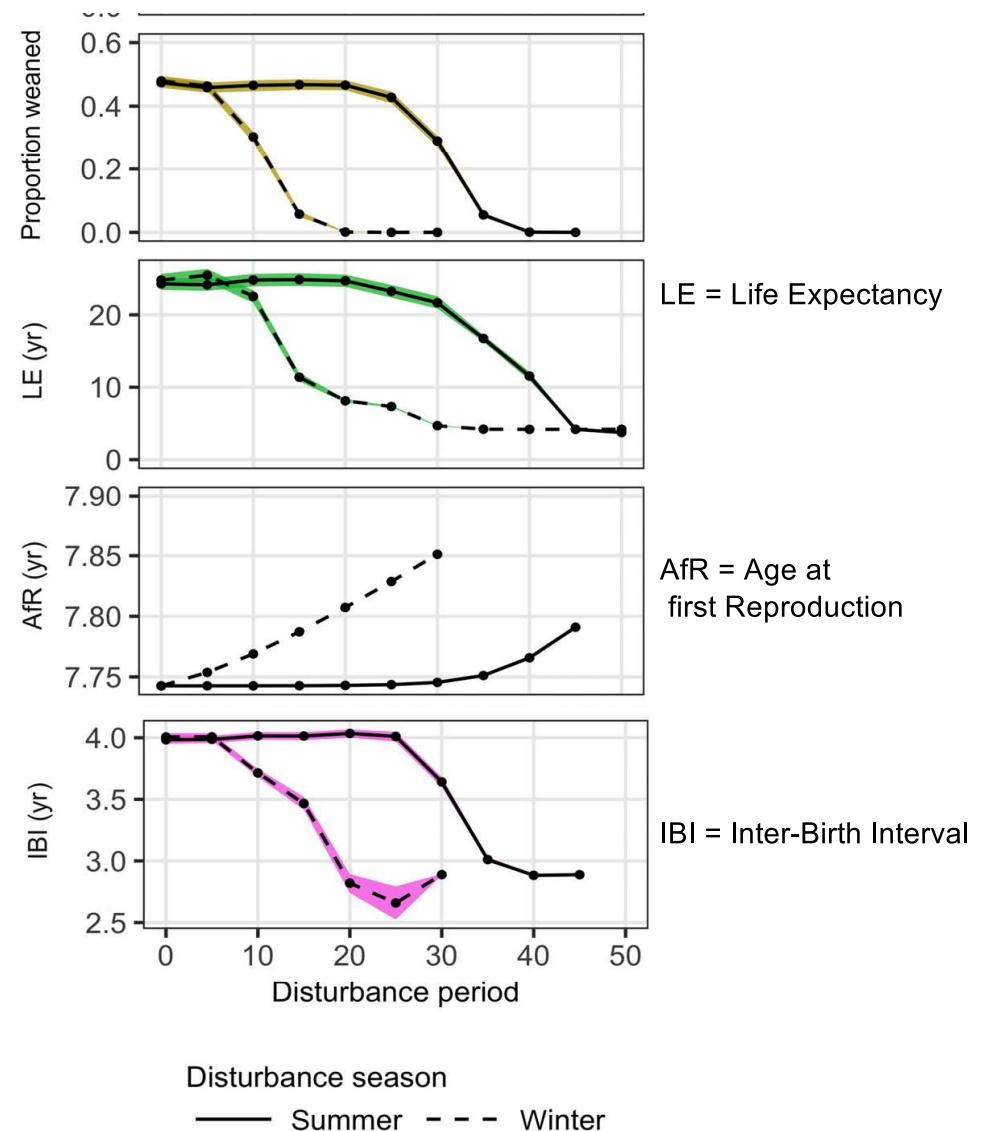
MONITORING VITAL RATES

- Changes in individual vital rates, particularly calf survival and inter-birth interval, may be more informative
- Values shown are for simulated pilot whales subject to 5-45 **consecutive** days of disturbance each year
- The consequences of these changes can be monitored during photo-ID, photogrammetry and visual surveys by determining the proportion of calves in the population
- Ultimately, they will lead to a decline in density, so it's important to monitor this, as well

Ecological Applications, 0(0), 2019, e01903
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Bio-energetic modeling of medium-sized cetaceans shows high sensitivity to disturbance in seasons of low resource supply

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'MSM4PCOD' – Task 3: Power Analysis.

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and Environmental Modelling

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OBJECTIVE

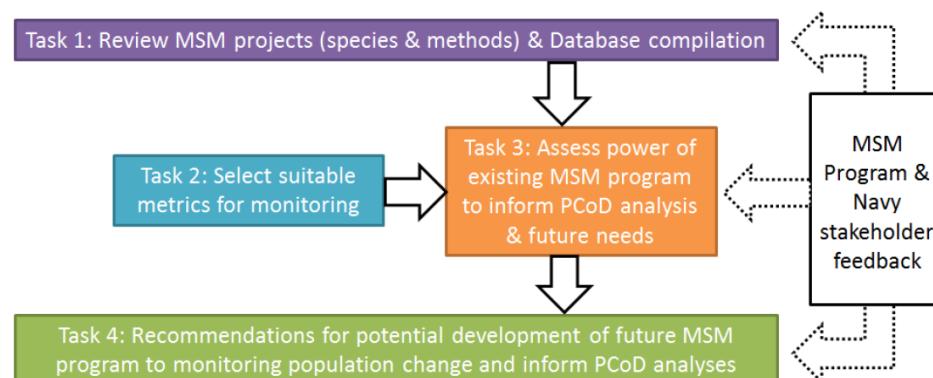
Project Scope & Objectives

The overall objective of the ‘MSM4PCoD’ project is to evaluate the MSM Program through the lens of PCoD models to determine how its efforts might be used to inform PCoD analyses. This will be via a scoping workshop and this could be supplemented by four optional tasks:

- Scoping Workshop: Hold a 2 day workshop with Navy stakeholders to determine if/how the MSM program might be supplemented to inform PCoD analyses.
- Optional task 1: Review current and historical MSM projects and methodologies for priority areas and species and compile into a reference database.

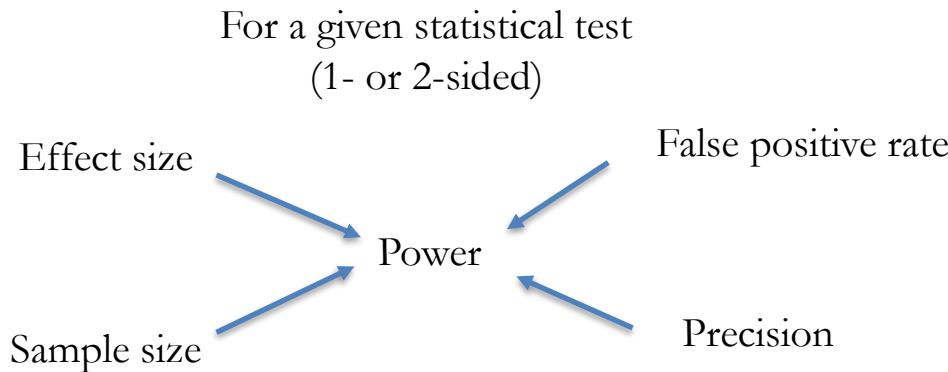
3

- Optional task 2: Select suitable metrics for monitoring populations of deep diving odontocetes and large baleen whales using PCoD models that already exist or are currently in development.
- Optional task 3: Conduct power analyses to assess the power of these metrics to inform PCoD analyses when collected within existing MSM projects, and determine the effort required to increase this power.
- Optional task 4: Prepare a report that synthesizes the results of the previous tasks and provides recommendations for the feasibility of developing MSM for PCoD.



WHAT IS “POWER ANALYSIS”?

- Narrow definition (from “classical” statistical inference):
 - Power: probability of correctly rejecting the null hypothesis
 - E.g., probability of detecting a specified decline in population density



- Power analysis: for a range of scenarios, specify 4 of the above quantities, derive the 5th
- E.g., What sample size is required to detect ...; What effect size is detectable...
- More broadly, can estimate expected uncertainty, probability of selecting correct model, etc.
 - Classical or Bayesian

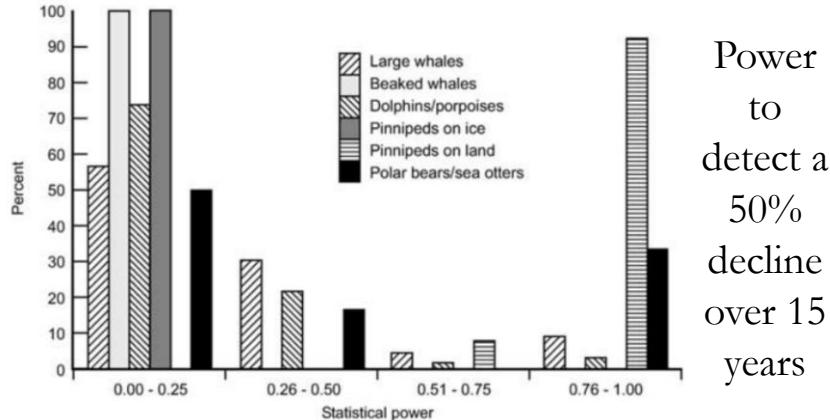
MARINE MAMMAL SCIENCE, 23(1): 157–175 (January 2007)
 © 2006 by the Society for Marine Mammalogy
 No claim to original US government works
 DOI: 10.1111/j.1748-7692.2006.00092.x

LESSONS FROM MONITORING TRENDS IN ABUNDANCE OF MARINE MAMMALS

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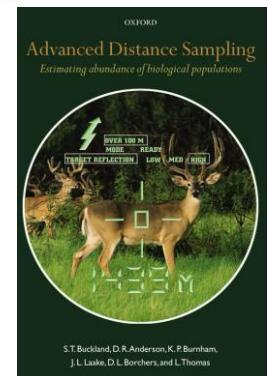
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Published May 7



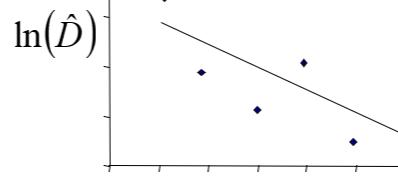
Global analysis of cetacean line-transect surveys: detecting trends in cetacean density

R. Jewell^{1,2,*}, L. Thomas³, C. M. Harris^{2,3}, K. Kaschner⁴, R. Wiff⁵, P. S. Hammond², N. J. Quick^{1,6}

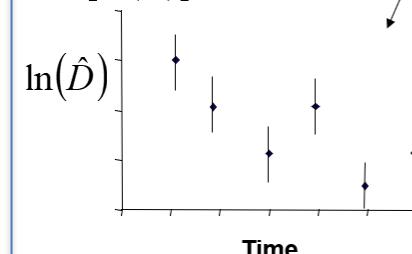


Estimating trends Components of variation

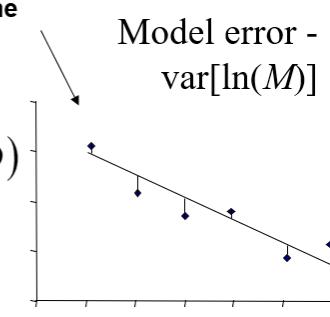
Total unexplained variation - $\text{Var}[\ln(T)]$



Sampling variation - $\text{Var}[\ln(D)]$



Model error - $\text{var}[\ln(M)]$



$$\text{var}[\ln(T)] = \text{var}[\ln(D)] + \text{var}[\ln(M)]$$

- 3 (related) strands of work:
 - Scenario development
 - Power calculations
 - Scoping methods for improving precision



SCENARIO DEVELOPMENT

- Goal:
 - Develop realistic scenarios of effect size, precision/variability and effort/sample size (current and realistic future) for input to power analysis
- Scenarios:
 - Long-term declines in abundance/demographic parameters
 - Sudden declines (relevant to early warning detection)
 - Scenarios from bio-energetics models (Task 2)



POWER CALCULATIONS

- Goal:
 - Calculate power for given scenarios
- Parameters monitored:
 - Density & demographic parameters
 - Metrics suggested by Task 2
- Methods
 - Analytic calculations
 - Monte Carlo simulation



IMPROVING PRECISION

- Goal:
 - Investigate methods for improving precision (and hence power) without greatly increasing spending (i.e., more “bang for the buck”)
- Potential avenues to investigate:
 - Combining data sources to better estimate parameters (e.g., telemetry + photo-ID)
 - Integrated population modelling (fitting population dynamics models with multiple data sources)
 - Potential for using new data sources (e.g., passive acoustics) if not covered above



TASK 4: RECOMMENDATIONS

- MSM Database reviewing monitoring carried out to date on priority species in priority regions that might inform PCoD analyses.
 - a. Delivered in spreadsheet format (unless format specified).
 - b. Guidance document for MSM database.
- Report on approach undertaken along with recommendations on how PCoD models/monitoring can be practically applied to existing MSM efforts.
- Manuscript(s) describing the results of Task 2 and 3 power analyses for one or two MSM case studies

LOGISTICS - TIMELINES

	2020	2021				2022				2023			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Contracting	■												
Task 1: Review		■	■	■	■	■	■	■	■	■			
Task 2: Metrics		■	■	■	■	■	■						
Task 3: Power				■	■	■	■	■	■	■	■	■	
Task 4: Reccom.										■	■	■	■
LMR IPR	■			■	■			■	■			■	■

NEXT STEPS

- Finalise scope for the project
 - Any major objections?
 - Further feedback?
- Workshop report
 - We'll summarise this process and the main outcomes
 - Atlantic mini-review
 - Pacific mini-review
 - Scoping review





THANK YOU! ANY QUESTIONS?

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