

science and included early career scientists. Goals of the workshops were to (1) review, discuss, and synthesize previous approaches and methods to study and document seabird-fisheries competition (e.g., observations/correlations, experiments, models), and (2) train young fisheries and seabird scientists in methods, challenges, and opportunities to document seabird-fisheries competition. Ultimately, these workshops were designed to support and facilitate production of a peer-reviewed publication tentatively entitled *Best Practices and Guidelines to Determine and Document Seabird-Fisheries Competition*, to be submitted to a peer-reviewed journal by 1 June 2016. A list of workshop participants and the agenda for each meeting are attached (Appendices 1-2).

Initially, each workshop began with two plenary presentations. In Cape Town, Drs. Robert Furness (University of Glasgow) and Richard Sherley (University of Cape Town) presented. In his presentation, Furness reviewed his long-term studies of seabird-fisheries competition in the North Sea focusing on the responses of seabirds to sandeel (*Ammodytes hexapterus*) fisheries, demonstrating how changes in other sandeel predators, notably groundfish such as cod, made assessment of fisheries impacts difficult to interpret. Sherley spoke on the subject of African penguin (*Spheniscus demersus*) responses to sardine and anchovy fisheries closure experiments off South Africa, concluding that more additional efforts are needed to determine if fisheries closures were having demographic effects on the penguin populations. In Seattle, Drs. Elizabeth (Libby) Logerwell (NOAA Fisheries) and Andre Punt (University of Washington) spoke. Logerwell described and assessed the fisheries closure experiments affecting Steller's sea lions (*Eumetopias jubatus*) in Alaska, while Punt presented on a relatively new modeling approach, Models of Intermediate Complexity for Ecosystems (MICE), relative to sardine and anchovy fisheries and brown pelicans (*Pelicanus occidentalis*) off California. Similar to Sherley, Logerwell described a number of issues making experimental results less robust than desired.

At both workshops, plenary discussions were followed by breakout groups targeting different aspect of seabird-fisheries competition. In Cape Town, the groups focused on methodology (observations, models, and experiments) and listed challenges and opportunities of each approach. In Seattle, small-group discussions focused on the conceptual models for assessing fisheries impacts on seabird food resources. Lessons learned from both workshops can be summarized as:

- Everything with seabirds is spatial: investigation of fisheries effects on seabird food availability must be spatially explicit, especially during the breeding season when seabirds are central-place foragers.
- Confounding environmental factors is a serious impediment to making reliable assessments of fisheries impacts on forage fish stocks and availability to seabirds.
- Often, questions regarding the pathways of response from fisheries to fish and fish to seabirds have been poorly articulated; frameworks for studies can be improved.
- There is a need to think about effects of other predators in the ecosystem on seabird prey availability (i.e., potential top-down and other competition effects coming from mammals and predatory fish that may actually consume more prey than seabirds do).
- Fisheries competition with seabirds needs to be examined in both breeding and non-breeding seasons. There is seasonal prey switching (i.e., what seabirds feed their young is not necessarily what the adults eat when not breeding).
- The numerical responses of seabirds to fluctuations in forage fish availability will be more easily modeled using shorter-term variables, such as time spent foraging or breeding success, rather than longer-term population parameters such as survival.
- Definition of forage fish should be broadened: "forage fish" include small, schooling pelagics, invertebrates such as squid and krill, and age-0 and age-1 juvenile predatory fishes. Data are

usually lacking for the juvenile stages. Moreover, if juveniles are what are consumed by seabirds and adult fish are fished by people, this greatly complicates assessing seabird-fisheries competition (but see Field et al. 2010).

Literature cited:

Cury, PM, IL Boyd, S Bonhommeau, T Anker-Nilssen, RJM Crawford, RW Furness, JA Mills, EJ Murphy, H Osterblom, M Paleczny, JF Piatt, J-P Roux, L Shannon, WJ Sydeman. 2011. Global seabird response to forage fish depletion—one-third for the birds. *Science* 334:1703-1706.

Field, JC, AD MacCall, RW Bradley, and WJ Sydeman. 2010. Estimating the impacts of fishing on dependent predators: a case study in the California Current. *Ecological Applications* 20:2223-2236.

Lewison, R, D Oro, BJ Godley, et al. 2012. Research priorities for seabirds: improving conservation and management in the 21st century. *Endangered Species Research* 17:93-121.

Pikitch, EK, KJ Rountos, TE Essington, et al. 2014. The global contribution of forage fish to marine fisheries and ecosystems. *Fish and Fisheries* 15:43-64.

Smith, ADM, CJ Brown, CM Bulman, EA Fulton, P Johnson, IC Kaplan, H Lozano-Montes, S Mackinson, M Marzloff, LJ Shanon, Y-J Shin, J Tam. 2011. Impacts of fishing low-trophic level species on marine ecosystems. *Science* 333:1147-1150.

Appendix 1. Workshop participants.

Cape Town:

Mayumi Arimitsu	USGS Alaska Science Center
Ashley Bennison	University College Cork
Sophie Bertrand	Institut de Recherche pour le Developpement (IRD)
Philipp Boersch-Supan	University of South Florida
Charlotte Boyd	University of Washington
Nicole Bransome	The Pew Charitable Trusts
Jaimie Cleeland	University of Tasmania
Robert Crawford	Department of Environmental Affairs, South Africa
Francis Daunt	Centre for Ecology and Hydrology
Robert Furness	University of Glasgow
Dimas Gianuca	University of Exeter
Amanda Gladics	Oregon State University
James Grecian	University of Glasgow
Yuna Kim	BirdLife International
Jennifer Lang	University of Washington
Thomas Mattern	University of Otago
Jim Mills	Retired
Taryn Morris	BirdLife International South Africa
Olaf Olsson	Stockholm Resilience Center
Herman Oosthuizen	Department of Environmental Affairs, South Africa
Elizabeth Phillips	University of Washington
Jennifer Provencher	Clemson University
Heather Renner	U.S. Fish and Wildlife Service
Jennifer Roberts	University of Cape Town
Dilek Sahin	Bogazici University
Claire Saraux	Institut Francais de Recherche pour L'exploration de la Mer
Lynne Shannon	University of Cape Town
Richard Sherley	University of Cape Town
Alejandro Simeone	Universidad Andres Bello
Robert Suryan	Oregon State University
William Sydeman	Farallon Institute for Advanced Ecosystem Research
Carl van der Lingen	Department of Agriculture, Forestry and Fisheries, South Africa
Ross Wanless	BirdLife International South Africa
Stephani Zador	Alaska Fisheries Science Center, NOAA

Seattle:

Ricardo Amoroso	University of Washington
Mayumi Arimitsu	USGS Alaska Science Center
Charlotte Boyd	University of Washington
Nicole Bransome	The Pew Charitable Trusts
Amanda Gladics	Oregon State University
Thomas Good	Northwest Fisheries Science Center
Laura Koehn	University of Washington
Jennifer Lang	University of Washington
Elizabeth (Libby) Logerwell	Alaska Fisheries Science Center
Alec MacCall	Retired; previously of National Marine Fisheries Service
Ken Morgan	Department of Fisheries and Oceans Canada
Julia Parrish	University of Washington
Elizabeth Phillips	University of Washington
Andre Punt	University of Washington
William Sydeman	Farallon Institute for Advanced Ecosystem Research
Julie Thayer	Farallon Institute for Advanced Ecosystem Research
Sarah Ann Thompson	Farallon Institute for Advanced Ecosystem Research
Stephani Zador	Alaska Fisheries Science Center

Scheduled but unable to attend due to illness:

Tim Essington	University of Washington
John Piatt	USGS

Appendix 2. Workshop agendas.

1. Cape Town

Agenda for Workshop on “Guidelines and Best Practices to Document Seabird - Fisheries Competition”

31 October 2015; South African Department of Environmental Affairs (SADEA) Boardroom, V&A Waterfront, Cape Town, South Africa

Conveners: Bill Sydeman (Farallon Institute) and Robert Crawford (SADEA)

Logistics (Leshia Upfold)

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Goals:

- 1) review, discuss, and synthesize previous methods to study and document seabird-fisheries competition (e.g., observations/correlations, experiments, models)**
- 2) train young fisheries and seabird scientists in methods, challenges, and opportunities to document seabird-fisheries competition,**
- 3) prepare a peer-reviewed publication entitled *Best Practices and Guidelines to Determine and Document Seabird-Fisheries Competition* (draft by 15 June 2016). Target journal: *Ecological Applications* or similar.**

A second workshop will be held in Seattle in early 2016.

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Background

- In coastal marine ecosystems, top predators such as seabirds and marine mammals and commercial fisheries may compete for the same limited resources, i.e., small pelagic fish.
- Recently, this topic has received great attention as fisheries for LTL forage nekton, such as krill, anchovy, sardine, have increased, and are projected to increase in the future (Smith et al. 2011, Cury et al. 2011, Pikitch et al. 2014).
- Documenting these interactions is difficult as it requires information on i) fisheries effects on forage nekton distribution, abundance, and spatial organization, ii) forage nekton relationships to seabird foraging ecology, predator-prey interactions, numerical responses/demography, and population dynamics.

Approaches to Date

- 1) food web models (ECOPATH, ATLANTIS) (Smith et al. 2011, Pikitch et al. 2013).
- 2) experimental manipulation of fisheries (e.g., time-area-island closures) (Atkinson et al. 2008, Mangel 2010, Conn et al. 2014; Pichegru et al. 2010).
- 3) Observational studies (Fredericksen et al. 2004, 2008b, Jahncke et al. 2004, Daunt et al. 2008, Field et al. 2010, Anderson et al. 1982, Furness and Tasker 2000, Fredericksen et al. 2008a, Cury et al. 2011, Sherley et al. 2013)

Some of the Issues: lack of controls in experiments, poor understanding of scale, confounding factors (climatic impacts) in correlative/observational studies, prey-switching, lack of syntheses.

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- i. Host: SADEA (Herman Osterthusian)
 - ii. Funding Agency: Pew Charitable Trust (Nikki Bransome, penguin program officer)

- iii. Participant Introductions: why are you interested in seabird-fishery competition?
- iv. Plenary Presentation: Bob Furness (Perspective on Documenting Seabird-Fisheries Competition)
- v. Plenary Presentation: Richard Sherley (African Penguin Case History)
- vi. Plenary Discussion: How to Communicate: getting industry, seabird ecologists, and fish/fisheries scientists on the same page.

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Lunch (to be provided)

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Breakout Groups - advantages, disadvantages, limitations, benefits, misconceptions, etc. of different approaches to understanding seabird - fisheries competition

- a) Models (Lynne)
- b) Experiments (Carl, Francis)
- c) Observations ()

Reports back from Breakout Groups

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Plenary - Outline Paper (Bill and Rob)

Discuss authorship, expected contributions of authors, role(s) of ECS, plans and needs for Seattle

Solutions? MPAs

Other business

2. Seattle

Agenda for Workshop II on "Guidelines and Best Practices to Document Seabird - Fisheries Competition"

0900-1700

19 January 2016; University of Washington School of Aquatic and Fishery Sciences (SAFS; Fishery Sciences Building), Rm. 203, Seattle, WA USA

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Conveners: Bill Sydeman (Farallon Institute) and Tim Essington (UW)

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Logistics: Sarah Ann Thompson (Farallon Institute)

Goals:

- 1) review, discuss, and synthesize previous approaches and methods to study and document seabird-fisheries competition (e.g., observations/correlations, experiments, models)
- 2) train young fisheries and seabird scientists in methods, challenges, and opportunities to document seabird-fisheries competition,
- 3) prepare a peer-reviewed publication entitled *Best Practices and Guidelines to Determine and Document Seabird-Fisheries Competition* (draft by 15 June 2016). Target journal: *Ecological Applications*, or similar.

Note: This is the second workshop on this topic. The first was held in Cape Town, South Africa, 31 October 2015.

Background

- In coastal marine ecosystems, top predators such as seabirds and marine mammals and commercial fisheries may compete for the same limited resources, i.e., small pelagic fish.
- Recently, this topic has received great attention as fisheries for lower trophic level forage nekton, such as krill, anchovy, sardine, have increased. Fisheries for these species are projected to increase in the future (Smith et al. 2011, Cury et al. 2011, Pikitch et al. 2014).
- Documenting **seabird-fisheries competition** is difficult as it requires spatially explicit information on i) fisheries effects on local to regional forage nekton distribution, abundance, and spatial organization, and ii) forage nekton relationships to seabird foraging ecology, predator-prey interactions, numerical responses/demography, and population dynamics.

Approaches to Date

- 1) complex food web models (ECOPATH, ATLANTIS) (Smith et al. 2011, Pikitch et al. 2014).
- 2) experimental manipulation of fisheries (e.g., time-area-island closures) (Atkinson et al. 2008, Mangel 2010, Conn et al. 2014; Pichegru et al. 2010).
- 3) observational studies (Fredericksen et al. 2004, 2008b, Jahncke et al. 2004, Daunt et al. 2008, Field et al. 2010, Anderson et al. 1982, Furness and Tasker 2000, Fredericksen et al. 2008a, Cury et al. 2011, Sherley et al. 2013).

Some of the Issues: lack of controls in experiments, poor understanding of scale, confounding factors (climatic impacts) in correlative/observational studies, prey-switching, lack of syntheses.

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Start: 0900

- i. Host: UW/SAFS (brief welcome by Tim Essington)
- ii. Funder: Pew Charitable Trust (brief welcome by Nikki Bransome)
- iii. Participant Introductions (All): names, affiliations and stated interests in seabird-fishery competition?
- iv. (0915) Project background, flow chart of information needs, update on project progress to date (Bill Sydeman)
- v. (0930) Plenary Presentation/Discussion: Dr. Elizabeth (Libby) Logerwell (NOAA-NMFS): *Review of Experimental Approaches to Document Fisheries Competition with Steller's Sea Lions in the North Pacific*

Break (1030)

vi. (1100) Plenary Presentation/Discussion: Dr. Andre Punt (UW/SAFS) *Models of Intermediate Complexity for Assessing Fisheries Competition with Seabirds*

Discussions: lessons learned from these presentations

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(1215) Lunch (hosted)

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1330 Breakout Groups - discuss advantages/disadvantages, limitations, benefits, misconceptions, etc. of different approaches to understanding seabird - fisheries competition

- a) Models (Koehn and Thompson - rapporteurs)
- b) Experiments (Lang and Arimitsu - rapporteurs)
- c) Observations (Phillips and Gladics - rapporteurs)

1500 (Coffee/Tea/Cookie Break)

(1530) Reports back from Breakout Groups

(1600) Discussion of scientific difficulties and possible solutions

list - what are the most difficult questions to address in this complicated topic: fisheries to fish or fish to seabirds or ????

how can mixed approaches be used to facilitate better understanding?

what approaches are best for each question?

Discussion: plans for paper, timing, authorship (expected contributions, etc.),

(1645) Meeting evaluation and wrap-up