**Project Title:** Connecting Marine Bird and Fish Time Series in Alaska: A Pilot Study of Environmental Co-Variation, with Potential Management Application (Short Title: Seabird-Fish Models)

**Project Period:** From Date: May 1, 2005 to 30 April 2006

**Name, Address, Telephone Number and Email Address of Applicant:**
William J. Sydeman, Marine Ecology Division, PRBO Conservation Science, 4990 Shoreline Highway, Stinson Beach, California 94970; Ph: (415) 868-1221 x 319, Email: wsvdeman@prbo.org

**Principal Investigator(s):** (Include name, affiliation and email address)
W.J. Sydeman, PRBO Conservation Science, wsvdeman@prbo.org

**Component 1 – Specific Project Needs (Goal and need):** NA

**Component 2 – General Research Priorities (a-g):** Primary: d(1); Secondary: d(2)

**Summary.** We propose a pilot study to investigate environmental co-variation in seabirds and fish in Alaska. We will examine two cases of coupled seabird-fish responses to environmental variation – seabirds of the Pribolof Islands and sockeye salmon of Bristol Bay (Bering Sea), and seabirds and herring of SE Alaska (Sitka region, Gulf of Alaska) - to test the hypothesis that seabird and fish parameters co-vary in time, with lagged relationships that may be exploited for management purposes. To test this hypothesis we will compile seabird and fish time-series readily available from state and federal agencies and examine co-variation in time series using dynamic multivariate statistical approaches (complex empirical orthogonal function analysis). We will investigate lags and leads in seabird-fish dynamics using correlation and regression analyses to determine if predictive relationships can be established. We anticipate a publication will result from this effort. If successful, this study will demonstrate how seabird-fish co-variation could be useful to both fisheries and seabird management in the North Pacific.

**Funding:**
- Total NPRB Funding Requested: $31,234
- Total Matching Funds Used: $3,500

**Legally Binding Authorizing Signature and Affiliation:**

[Signature]
Ellie M. Cohen, Executive Director

(NOT TO EXCEED ONE PAGE)
Connecting Marine Bird and Fish Time Series in Alaska: A Pilot Study of Environmental Co-Variation, with Potential Management Application (Short Title: Seabird-Fish Models)

Summary
We propose a study to investigate environmental co-variation in seabirds and fish in Alaska. We will examine two cases of coupled seabird-fish responses to environmental variation – seabirds of the Pribolof Islands and sockeye salmon of Bristol Bay (Bering Sea), and seabirds and herring of SE Alaska (Sitka region, Gulf of Alaska) - to test the hypothesis that seabird and fish parameters co-vary in time, with lagged relationships that may be exploited for management purposes. To test this hypothesis we will compile seabird and fish time-series readily available from state and federal agencies and examine co-variation in time series using dynamic multivariate statistical approaches (complex empirical orthogonal function analysis). We will investigate lags and leads in seabird-fish dynamics using correlation and regression analyses to determine if predictive relationships can be established. We anticipate that a publication will result from this effort. If successful, this study will demonstrate how seabird-fish co-variation could be useful to both fisheries and seabird management in the North Pacific.

Research Plan
Understanding ecosystem fluctuations on multiple temporal and spatial scales has become a central focus in marine science (McGowan et al. 1998, Steele 1998, Sydeman 2004). Quantifying ecosystem variability is critical in fisheries science (Beamish and Bouillon, Mantua et al. 1997, Hollowed et al. 1998) for adaptive management of marine resources, though few fisheries are currently managed from an environmental perspective (Botsford et al. 1997). Environmental variation in the U.S. EEZ has been shown to affect the spawning rates, recruitment, growth, survival, and biomass of many key commercial stocks such as salmonids, groundfish, and crabs (Kruse 1998, Hare and Mantua 2000, Miller and Sydeman 2004). Interannual to interdecadal environmental variation also affects forage fish (Hatch and Sanger 1992, Anderson and Piatt 1999) and zooplankton (Brodeur et al. 1996, Mackas et al. 1998) communities. Seabirds demonstrate fluctuations in abundance and demographic/life history parameters (e.g., fecundity, reproductive performance, survival, timing of egg-laying) in relation to environmental variability as well (Sydeman et al. 2001, Jones et al. 2002, Hyrenbach and Veit 2003). Therefore, to fully understand ecosystem-level fluctuations it is important to connect and quantify the temporal covariance in fish, forage fish, zooplankton, and seabird dynamics (e.g., Aebischer et al. 1990). Only through the linkage of time series for differing organisms of different trophic levels can a thorough analysis of coupled climate-ecosystem perturbations be established. Moreover, if lags or leads in patterns of co-variation are found, predictive relationships may be established that could be useful in a management context. For example, Lyver et al. (1999) suggest that productivity increases for shearwaters in New Zealand precede the arrival of El Nino events, and therefore can be used to predict oncoming environmental change. In this project, we will connect seabird and fish time series to determine if relationships between these groups in Alaska can be used in ecological forecasting and fisheries management.

Project Goal
Herein, we propose a pilot project designed to meet the growing need for a deeper, better understanding of the complex ecosystem variability that affects fish and fisheries and marine wildlife (seabirds and marine mammals) in the North Pacific. For decades, marine ornithologists have promoted the concept that seabirds provide indices to variation in marine ecosystems, with an emphasis on changes in lower trophic-level “prey” organisms (Cairns 1987, Montevecchi 1993, Furness and Camphuysen 1997). However, marine ornithologists have generally neglected to effectively bring their work into the realm of fisheries science, management, and conservation
Sydeman – Seabird-Fish Models

(Cairns 1993). In few cases have functional (possibly predictive) relationships between seabirds and fish and fisheries been developed (e.g., Miller and Sydeman 2004).

There are numerous advantages of linking seabird and fisheries science and management. For fish and fisheries science, seabirds may be effective monitors and samplers of the marine environment; they are relatively easy to study, and conspicuous, allowing for large sample sizes and modern statistical applications. Most importantly, seabirds provide spatial and temporal integration of the ecosystem/food web dynamics that drive important fish populations and fishery stocks. For seabirds, fish provide a prey base. For example, many seabirds feed on the 0 age-class of large predatory fish (e.g., pollock; Hatch and Sanger 1992, Hunt et al. 2000). Therefore, connecting seabird dynamics with fish/fishery dynamics will help in interpreting seabird population trends and patterns of distribution and abundance. Seabird and fish/fishery management agencies and scientists do not often cross paths. Therefore, this project will help bridge the scientific gap between seabird ecologists, fisheries ecologists, and seabird-fishery management groups in Alaska, particularly from the standpoint of food web dynamics and the triad of predator(seabirds)-, prey(fish)-, and fisheries(human)-interactions.

Project Responsiveness to NPRB Research Priorities

The NPRB aims to develop a comprehensive, science-based program to better understand marine ecosystem variability and fisheries of the North Pacific and the Bering Sea. NPRB's enabling legislation calls for advances in our understanding of marine ecosystems, with particular emphasis on commercially and recreationally important upper trophic level predators: marine mammals, seabirds, and large fish. This proposal addresses Component 2 (General Research Priorities), section d (Fisheries and Living Resource Management), question 1 (connecting fisheries and living marine resource management and science) of the 2005 NPRB RFP. This project will also address previously established NPRB priorities – e.g., form and function of North Pacific and Bering Sea marine ecosystems (NPRB Research Priority – a[1]), with emphasis on seabirds and their predator-prey relationships (Research Priority b). This research will provide a novel, inter-disciplinary perspective by connecting seabirds with fish and fisheries in Alaska.

The Concept of “Trophic Equivalency” and Application to Fisheries Science

Herein, we present a novel conceptual approach in fisheries science. We base our conceptual model on the fact that many fish and marine birds demonstrate “trophic-equivalency”, that is they exist at the same trophic level in coastal and pelagic food webs, and eat much of the same prey. Functionally, they may be competitors (that is not the focus of this project, though further understanding of competitive relationships may result). Most large fish of commercial interest and most marine birds are secondary and tertiary consumers: both groups forage extensively on macro-zooplankton (large copepods, amphipods, and krill), squids, and small fish (young-of-the-year predatory species such as pollock, or “forage fish” like sandlance and capelin). These forage species have shown major changes (increases, decreases and changes in population structure) in Alaska over time (Anderson and Piatt 1999), and have been the focus of previous requests for proposals (NPRB RFP 2004). While there is need to document the details of dietary similarities and/or dissimilarities between important fish stocks and seabirds in Alaska (and we will do so as part of this project), the concept of “trophic equivalency” is attractive in a fisheries management context because investigations of an easy to study “trophic-equivalent” (like a seabird) may provide information on a difficult to study species (like a groundfish). In particular, factors affecting the oceanic life stage of many fish, including, for example, Alaskan herring and salmonids, are not well understood, though it is now apparent that food in the ocean plays an important role (Mantua et al. 1997, Hollowed et al. 1998, Hare and Mantua 2000). Better understanding of fish survival at sea and effects of food web variability on growth and body condition would aid in predicting the numbers/biomass and reproductive capacity of these fish.
when they return from the sea, critical parameters in fisheries decision rules. If the same factors that affect fish survival, growth and condition at sea also affect aspects of seabird life history, demography, and abundance, then measurements of seabirds could be used as an appropriate proxy for the food web dynamics that affect fish. From a mechanistic standpoint, this conceptual model is based upon: (1) establishing functional relationships between ecosystem variability (i.e., changes in the distribution and abundance of food resources) and seabirds (abundance on colonies or at sea, timing of breeding, reproductive performance, provisioning rates and diet, etc.), (2) establishing correlations between the diet and prey use of seabirds and fish, and (3) developing quantitative relationships describing the co-variation (based on “trophic equivalency”) between seabirds and fish stocks. In this pilot study, we will focus, mostly on (3), with less effort devoted to (1) and (2) because if co-variation cannot be established, working out the mechanisms may not be necessary. Furthermore, seabird dynamics and the dynamics of important fish and fisheries are unlikely to be temporally synchronous (we anticipate lags and leads in co-variation relationships). This may complicate analytical issues, but there is a significant advantage here; if there are leads between seabird dynamics and fishery dynamics, equations that may forecast changes in return rates or body condition of fish could be developed. If leads were on the order of months, fisheries managers could use such predictions in annual decision-making activities.

Does “Trophic Equivalency” Work?

Case I. - In northern California, some seabirds (e.g., auklets, murres, and gulls) have very similar diets to herring. We have examined the relationship between prey availability and reproductive performance of a planktivorous seabird (Cassin’s Auklet), and the co-variation and relationships between auklets and herring. As prey availability improves, the birds breed earlier and reproductive performance generally increases, though in this case one species of euphausiid prey seems to influence timing and the other performance (Abraham and Sydeman 2004). Simultaneously, we have investigated the dynamics of a nearby herring stock (San Francisco Bay) that is targeted by a substantial fishery, including data on biomass and body condition. We have found co-variation between the reproductive performance of the auklets in current year “x” and biomass and body condition of herring in year “x+1” (W.J. Sydeman and K.L. Mills, unpublished data); ~60% of the variation in herring biomass (based on 1983-2000 data) can be explained by the reproductive performance of these plankton-eating seabirds in the year before. Notably, as the seabird data leads the herring data by 3+ months (seabird reproductive performance is measured in March-August, while herring biomass and condition in December-February in the following year), this information is useful in a predictive sense, and managers (California Department of Fish and Game) are now using this information in setting annual harvest goals (poor reproduction leads to a reduction in harvest from 15% to 10% of estimated biomass). While we do not have detailed information on herring diet at sea, we hypothesize that these relationships persist because herring and auklets are both reliant on the same prey species, mostly euphausiid crustaceans and ichthoplankton (larval flatfish, larval squid, etc.). There is no reason why similar relationships could not be established for Alaskan seabirds and fisheries.

And, importantly, there is a great deal of data to be worked with from Alaskan fisheries (NMFS, ADFG) and seabird (USFWS) agencies. This project will make use of data that has already been collected, but is not yet being used to its full potential.

Case II. - Another example in northern California concerns Central Valley Chinook salmon. We have established similar relationships for this stock and seabirds in the region. In this case, however, we have combined data on the reproductive performance for 3 species of seabirds over three years to match the oceanic phase of life for Chinook, and evaluated predictions of return rates of salmon based on a “jack” (precocious male) index (used by the Pacific Fisheries Management Council) relative to predictions made by combining “jack” data with data from the seabirds (Figure 1). Notably, the precision of predictions increased substantially (R² increased from .38 to .63) by using the seabird data (K.L. Mills and W.J. Sydeman – Seabird-Fish Models
Sydeman, unpublished data). Moreover, we are beginning to develop a mechanistic appreciation for this result: the seabirds and salmon are “trophic equivalents”. Both the birds and the salmon rely on juvenile rockfish (Sebastes spp.) as prey (Figure 2). A non-linear function between the take of juvenile Sebastes by Chinook salmon and 3 species of seabirds revealed strong co-variation over many years ($R^2=.67$ to .90).

**Figure 1.** Predictive equations used to determine return rates of Chinook salmon (CVI = Central Valley index) in northern California. (a) The current equation used by the Pacific Fisheries Management Council (PFMC) to predict return rates: number of “jacks” in the previous year is used to estimate number of returns ($R^2=.38$); (b) an equation we developed (Mills and Sydeman, unpublished data) using the annual reproductive performance (no. young produced per female) of seabirds on the Farallon Islands against the CVI ($R^2=.63$). In comparing the results using “jacks” and “jacks plus seabirds” against actual return rates, the “jack plus seabird” estimator improved both the accuracy (average) and precision (range) of the estimate (range of mis-estimates for “jacks” from –50% to +67%; range of mis-estimates for “jacks plus seabirds” from –37% to +45%). Over-estimation and under-estimation using the combined jack and seabird index was less likely.

**Figure 2.** The concept of “trophic equivalency” as an explanation for the data presented in Figure 1. Shown in this figure is the relationship between seabirds and salmon in the take of juvenile rockfish (Sebastes spp.) as prey over 17 years (1983-1999) in the California Current. Marine bird diet reflects prey returned to offspring during late May – early August each year. Salmon diet reflects the number of juvenile Sebastes found per stomach taken by party boats fishing in summer in the Gulf of the Farallones. There is a high degree of concordance in Sebastes use by birds and salmon ($R^2 = 0.67 - 0.90$). COMU = Common Murre (Uria aalge), PIGU=Pigeon Guillemot (Cepphus grylle), RHAU = Rhinoceros Auklet (Cerorhinca
monocerata). Taken from Mills, K.L., S. Ralston, T. Laidig, and W.J. Sydeman, in press. The use of top predator diet as indicators of pelagic juvenile rockfish (Sebastes) abundance in the California Current system. Fisheries Oceanography.

Project Hypotheses
The overarching goal of this project is to investigate the hypothesis that marine birds, as “trophic equivalents”, can be used to forecast how variable oceanographic conditions affect numbers/biomass and body condition of fish during their time at sea. Specifically, we will: (1) conduct a literature review to document the trophic (i.e., food habit) similarities (“trophic equivalency”) between marine birds, herring and salmon in Alaska; (2) test for co-variation in herring, salmon, and seabird time series, and (3) investigate whether patterns of co-variation can be used in a predictive sense. We will examine the phasing of co-variation and ask: are there any cases of lags or leads that could be used to predict one from the other? We will focus this pilot effort on two case histories: herring populations and fisheries in SE Alaska, and salmonids of the Bering Sea, notably Bristol Bay sockeye salmon. We will use USFWS seabird time series from SE Alaska and the Pribolofs to examine seabird-fish co-variation.

Analytical Approach
Our project will have two analytical components focused on measuring and understanding the temporal co-variation and phasing (in-phase, lagged, or out-of-phase) of seabird and fish time series datasets (Chatfield 2004).

First, we will synthesize disparate seabird time series, including multi-species “community level” datasets on seabird timing of breeding and reproductive performance from Alaskan colonies (~8 species, ~25 years, St. George Island, St. Lazaria Island) using dynamic multivariate statistics. We will use empirical orthogonal function (EOF) analysis to create linear combinations of timing and performance variables. Conceptually, timing of breeding may reflect prey availability during the late winter and early spring “pre-breeding period”, generally May-June of each year. Reproductive performance, however, reflects oceanic conditions over entire seasons, from June through September. Consequently, by combining different parameters, we will establish a series of functions that represent different temporal aspects of the environment. We also envision different combinations of species that would represent different foraging modes, trophic levels, and foraging habitats. For example, by combining information on auklets, a quantitative index for “planktivorous” birds could be developed. The index for these species would provide information on the availability of zooplankton that is also a heavily exploited food of salmon and herring feeding in these regions. In contrast, by combining gull and murre parameters, a “piscivorous” bird index could be developed. Different species combinations will also represent different foraging ambiats, neritic to offshore to shelf/break slope. We will take the leading EOF to represent each particular temporal, trophic level, and/or foraging habitat index.

We will examine species-parameter “factor loadings” (correlations) with each EOF to interpret these indices.

Second, we will use our derived EOFs to model co-variance in fish abundance (numbers and biomass) and body condition (when available, mass/length^3) each year using data available from state and federal fisheries management agencies. We will use lagged and unlagged correlation and regression analyses to develop these models. We will adjust degrees of freedom based on autocorrelation functions (Pyper and Peterman 1998). Our models will consider how multivariate seabird parameters in year “x” (or a combination of year “x”, year “x-1”, and year “x-2” – for salmon) can be related to herring or salmon time series parameters in year “x” or year “x + 1” and/or year “x+2”. In other words, we will use derived seabird metrics in one year to forecast, if possible, fish stocks and fish body condition in following years. We will collaborate with state and federal agencies in this effort including ADFG, NOAA-National Marine Fisheries Service, USFWS, and the North Pacific Fisheries Management Council (NPFMC).
Fundamentally, our hope is that this project demonstrates that connecting and combining information from multiple sources and organisms is useful to the management of commercially valuable fish in Alaska. This project presents a novel approach for ecosystem and fisheries management. The work could be applicable to many coastal marine ecosystems in the North Pacific where salmon and herring are important ecosystem components, and may have application to other fish and fisheries in Alaska as well. Our initial products will be presentations of results at scientific conferences, outreach via websites (NPRB, GEM, PRBO Conservation Science, and others), and a publication in the scientific literature. We anticipate producing at least one paper for publication in a peer-reviewed journal (Fisheries Oceanography, Marine Ecology Progress Series, or Fish and Fisheries). Our long-term goal is inclusion of this non-traditional information in fisheries management decisions. Having fisheries managers from ADFG, NOAA-NMFS, and NPFMC recognize and use this information would ensure application of project results in a management and conservation context. This will be our ultimate determination of success. We also would like this non-traditional information to be accepted by fisheries biologists as another way to assess ecological factors affecting survival of fish during the “black box” of their life cycle.

Project Structure and Management

William J. Sydeman, PI. Dr. Sydeman will oversee the project, conduct multivariate co-variation analyses, and prepare a paper on this topic for publication in the primary literature. Dr. Sydeman will supervise an informatics manager (Ms. Christine Abraham) who will acquire and manipulate the seabird and fish-fishery data to be used in this project. Dr. Sydeman will collaborate with Dr. Gordon Kruse (UAF, Juneau) and Mr. Vernon Byrd (USFWS, Homer) to analyze Alaskan marine bird – fish/fishery co-variation.

Dr. Kruse is a fisheries expert and previously employed by the Alaska Dept. of Fish and Game (currently a professor of fishery science at UAF). Dr. Kruse will serve as an advisor and cooperator for the project. Dr. Kruse is intimately familiar with fish and fisheries of the Bering Sea and Gulf of Alaska, and will aid Dr. Sydeman and Ms. Abraham in selecting and acquiring the best fish/fishery datasets for this project. Dr. Kruse is a member of the Statistical and Scientific Committee of the NPFMC.

Mr. Byrd is a seabird ecologist with the USFWS and leads the Alaska Maritime National Wildlife Refuge’s seabird monitoring program. Mr. Byrd will work with Dr. Sydeman to obtain appropriate seabird data from the Pribolof Islands and SE Alaska (St. Lazaria Island), and help guide the utility of seabird time series. Dr. Sydeman and Mr. Byrd have successfully collaborated on a number of projects in the past.

Budget Justification

(1) Costs for data management, statistical analysis, and reporting:

We are requesting 2 months of time for PI Sydeman to administer the project, supervise data management staff, conduct analyses, prepare presentations and progress reports, and prepare a paper for publication. Dr. Sydeman’s average monthly salary is estimated at $6,791/month. Benefits for Dr. Sydeman are calculated at 35% of salary. Costs for Dr. Sydeman are $18,336 ($13,582 in salary and $4,754 in benefits). Fringe benefits include full health and dental insurance, paid vacation, and employer contributions to a retirement plan.

An Informatics Manager (Ms. C.L. Abraham) is required to acquire data from agencies (ADFG, USFWS, NMFS), manipulate data, and create databases amenable to multivariate EOF and correlation/regression analyses. Ms. Abraham will also conduct the literature review on “trophic equivalency”. We are requesting 1 month of time for the Database Manager @
$3,605/month. Benefits for the Database Manager are calculated at 35% of salary. Costs for the
Database Manager are $4,872 ($3,605 in salary; $1,267 in benefits).

(2) Costs for coordination:
We are requesting $1,000 for travel to Alaska for the Database Manager to work with Dr.
Kruse and Mr. Byrd on data acquisition, and/or for the annual Marine Science in Alaska
conference. Travel costs for Dr. Sydeman to attend the conference will be borne by NPRB grant
no. F0409.

(3) Costs for outreach
As this is a pilot project, we are not, at this time, requesting any support for public
outreach. If the NPRB requests a public outreach component for the project, we would be happy
to design one. We will make a scientific presentation about this project at the 2005 North Pacific
Marine Science Organization (PICES) meeting in Vladivostok, Russia, and at the 2006 Marine
Science in Alaska conference in Anchorage, AK. As one of the co-Chairs to the PICES Advisory
Panel for Marine Birds and Mammals, and as a U.S. delegate to the PICES MONITOR Technical
Committee, Dr. Sydeman’s cost for attending the PICES meetings will be borne by the National
Science Foundation via UAF (SFOS; Dr. Vera Alexander). The travel cost for this meeting is
valued at ~$3,500
Cost Sharing: $3,500.

Total Costs

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[Note: 29% is applied to total costs, excluding permanent equipment (none specified) and international travel (none specified); 29% is PRBO’s NSF-approved indirect cost rate]

| Total Budget Request of NPRB:       | $31,234    |
| Total Cost Sharing:                 | $ 3,500 (NSF) |
| Total Project Costs                 | $34,734 (ratio: 90% NPRB to 10% NSF) |

Literature Cited

Abraham, C.L. and W.J. Sydeman. (2004). Ocean climate, euphausiids, and auklet nesting:

interannual trends and variation in phenology, diet, and growth of a planktivorous seabird,


ocean climate regime shift. Marine Ecology Progress Series 189:117-123.


Brodeur, R.D., Frost, B.W., Hare, S.R., Francis, R.C., & Ingraham, W.J., Jr. (1996). Interannual
variations in zooplankton biomass in the Gulf of Alaska, and covariation with California

Botsford, L.W., J-C. Castilla, and C.H. Peterson. (1997). The management of fisheries and


Biographical Sketch - WILLIAM J. SYDEMAN

Born: 24 August 1957; Mailing Address: PRBO/Marine Ecology Division, 4990 Shoreline Highway, Stinson Beach, CA 94970; (415) 868-1221 x. 319 (voice); (415) 868-1946 (fax); wsydeman@prbo.org

EDUCATION:
M.S., Biology, Northern Arizona University, Flagstaff, AZ (1985).
B.S., Biology, Lewis and Clark College, Portland, OR. (1979)

APPOINTMENTS/PROFESSIONAL EXPERIENCE:
12/00 – present, Research Associate, Integrative Oceanography, SIO, University of California, San Diego.
10/99 – present, Adjunct Professor, Biology, San Francisco State University, San Francisco.
1/92 - present.  Director, Marine Ecology Division, PRBO Conservation Science, Stinson Beach. Design and implement a long-term research program on the foraging ecology, population biology, and conservation of marine vertebrates in the California Current and other North Pacific Ocean ecosystems.
1/89 - 1/92.  Farallon Island Project Research Director, Point Reyes Bird Observatory, Stinson Beach.
3/86 - 12/88.  Staff Biologist, Point Reyes Bird Observatory, Stinson Beach, California.

PROFESSIONAL SERVICES:
10/03 – Co-Chair – Advisory Panel for Marine Birds and Mammals, PICES
10/03 – Chair/co-convener, Workshop – “Ecosystem Status Reports”, PICES/MONITOR, Seoul, Korea
5/03 – Member, Ecosystem Monitoring Working Group, cross-cutting; CA Marine Sanctuaries
1/03 – Member, Marine Reserves and Krill Harvesting Working Groups, Monterey Bay NMS
12/02 – present – Editorial Board, CalFED Publications
2/00 - 2/02 – Chair, Pacific Seabird Group (PSG)
10/00 – present – MONITOR Task Team, North Pacific Marine Science Organization (PICES)
1/99 – present - Editorial Board, Marine Ornithology
4/98 – 1/00 – Editor, Technical Submissions, Pacific Seabirds
1/99 – 1/01 - Squid Research Scientific Committee, California Department of Fish and Game (CDFG)
12/99 – present - Research Advisory Panel (RAP), Monterey Bay National Marine Sanctuary
1/97 – 1/99 – Chair, Seabird Restoration Committee, Pacific Seabird Group (PSG)
1/99 – Convener, Symposium entitled “Climate change and seabird response”, Pacific Seabird Group

FIVE PUBLICATIONS RELEVANT TO THE PROPOSED RESEARCH:
Mills, K.L., S.Ralston, T. Laidig, and W.J. Sydeman.  In press.  Top predator diets as indicators of pelagic juvenile rockfish (Sebastes spp.) abundance in the California Current System.  Fisheries Oceanography


FIVE OTHER SIGNIFICANT PUBLICATIONS:


PH.D. ADVISORS:
Drs. Jim Quinn, Louis Botsford, Alec MacCall, Susan Harrison, Alan Hastings; Primary - Dr. Jim Quinn

COLLABORATORS IN THE LAST 48 MONTHS:
Christine Abraham, Sarah Allen, Doug Bertram, Russ Bradley, Steve Bograd, Vernon Byrd, Derek Lee, Scott Hatch, Michelle Hester, Peter Hodum, David Hyrenbach, Alec MacCall, Kyra Mills, Ken Morgan, Scott Newman, Nadav Nur, Peter Pyle, Steve Ralston, Frank Schwing, Leslie Slater, Thomas B. Smith, Julie Thayer, Richard Veit, Elizabeth Venrick, Peggy Yen, Pete Warzybok

CURRENT AND FORMER STUDENTS:
Julie Thayer, University of California, Davis, Ph.D., in progress (w/ Dr. Daniel Anderson).
Shaye Wolf, University of California, Santa Cruz, Ph.D., in progress (w/ Dr. Don Croll).
Meredith Elliott, San Francisco State University, M.S., in progress (w/ Dr. Ralph Larson).
Jason Yakich, San Francisco State University, M.S., in progress (w/ Dr. Ralph Larson).
Ellie Owen, University of East Anglia (Britain), B.S., Honors Thesis, 2004 (w/ Dr. Bill Sutherland).
Jennifer Roth, Humboldt State University, M.S., 2003 (w/ Dr. Mark Colwell).
Daniela Roemer, University of Jena (Germany), M.S., 2002 (w/ Dr. Francois Buscot).
Michelle Hester, Moss Landing Marine Laboratory, M.S., 1998 (w. Dr. Jim Harvey).
**NPRB BUDGET SUMMARY FORM**

**PROJECT TITLE:** North Pacific Ecosystem Structure  
**PRINCIPAL INVESTIGATOR:** Sydeman and Hyrenbach

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**Cost Categories**

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<td>4. Equipment</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Supplies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Contractual/Consultants</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7. Other (Include $2000 for education and outreach)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Total Direct Costs</strong></td>
<td>24,214</td>
<td>0</td>
<td>24,214</td>
<td>3,500</td>
</tr>
<tr>
<td><strong>Indirect Costs</strong></td>
<td>7,020</td>
<td></td>
<td>7,020</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL PROJECT COSTS</strong></td>
<td>31,234</td>
<td>0</td>
<td>31,234</td>
<td>3,500</td>
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