

North Pacific Research Board Workshop Report

Climate impacts on the Gulf of Alaska Identifying the priority scientific issues in the context of management topics

**February 27-28, 2007
Juneau, Alaska**

The North Pacific Research Board (NPRB), the Alaska Ocean Observing System (AOOS), and the NOAA Auke Bay Lab (ABL) organized this workshop to identify specific observational and modeling issues to be addressed in carrying forward a coordinated research program on assessing and predicting climate impacts on marine resources and ecosystems in the Gulf of Alaska and inshore waters.

Climate impacts on the Gulf of Alaska (GOA) are critically important to fishery managers because this ecosystem is subject to climate variations in various forms and frequencies including strong seasonal and interannual changes, cyclical ENSO and PDO patterns, more regional fluctuations in the timing of the spring transition, and longer-term changes of unknown origin. There are long physical and biological records that show correlations between physical forcing by these signals and ecosystem components ranging from tree rings, to plankton, to upper trophic level predators. There are good reasons to believe these correlations because the climate variability should modulate nutrient supply to the lowest trophic levels while ocean temperature and other physical characteristics are known to affect animal behavior in both shallow and deep-water regimes.

Although the case for strong climate impacts on oceanic ecosystems and its nearshore waters is strong, it has been difficult to clarify the mechanisms and predictability of these impacts. In order to use developing predictions of physical climate variability to improve management of marine resources and ecosystems it is necessary that:

1. Methods for describing the present physical state of the ocean and predicting future states be developed and implemented;
2. Predictions of climate variability on selected trophic levels must be tested so that we can determine if they are reliable enough for management decisions; and
3. Methods of extending the predictability of climate impacts on higher trophic levels must also be developed.

The NPRB will launch an Integrated Ecosystem Research Program (IERP) for the Gulf of Alaska in October 2007. To guide the development of the IERP implementation plan the NPRB planning team identified 8 key management issues that may be scientifically tractable through the proposed \$7M Integrated Ecosystem Research Program. A workshop at the Alaska Marine Science Symposium revised this list of topical issues as follows:

1. Periodic regime shifts and climate change: climate variability
2. Marine mammals, seabirds, and endangered species
3. Forage species

4. Carrying capacity
5. Crab recovery and species response to management strategies

One objective of the Juneau workshop was to further refine this list by identifying specific research and monitoring needs in the Gulf of Alaska Large Marine Ecosystem in the context of management issues identified by the IERP planning team. This objective would be achieved through a series of presentations, discussions, and working sessions categorized by physical and biological observations, and physical and biological modeling. The presentations focused on:

1. Describing the physical state of the Alaska Current and Alaska Coastal Current System and predicting inter-annual to decadal changes;
2. Testing predictions of climate impacts on selected trophic levels to see whether they are reliable enough to inform management decisions;
3. Improving knowledge and models of other trophic levels so that climate impacts on them can also be predicted;
4. Optimizing small (100's km) and large (1000's km) scale ocean observing systems, including observation platforms and data assimilation models, to benefit the fishery management community (including marine mammals and seabirds).

Summary findings of the workshop

The priority scientific issues confounding accurate predictions of the effects of climate variability on managed fish populations are:

1. Inadequate understanding of fresh water forcing and how this affects stratification of the surface layer at vertical scales of <10 meters, and the ability to predict the spatially explicit formation of fronts and eddies at horizontal scales of 1 km and time scales of days to weeks; and data assimilation techniques and the requisite telemetered sensor platforms need to be developed to constrain physical and biological models;
2. The NPZ is a fundamental biological component of the ecosystem driven largely by ocean physics and in order to get meaningful forecasts from an NPZ model the physical models need to be correct (see #1); and key parameters driving the sensitivity of NPZ models need to be identified and quantified;
3. Forage species tend to aggregate in space and time and these aggregations are an important food source for higher trophic level animals including fishes, marine mammals and seabirds, therefore, models need to be developed that can forecast the location and timing of these critical prey aggregations (see #1 & 2); and the higher trophic level animals have great potential as indicators of forage species aggregations for model validation or data assimilation through use of real-time telemetry tags or acoustical tracking; and
4. Information on life histories, behavior, sources of mortality, and the spatial and temporal distributions of key forage species is currently inadequate for making

meaningful forecasts of their abundances relative to climate variability (see #1, 2 & 3).

The ability to accurately forecast the effects of climate variability on all higher trophic levels, including humans, will depend largely on a better understanding of these key issues and this provides substantial justification for the first GOA IERP to focus on resolving them. Based on these findings the workshop steering committee further narrowed and prioritized the focus issues so that the first GOA IERP should address one of the following:

1. Forage species (including but not limited to: sandlance, capelin, myctophids, herring)
The need to understand the population dynamics and life histories of forage species was identified consistently by several groups that recognized the value of these animals in support of all the higher trophic levels of the ecosystem. In particular to enable forecasting there needs to be a better understanding of the dynamical coupling between NPZ and forage species.
2. Crab recovery
On the basis of developing knowledge of physical circulation patterns, population status, larval duration, and relevant adult behaviors of crabs in the Gulf of Alaska, there is a need to understand how ecosystem processes interact to enhance or inhibit recovery of many previously important invertebrate species such as red king, Dungeness, and Tanner crabs in the Gulf of Alaska.
3. Endangered species
There is a continuing need to understand why the dynamics of some subpopulations are spatially distinct in eastern versus western domains of the Gulf of Alaska.

The presentations are available for viewing or download from the NPRB web site (www.nprb.org/research/goa_climate.htm). The sessions and presentation topics were as follows:

Session 1: Program overviews

Workshop Introduction
NPRB Integrated Ecosystem Research Program
Alaska Ocean Observing System
GLOBEC
Pacific Coast Ocean Observing System (PaCOOS)
Overview of the GOA IERP

Phil Mundy (ABL)
Clarence Pautzke (NPRB)
Molly McCammon (AOOS)
Beth Turner (NOAA)
Liz Clarke (NMFS)
Carl Schoch (AOOS)

Session 2: Physical observations

Climate Scales: review of physical observations
Terrestrial forcing of the coastal environment
Air Sea forcing of the Gulf of Alaska
Observing: Physical processes governing lower trophic levels
Observing: Physical processes governing upper trophic levels
Discussion: Improvements in physical observations

Tom Royer (ODU)
Tom Weingartner (UAF)
Bill Crawford (IOS)
Sonia Batten (SAHFOS/IOS)
Phyllis Stabenon (PMEL)
Steve Okkonen (UAF)

Session 3: Biological observations

Climate Scales: review of biological observations
Observing lower trophic levels: NPZ
Observing upper trophic levels: Forage species
Observing upper trophic levels: Fish species
Observing upper trophic levels: Endangered species
Discussion: Improvements in biological observations

Ricardo Letelier (OSU)
Suzanne Strom (WWU)
Alex Wertheimer (ABL)
Anne Hollowed (NMFS)
Kate Stafford (UW)
Mike Dagg (LSU)

Session 4: Modeling physical processes

Modeling: Hydrodynamics
Modeling: Physical processes governing NPZ
Unresolved processes in physical models
Discussion: Improvements in models

Yi Chao (JPL)
Ken Coyle (UAF)
Hal Batchelder (OSU)
Hal Batchelder (OSU)

Session 5: Modeling biological processes

Workshop Introduction
Modeling upper trophic levels: Forage species
Modeling upper trophic levels: Fish species
Modeling human socio-economics
Unresolved mechanisms in population and ecosystem models
Discussion: Improving data input to fisheries management

Bill Smoker (UAF)
Brenda Norcross (UAF)
Terry Quinn (UAF)
Sarah Kruse (Ecotrust)
Kerim Aydin (NMFS)
Franz Mueter (Sigma Plus)

Group 1: Observations: Physical and biological measurements Frank Whitney (IOS)

Group 2: Modeling: Hydrodynamic and biological models Yi Chao (JPL)

**Workshop: Climate Impacts on the Gulf of Alaska LME
(based on notes from Hal Batchelder and Carl Schoch)**

Session 1: Program overviews

Pautzke – North Pacific Research Board

IERP—Integrated Ecosystems Research Program

Funding levels: Bering Sea 57%; Gulf of Alaska 37%; Arctic 6% for 2002-2006

-interdisciplinary teams to investigate regional and large scale ecosystem structure and function.
- workshops; GOA opportunities; spatially responsive Sea lion pops; PWS processes, biotic and abiotic; trawl fisheries and predator impacts on Pollock/forage fish and decline of steller sea lions

Sept 2007 – final approval of GOA IERP RFP;

Nov 23- pre-proposals due

Plan work in GOA starts in 2008; Field work in 2009

One year of planning and synthesis and analysis of existing data; 3-4 years of field work, one year of synthesis

NPRB focus is on research, process studies and identifying future monitoring needs.

McCannon – Alaska Ocean Observing System

Perhaps future NOPP BAO for Integrated Ecosystem Assessments – next few years

Pacific Basin OOS integration; May meeting in Portland OR (Clarke)

Schoch - Alaska Ocean Observing System (continued)

Favor of nested designs; how can we strategically deploy an array of instruments that will best inform models

Using PWS as pilot project for an end-to-end observing system

WRF forecasts of winds/atmospheric processes; reinitialized every 6 hr

SWAN wave model

Yi Chao and J. McWilliams developing nested ROMS model

Operational ROMS model; basin scale then three nested levels 10/3.6/1.2km (1.2km in PWS)

Turner— GLOBEC

\$40M total to CGOA GLOBEC; 1997-2009

Legacy—data, PR synthesis, model advances, model products, advancing ecosystem based management (led by NOAA PIs), informing ocean observing systems, (papers, special volumes, books), cadre of graduate students trained in cross-disc. Oceanography, influence of GLOBEC on future scientific programs

Ecological Forecasting: understanding; knowledge of ecosystem status; forecasting and translation tools

Fill gaps in scientific uncertainty, integrate disciplines

Quantify forecast uncertainty

Users—communication between scientists and managers;

Uncertainty and skill assessment—March 6-8, 2007 workshop on skill assessment (SA); provide advice back to NOAA about types of models for SA; how to do SA of coupled biophysical models

Liz Clarke— Pacific Coast Ocean Observing System (PaCOOS)

Transboundary ecological observing activity for fisheries, birds and mammals and plankton (esp. HABS)

Need to include Canada as well as COW.

ATLANTIS – fisheries, ecology and hydrographic submodels with feedback from fisheries to ecology submodel

CCLME guidance: improved regional programs; involve stakeholders, products of direct use; link to CAMEO (Comparative Analysis of Marine Ocean)

Stakeholder based governance; conserve essential parts/processes; develop methods;

Workshop Result: Scientists interested in upper trophic level models and classic stock assessment modelers met with those interested in dynamical models of the physical state of the CCE.

Schoch – Overview of the Gulf of Alaska Integrated Ecosystem Research Program

\$7M over 6 years

“gain comprehensive understanding so that we can forecast fish populations/resources”

Look at models that are best suited to a particular management issue

Iterative process; model, predict and observe, revisit

Planning team recommends one of the following eight topical issues for the IERP: periodic regime shifts; seabirds, mammals and endangered species; forage species; carrying capacity; crab recovery; climate change; species response to management strategies.

Modeling ocean physics and selected trophic levels to: develop forecasts for selected fish species under varying climate and describe climate-physics-fish., develop and test prediction capability.

Session 2: Physical observations

Royer – Climate Scales: review of physical observations

Low frequency (interdecadal changes) are occurring;

Changes propagate through the GOA

Continued time series are essential for quantifying these changes

Many data sets are languishing; awaiting analysis

Sitka air temp (1828-present)—dominated by 18 and 50 year signals

GAK1 mooring– positive trend in both upper (.03C/yr) and lower layer (.024C/yr) temperature

Salinity in upper layer is decreasing while lower layer salinity is increasing suggesting increased vertical stratification

Musgraves SALMON proj. GAK4 mooring ADCP from March 2000-March-2001; u is always westward; onshore flow near surface; offshore flow from 10-60 m (estuarine like) and onshore flow in deep layer bringing salty, nutrient rich water onshore.

Split and merge algorithm estimate of MLD along Seward line shows that MLD reaches the bottom of the shelf annually.

Midshelf upwelling due to wind-stress curl on Seward Line from late summer into winter

Tree-ring data (Wilson et al. 2007)—identify regime shifts about every 26 years since about 1640 AD

Weingartner – Terrestrial forcing of the coastal environment

Storm tracks; carry winds, clouds, moisture

Tall coastal mountains

Langara BC lighthouse data from 1940- (decreased salinity; increased temperature (at surface only))

Middleton island (since 1948) monthly mean wind forcing (alongshore winds)

Traditional Bakun upwelling indices are not capturing the orographically influenced winds of the northern gulf

Precip measurements are suspect due to small scale orographic effects

Crawford— Air Sea forcing of the Gulf of Alaska

Changes in intensity of storms and storm track are both really important

ALPI index (Beamish); most intense storms during warmer periods

Raible et al. 2005 J. of Climate 18.

Shape of the Aleutian Low is critical in determining winds that influence SST.

Bifurcation point of WWD from monthly images of dynamic height (from Howard Freeland's web page)

Crawford et al. (subm to PiO) – eastward wind along line P is related to surface temperature; 76-77 regime shift in wind patterns

North of 54N, half the chlorophyll is in eddies, but this represents only 10% of the surface area

Batten: Observing: Physical processes governing lower trophic levels

Eddy activity can intensify chlorophyll out to 300 km offshore

Vertical processes within the eddy can inject nutrients into surface layers

There is interannual variability in eddy strength and frequency with EN years producing larger, longer lived Haida eddies; might change with climate change

CGOA tends to be light limited; Increased FW input, increased temperatures in nearshore waters may increase stratification and change the timing of the spring bloom

Potential mismatch of prey and predators.

Large-scale circulation from ARGO project. 2002 dividing line was 8 deg N of usual location.

June 2003 dividing streamline was much further south.

Time series of North Pacific current.

Stabeno — Observing: Physical processes governing upper trophic levels

Focus on ACC impact on fish. ACC flow is stronger in winter. Relatively low transport in summer.

SEAK mooring; outflow at surface; inflow below ca. 120m depth; very strong tidally influenced bottom circulation;

Shelikof Strait and Pollock—goal is to predict recruitment; identify three processes that determine the variability; FW input, windiness as first feeders, how strong is ACC (lost of larvae offshore); prediction worked for a few years, but climate change (regime shift) disrupted understanding and changed the rules; capelin offshore off of Kodiak, but Pollock are more inshore

OCC sampling from 2003 shows different distributions of pink salmon and zooplankton biomass; pinks are near the ACC front
NEP grid does not show good correlations with ACC transport; higher resolution ROMS does much better estimate of ACC currents/transports
Need hi rez ROMS with hi-rez atmospheric model in order to accurately represent the ACC circulation.

Okkonen— Discussion: Improvements in physical observations

Shelf break fields of S/T from a NPGS model (9 km grid); surface layer has strongest annual cycle; bottom layer has strong annual cycle, but also has lots of strong coherence with 5-20 yr cycles; from power spectra done between PDO and T or S.

Session 3: Biological observations

Letelier— Climate Scales: review of biological observations

Structure is state variables; function is rates, fluxes

Need long-time series to examine climate

A biological unit becomes under stress when the rate of change in the environment is faster than its rate of adaptation.

Micrometer scale is where the action happens

Meter scale (fine vertical structure)

Changes alone don't differentiate between changes in ecosystem structure and simple advective processes—need ancillary data on other variables.

SOMs is Self Organizing Maps, not spatial optimizing mapping!

Can be used to assess where to place observations/moorings and what spatial scales of sampling repeat other observations

How do we merge biological models at different spatial scales.

Strom— Observing lower trophic levels: NPZ

Changing resource availability and effects on PP, partitioning of PP and consequent fate; shift in phenology and species ranges

NPZ models and sensitivity analysis

Changing resources: light, macronutrients and micronutrients; light can be limiting (from Stn P and GAK line experiments); NO₃ additions mattered a lot in the ACC; dissolved Fe (Series Expt)—where does the iron come from and how does it get there? April 6, 2002 clear SeaWiFS image. May 27, 2000 SeaWiFS image clear.

NPZ models and sensitivity analysis—Fujii et al. DSR2, 49, 5441; Ji et al. DSR2, 53, 2656.

Diatom Si:N uptake ratio; temperature dependence of growth, mortality, grazing; max grazing rate of major diatoms

Microzooplankton reduce the food web efficiency. 60% of spring bloom in CGOA is not accounted for by zooplankton grazing—either sinks or is advected away

Limitation by multiple resources

Food web pathways as important as magnitude;

Effects of southern species and life cycle timing.

Wertheimer— Observing upper trophic levels: Forage species

Salmon as sentinel species; long record showing low frequency variability

Wild-hatchery interactions important

Leigh Rubint comic about survival of young;

SECM project; expectation that information will be useful for making projections

Forecast model doesn't do a very good job of hitting the years that turn out to be poor survival years (model based on juvenile abundance and May temperature)

Salmon in SEAK are not requiring much of the standing stock of zooplankton during the summer months. But huge amounts of nighttime biomass (eulachon, walleye Pollock)—big consumers of secondary production—during day forage fish tend to be deeper than standard trawl depth.

Hollowed— Observing upper trophic levels: Fish species

NMFS sampling

Longline survey along shelf-edge (for sablefish only?)

RACE groundfish assessment program; stratified random sampling; trawl; 2007 GOA shelf sampling; 2008 Aleutian Island region

Midwater acoustics assessment (Pollock centric group); starting to look at capelin, Pcod, northern rockfish; from Oscar Dyson, which has underway oceanography; Shumagin region (Feb), Shelikof St (March), alternate years Kodiak Island or western central GOA

PMEL May cruise for larval surveys in Shelikof strait.

Sampling is imperfect—biases; herding; escapement; untrawlable grounds

Underway oceanography; understand fish movement; environmental effects on growth and maturation; use ships of opportunity, esp. commercial fleet.

Kate Stafford- Observing upper trophic levels: Endangered species

How do we monitor large mobile predators?

Top predators take a lot of energy out of the pelagic system—feed on all levels of the trophic system

Many large whales are increasing in abundance; what is their impact on forage species?

Most will concentrate near their prey; some are restricted to nearshore rookeries.

Scales: micro patches (individual foraging) to meso-scale (fronts; aggregate with prey) to large scales (forced by currents & water masses)

Whales (cetaceans) may respond to environmental change by changing distribution; pinnipeds and marine birds have nesting req'd terrestrial; therefore changes in environmental conditions may result in change in survival and reproduction

Tagging—need lots of individuals tagged because of hi-interind. Variation; extrapolation is difficult.

Nest small scale high rez projects with meso and large-scale projects

Dagg— Discussion: Improvements in biological observations

Priorities need to be set; task is large and complex

Physics to phytoplankton (pretty good understanding)

LTL complexity and biophysical coupling (not yet)

LTL models – species groups/types (good progress)

LTL models – species (not yet)

LTL – forage fish linkages (not yet)

Basic biology; scientific approach (oceanography vs. fisheries mindset); time and space scales;

Fish – mammal, bird, human linkages (???)

Emphasis should be on LTL- forage fish linkages

Other issues: Correlations vs. mechanisms (rarely apparent; new conditions with new climates—do previous relations hold?)

Indicators vs. models (indicators are only important in the broadest context); synthetic model provides mechanisms

Linkages between empiricists, modelers and monitoring

Session 4: Modeling physical processes

Chao— Modeling: Hydrodynamics

Scales from decadal-seasonal-synoptic (few days)

Future climate projection (does not require DA; probabilistic projection) vs. synoptic ocean forecast (requires DA; deterministic projection)

State of the art observation; how many buoys/gliders, etc. Make prediction in near real time and find out tomorrow whether you are right or wrong.

Practice the model forecast frequently.

Aquarius (2009) satellite data for salinity.

No Quikscat follow on mission. Altimeter is ok shape. Golden age of satellite oceanography may be over.

Data- model synthesis after finishing the observation project (often as afterthought) is not optimal.

Engage the policy and decisions makers as an early partner.

Coyle— Modeling: Physical processes forcing NPZ

Response of ecosystem model to light, nutrients and stratification.

1D GAK6 simulation forced by stored 3-D fields.

Observations show blooms occur in May; model suggested earlier blooms (Mar-Apr); no July NO₃ in obs; still there in model; Stability in observations is low until July-Aug; model shows hi stability in March, then low in April-May and increasing into the summer;

Showed Whitlege and Stockwell primary production data—shows peak in May

Showed poor match between model and observations; created “hacks” or “fixes” to light levels; negatively impacts total primary production. Tuning the phytoplankton doubling rate in the model (doubled from 0.85 to 1.8). Massaged the guts of ROMS—changed mixing.

Batchelder— Unresolved processes in physical models: An Ecosystem Modeler’s Expectations of Physical Ocean Models

- Ocean models will be important tools to investigate and describe physical and biological responses resulting from climate variability.

- A priority of future research will be to ground truth the output from these models and develop approaches to directly or indirectly extend them to address higher trophic level dynamics.

- The development of spatially resolved models to predict and assess the implications of climate variability and change on ecosystems is crucial for planning adaptation strategies.

- How well do the ROMS NEP physics match our perception and data from the real NEP ocean (esp. of KEY processes)?

Batchelder—Discussion Section

Summary comments:

Physical data are sparse, infrequent and often biased

Sparse – esp. below the surface; salinity

Biased – spatially, few places with full suite of observations (T,S,velocity)

Ecosystem data more sparse, more infrequent, and more biased.

Chlorophyll in surface layer, at some times and places (where there are no clouds)

Zooplankton observations—poor spatial and temporal coverage; sometimes missing taxonomic detail (reported as biomass or abundance).

Evaluation of model performance hindered by lack of independent data.

Need to define a specific target for a model—there is no generic, universal ecosystem model.

Need to define goals and expectations for models, and how to interpret the results and gauge success. Establishing credibility of a model within the domain of its intended use.

Model-data judgements rely on statistics and estimates of uncertainty. But what is truth?

“Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know.” Donald Rumsfeld

"I would not say that the future is necessarily less predictable than the past. I think the past was not predictable when it started." Donald Rumsfeld

Session 5: Modeling biological processes

Brenda Norcross— Modeling upper trophic levels: Forage species

Herring spawn nearshore in April; larvae advected

Early life history model of survival through age-1

Used statistical distributions of survival to account for uncertainty

Data from published literature; therefore, no interannual variability

Egg stage (21 days)—WHY not a function of temperature?? (0.07 d-1)

PWS model (Rooper et al.)

Larval stage (92 days)—best data from Auke Bay (0.07 d-1)

Mortality caused by advection, predation and starvation

Fall Juvenile stage (also 92 days)—(0.01 d-1)greatest mortality likely due to predation; averaged from data from 4 bays in PWS

Winter Juvenile Stage (next 135 days) (Patrick 2000) (0.004 d-1) survival is very variable

Survival = 118 age-1 from 1 million eggs

Fecundity of an individual female is about 4 million eggs

Sensitivity analysis—altered each stages survival by 10%; larval mortality was most important factor controlling survival in herring (and probably other species)

Thornton and Norcross (submitted), larval herring growth model; embedded into PWS

biophysical model (Eslinger et al. 2001); separated larval phase into yolk-sac and feeding stages; metamorphosis at 25 mm length.; temperature dependent growth processes; highly stratified warm waters with low food availability are poor for supporting herring growth to metamorphosis size; need measurements of ocean conditions (food and temperature) to evaluate what might be responsible for good vs. poor YCS; larval growth will impact subsequent juvenile survival; 1997 related to stable ocean

What was the survival of 1997 herring vs. the higher survival year? 1997 was a bad YC

Terry Quinn— Modeling upper trophic levels: Fish species

The holy grail: AGE STRUCTURED ANALYSIS

Stock assessment: Data collection (fishery and fishery independent), Modeling and Analysis (pop dyn, uncertainty and environment), and Management Recommendations (biological reference points, sustainability and plan of action)

Fishery Harvest includes total catch and kill (incl. bycatch), composition (length, age, sex), and catch per unit effort

Biological information includes survey index of abundance, natural mortality, recruitment, growth movement and migration and fecundity.

Modelling—New abundance = previous minus losses plus additions.

Natural mortality (constant = 0.2), estimated, a function of predators, a function of disease, a random walk.

Recruitment is usually estimated annually—abundance at the earliest age (survival of eggs to being harvested. Assumes that recruitment is estimable from the population of interest only (environment independent).

Challenges:

- 1) stochasticity—what effects recruitment; spawner biomass, egg production, temporal change in the environment; tremendous variability, an unsolvable problem? (a KNOWN UNKNOWN?)
- 2) Varying natural mortality—assume something usually; probably a function of age (may be U-shaped); function of predators and disease; cause and effect requires study of early life history
- 3) Multiple datasets—not data poor; data conflict can affect interpretation of population dynamics; case study PWS herring 1993 spawners only 25% of expected value. Suspected possible disease for high mortality. Population modeling can expose conflicts in data sets, like miles of milt vs. egg survey data from PWS immediately following the PWS oil spill.

Ecosystem input to fisheries models: physical and oceanographic variables in relation to recruitment; LTL data relation to recruitment; understanding mortality and growth of the fish population early life history; disease and predation may have an effect on natural mortality
Fishery model output to ecosystem studies: recruitment as a time series; natural mortality as a time series, abundance trends; patterns trends and anomalies; spatially explicit models using spatial survey data and compartment models.

Lot of data, but also lots of parameters. Innovative solutions have and will occur. Many interesting theoretical issues need attention.

Sarah Kruse— Modeling human socio-economics

Goals: establish links between fisheries and community well being; create regional economic models;

Data: fisheries: Prices, processing production by species and product; variable /fixed costs for vessels and processeors; spatial-tempor dist of fisheries; employment

Community level: subsistence harvest; community and regional economic data

Lack of socioeconomic data makes analysis, predictive modeling, pre- and post-studies difficult to do—data are available at decadal frequency only (census info); data are not detailed; do not

account for fishing effect. Data can be unreliable; fish don't give strategic responses, humans do (they lie).

“community well being” – how is this defined? Its difficult to define it. It includes having access to basic needs (employment, income, shelter), but there are also quality aspects (value judgement), age structure of fisherman.

Goal: focus on establishing baseline data by pooling coherent data-set; mine TEK and LTK data sources; improve collection methods

Confidentiality issues.

Many communities are sick of being surveyed.

Be realistic and start small, and can't be done as an afterthought.

Kerim Aydin— Unresolved mechanisms in population and ecosystem models

Coupling climate and biology: what is a “regime shift”?

Duffy-Anderson et al. 2005; Ecol. Complex., 2, 205 – a change in attractors, a phase shift.

Ex 1: NEMURO coupled to ECOSIM with pink salmon bioenergetics model at OSP. NPZ models need to consider the impacts of changes at higher trophic levels on LTL dynamics (at least at the euphausiid- foraging fish level).

Matching foraging depth with MLD utilization using archival tag info on depth of foraging.

Diet switching is positive feedback for growth. Small initial size difference in pink accelerated to large differences at end of the summer—mostly due to switch in dominant prey type—earlier switch to better squid feed. Not enough food during winter, even though food demand is not particularly hi per fish at that time. Zoopl. Abundance is so low at OSP in winter. Critical size/critical time hypothesis.

Make swimming speed a cost/benefit operation—cost function is speed and temperature dependent; benefit depends on prey density and so is density dependent.

Leo Cullum (Please elaborate on “then something bad happened” COMIC)

Local interaction scales to very differet predictions—robust management of this uncertainty is the objective.

Evolution of single-species assessments to include advice from multispecies models and indicators.

Franz Mueter— Discussion: Improving data input to fisheries management

Goals:

- 1) identify key models and model products to support fisheries management
- 2) identify key data requirements to support biological and socio-economic models
- 3) identify major gaps

How are fisheries data is used to meet management goals. Modified rhomboid model.

Data gaps: biology/life history parameters, abundance of forage species and sensitive/indicator species; spatially explicit models; movement/migration to resolve stock structure and improve single species models; climate effects on growth, maturity, etc.

Model gaps: lack of linkages between physics/NPZ and upper trophic levels and to match output of model input at next level; intermediate models between whole system and single species models (partial systems or minimum realistic models; economic and socio-economic modeling with cost/benefit analysis

Breakout session: Observations: Physical and biological measurements (Frank Whitney chair)

1. What issues are you interested in that might suit the aims of NPRB?
 - physics – ocean stratification affects primary prod, zoo distribution (need better handle on fresh water); wind fields needed (intensifying?);
 - salmon enhancement and impacts on forage fish
 - early life history and recruitment; stock structure (time and space)
 - predict climate change and its effect on Alaska, scale down IPCC models
 - comparison between regions – sea lions, crabs, shrimp (regional stability important?)
 - subtidal, nearshore habitat changes (new predators, climate change...)
 - humpback whale diet, variability across Gulf
 - try to get data throughout year, continuous data when possible
 - collect data specific to regions – feed specific models
 - large scale models need to satisfy needs of coastal studies
 - How might larval transport vs behavior change, what is it at present – physical, biological interactions –connectivity
 - Functional relationships – physio studies (lab)
 - Account for ocean acidification (impact on phyto and zoo) and reduced ventilation of the ocean interior (loss of slope habitat)
2. How will solving them assist fisheries management?
 - better understanding of risk – mariculture, human health (oysters)
 - stock structure info aids management (better understanding of production)
 - better estimates of variability (spatial and temporal)
 - species interactions will modify exploitation of a single stock
 - model improvements (mortality and recruitment)
 - need to show that new knowledge will help management
3. What new information do we need to know to help resolve issues?
 - seasonal diet data
 - time and space scales (standardize measurements in regions over long term; leverage additional support e.g. EVOS)
 - increase data collection on existing fish surveys (oceanographers)
 - someone must use the data for it to be relevant
 - benthic mapping, seabed classification
 - tracking transients (seasonal, spatial)
 - range of species, how it could change
 - the human dimension
 - Better hydrology
4. Field program design -
 - define scope of proposal
 - sample several regions along coast, standardize measurements
 - leverage, using existing resources, expand vessel-of-opportunity
 - institutionalize long term data collection

- tight coupling of modeling and field observations, adapt sampling to suit model needs
- balance monitoring and process studies
- opportunity to train and bring in new expertise (retention?)
- data management
- Costs of fishing fleets, how might they change?

Breakout session: Modeling-Hydrodynamic and biological models (Yi Chao is chair, Batchelder and Mueter co-chairs)

Notes from going around the room for comments on where effort should be expended to improve understanding of how GOA ecosystem works and how to contribute to NPRB goals.

Hal Batchelder – transition from concentration based LTL to fish models that must include behavior and deal with complex life histories

Franz Mueter– provide indices derived from LTL models that could be used to inform management of fish

Suzanne Strom – NPZ models can get the right answer for the wrong reason, which may not matter if all you want is N, P or Z, but it will matter when you try to connect that model to a higher trophic level; NPZ models are not that far enough along; major issues remain for connecting them to higher trophic levels; there is clearly an information gap between mesozooplankton and fish; phytoplankton are very understudied—composition for example, in the GOA

Francis W. – get to the minimum realistic model; Dagg summary; work on the linkages between trophic levels; model and data interaction must be direct and ongoing

Ken Coyle – physical model has to be able to hindcast correctly; biological system is very sensitive to the physics being represented in the model; models must have supporting data (assimilation); esp. short generation time biological components; higher trophics must be linked directly into the LTL models—not run with output of the LTL models (e.g., run independently)

Clarence Pautzke – climate change maybe shouldn't be the focus; NPRB will need a foundation of success, first goal needs to be achievable

Kerim Aydin – Bering Sea is a monodirectional change; GOA is more complex from top to bottom—more variable, including dynamics of the regime shift; management context of strategy evaluations—long-term perspective (20-50 years out).

Liz Clarke – connection to higher trophic levels is difficult, perhaps never attained anywhere; but NPRB want's a successful outcome from this first; spatially-explicit context is important

Terry Quinn—emphasize the diversity of habitats (canyons, gullies,); characterizing habitat relations is important

Tom Weingartner—not getting stratification right on the CGOA shelf—implications for heat transfer and biological; 3D problem; problem perhaps related to how FW is coming into the system; do we know the runoff (terrestrial issue); going to need mesoscale meteorological component to get better physical forcing; difficult to get radiative forcing correctly; get more observations of radiation along shore (local school observations and an outreach tool).

Yi Chao—do model intercomparison (esp. of physics);

Brenda Norcross—issue of scale; connection of NPZ to biomass and stock assessment is not currently known how to accomplish this; ICES started with herring—but we haven't solved the recruitment problem;

Beth Turner—defining success for the program is critical; which of 8 topics can we define success; likes connection of LTL to HTL; could continue measurements and process studies along the GLOBEC line; pick a different area because it is different and do a comparison; can't do both because too expensive; enigmatic (mystery) production in the GOA—hasn't been discussed at this workshop; likely the stratification may be responsible; production is very localized; Seward line is anomalously low production compared to other shelf regions;

Sue Saupé—need to link nearshore with offshore; habitat is important, including the intertidal; models don't well in the nearshore; edges are major part of the system

Dana Hanselman—stock assessment interests; would like to include LTL input into the SA process; lots of potential for forage fish – commercial fish interactions; need more information about many marine fish populations (natural history);

Chris Lunsford—need to improve observations, esp. of forage fish life history; recruitment is baffling in groundfish—they examine time series and look for relationships with their successful YC