Pacific Implementation Panel Meeting Report
Scripps Institution of Oceanography
La Jolla, California
November 15-16, 2004

Members attending: Ichiro Fukumori, Billy Kessler, Nate Mantua, Art Miller, Paul Robbins, Niklas Schneider, Dan Rudnick, Sumant Nigam
Member attending by conference call: Clara Deser
Members absent: Mike Gregg, Max Suarez
Guests: Bruce Cornuelle, Russ Davis, David Legler, Zhengyu Liu, Roger Lukas

1.After brief introductory comments by chairs Nigam and Rudnick, the meeting opened with a presentation by Legler on CLIVAR reorganization. The chairs of PIP were not informed of the reorganization until the afternoon preceding the meeting, and this presentation was new to PIP members. The ensuing discussion touched on a number of topics:

a. The receptiveness of agencies to advice from CLIVAR panels balanced against "adding value" to established agency programs.
b. The effect of the new organization as a new mapping. Instead of geographical panels, the new structure will be organized by objectives. For example, Pacific Decadal Variability as a topic of study will be split in the new structure, where it would have a natural home in the existing structure.
c. Coordination with the international panels will be an issue.
d. A number of questions were raised on how the reorganization would affect PIP initiatives that were to be the focus of the meeting.

2. Mantua made a presentation on Pacific Climate and Ecosystems. The following write-up was contributed by Mantua.

Three topics were discussed. First, the PICES/CLIVAR workshop on cross-scale interactions that was held on Oct 23-24 in Honolulu. Second, the NOAA Initiative to study climate impacts on North Pacific Marine Ecosystems. And third, the Bering Ecosystem Study science plan.

a. The PICES/CLIVAR workshop followed a week of PICES talks that covered many fishery oceanography topics, ranging from ecosystem shifts, climate impacts on the carbon cycle, to top-down versus bottom-up impacts on marine ecosystems. "Cross-scale interactions" was the theme for the PICES/CLIVAR workshop. The workshop was well attended, with ~40 fishery oceanography scientists, and perhaps 5 or 6 climate scientists that I would consider to be part of the CLIVAR community. Talks at this workshop again covered a broad collection of fishery oceanography topics, but in this case most were focused on regional scale biophysical interactions rather than basin scale evidence for ecosystem regime shifts. On each day an hour-long discussion period followed the talks, and on the question of "how can PICES and CLIVAR work together?" these possibilities were raised: i) CLIVAR scientists can collaborate with PICES scientists on studies aimed at better understanding the mechanisms linking environmental changes to ecosystem changes, primarily at regional and smaller spatial scales for many ecosystem studies, but also at large scales for understanding the biophysical interactions

controlling priimary production; ii) CLIVAR scientists can aid PICES studies by providing physical data for the subsurface oceans, namely observations and model simulated fields at spatial and temporal resolutions commensurate with ecosystem data.

Additional outcomes of the discussion periods were these two conclusions: i) there remains abundant evidence that climate variations exert very important influences on ecosystems, and that climate teleconnections often synchronize large and lasting ecosystem changes in very distant regions, yet the mechanisms causing the ecosystem changes remain largely unknown; and ii) perhaps too much emphasis has been placed on large scale, climate-driven, ecosystem regime shifts in the Pacific, and too little emphasis has been put on understanding the mechanisms linking ecosystem shifts with proximate environmental changes.

b. A "North Pacific Climate Regimes and Ecosystem Prediction (NPCREP)" program planning meeting was held September 13-14 at the Talaris Conference Center in Seattle. Attendees included Ned Cyr and Kenric Osgood, program managers from NOAA Fisheries headquarters in Washington DC that are now running what I believe they call "the climate office" for NOAA Fisheries. This was a relatively small, invite only science planning meeting aimed at revising the NPCREP science prospectus for this recently funded NOAA initiative. Organizers were Allen Macklin, Phyllis Stabeno, and Jeff Napp, all at NOAA/PMEL in Seattle. The study area is to be both the Bering Sea and Gulf of Alaska, with an emphasis on science to support fishery management in these two commercially productive regions. Very few attendees were from the CLIVAR/climate research community, and there ought to be an opportunity to link CLIVAR interests and activities with this newly funded program.

c. The recently published Bering Ecosystem Study (BEST) science plan outlines a multi-year research initiative that aims to improve the understanding for climate impacts on eastern Bering Sea marine ecosystems. George Hunt, from U.C. Irvine, is the planning group chair. The over-arching question to be addressed in this program is: how will climate change affect the marine ecosystems of the eastern Bering Sea? If this science plan results in a funded program, it seems like another potentially good partner for CLIVAR efforts to contribute to ecosystem impacts studies.

Mantua will also have an opportunity to speak with Ned Cyr in December, to discuss with him the CLIVAR PIP interests in building explicit ties between CLIVAR and NOAA supported Pacific ecosystem studies.

3. Davis and Cornuelle made presentations on the Consortium on the Ocean's Role in Climate (CORC). The objectives of CORC are to: (a) Add new observations to the Ocean Climate Observing System, (b) Utilize data assimilating models to define mechanisms of ocean climate variability, (c) Develop new methods and instruments to observe climate variability and change in the ocean. CORC began in 1992 with emphasis on abrupt climate change, forecasting climate variability, and Southern Ocean climate processes. CORC was headed by LDEO/SIO but including over 20 institutions. Over the years parts (and funds) of CORC were spun off into the IRI and the ECPC. Lamont and SIO started separate programs, with SIO focusing on improving the Ocean Climate Observing System, first with an emphasis on the Southern Ocean and more

recently on the Pacific.

In recent years, CORC has consisted of the following elements:

Augmenting Ocean Climate Observing System
- High Resolution XBT/XCTD Sections (Roemmich)
- VOS Surface Flux Transects (Weller)
- Surface Drifters for SST and Surface *U* (Niiler)
- Pre-Argo Profiling Floats in Equatorial Pacific (Davis)

Data-Assimilating Modeling
- Tropical Pacific (Cornuelle, Miller, Stammer)

Improving Observing Technology
- Underway CTD (Rudnick)
- Gliders for Boundary Currents (Davis)
- Improved CTDs for Profiling Floats (Schmitt)

Cornuelle offered detailed results indicating the success of the CORC equatorial model. The model will likely be valuable in planning the upcoming PUMP equatorial process study (see below).

4. Davis made a presentation on the Pacific Coastal Ocean Observing System (PaCOOS). While people care most about the climate of the atmosphere, ocean ecosystems are extremely responsive to the ocean's climate. The 55-year CalCOFI time series has exposed some of the mechanisms and impacts of climate variability in the California Current. PaCOOS, currently being planned by the NMFS, presents an opportunity to expand CLIVAR to study these important climate phenomena. The connection between species abundance and climate is now well-established, although the mechanisms remain elusive. A clear opportunity exists for CLIVAR to enhance its relevance by contributing to this important societal problem.

5. Lukas made a presentation on the Kuroshio Extension System Study (KESS). The following write-up was contributed by KESS PI Bo Qiu.

Endorsed by the US-CLIVAR Pacific Implementation Panel (PIP), the KESS program was funded by NSF in 2003 as a process-oriented collaborative research project in the Pacific basin. The observational program involves the PIs from WHOI (N. Hogg, S. Jayne), URI (R. Watts, K. Donohue), UH (B. Qiu, P. Hacker), and Univeristy of Hokkaido (H. Mitsudera). The overall goal of KESS is to clarify the dynamic processes governing the variability of the Kuroshio Extension and the recirculation gyre and to assess their roles in the coupled climate system. The detailed rationales and science plan of KESS can be found at: http://www.po.gso.uri.edu/kess/ .

In 2004, a new program named the Kuroshio Extension Observatory (KEO) was added to KESS with the support from NOAA. KEO is led by M. Cronin of NOAA-PMEL and one of its emphases is to provide a midlatitude reference site of surface heat fluxes for AGCM reanalysis products (for more details, see http://www.pmel.noaa.gov/keo/index.html). In this fall, a new

proposal (PIs: S.-P. Xie and B. Qiu of UH) to conduct atmospheric soundings across the Kuroshio Extension front was submitted to NSF-ATM. NSF is likely to make its decision in late 2004. If funded, atmospheric PBL measurements will be added to the 2005/06 KESS cruises.

The first KESS cruise took place from April 24 to June 19, 2004, on board of R/V Thompson. During the 2 legs, an array of 46 URI CPIES (Current and Pressure recording Inverted Echo Sounders), 7 WHOI MP (Moored Profiler) moorings, and 20 UH Apex/Argo profiling floats were deployed. The PMEL KEO mooring successfully set up at 145E and 32.5N. Also conducted during the cruise were the 125 CTD casts (58 of which was for a feature survey on the mesoscale driven cross-frontal flow)and numerous deep-reaching (~750m) ADCP transects crisscrossing the KE jet. All telemetered moored and profiling float data are being made public through the PMEL and UH websites:
http://www.pmel.noaa.gov/keo/index.html and
http://www.soest.hawaii.edu/snol/ .

With the start of KESS, considerable efforts have also been made by the US PIs and Japanese colleagues to enhance the scientific objectives put forth in the original KESS proposal. In 2004, 3 independent proposals have been submitted by Japanese colleagues to various Japanese funding agencies: Drs. K. Okuda and I. Yasuda proposed to study the variability and water mass formation in the Kuroshio Extension and recirculation gyre region; Drs. Y. Tanimoto, H. Nakamura and F. Kobashi, the ocean-atmosphere interaction across the Kuroshio Extension front; and Dr. M. Kubota, the ocean surface flux in the Kuroshio Extension region.

In addition to the observational program, Dr. J. McClean of NPS was funded by NSF in conjunction with KESS. Her study will focus on mesoscale eddy heat transport and along-isopycnal mixing in the WBC regions and comparisons will be made with in-situ KESS observations. Collaborations are also being sought by KESS PIs with Drs. H. Hurlburt and J. Metzger of NRL to compare NRL's 1/12 deg. Pacific HYCOM output to the KESS observations. The model will be used to provide broad-scale context for KESS and the in-situ measurements will be used to improve model parameterizations.

6. Robbins presented the International Nusantara STratification ANd Transport (INSTANT) program. INSTANT PI Janet Sprintall prepared the presentation. INSTANT is 3-year field program of 11 moorings that measure currents, temperature and salinity in the major inflow and outflow passages of the Indonesian Throughflow (ITF) between the Pacific and Indian Oceans. The ITF has an impact on the heat and freshwater budget and SST of the Pacific Ocean, although the size of the mass, heat and freshwater flux of the ITF is not yet well defined.

INSTANT objectives are to:

1) Determine full depth V, T, S of the ITF and its heat and freshwater flux
2) Resolve intraseasonal, seasonal and annual characteristics of ITF
3) Investigate storage and modification of waters in the internal Indonesian seas
4) Design a cost-effective, long-term monitoring strategy for the ITF.

INSTANT is an international collaboration of scientists from

USA (NSF Funded) - Janet Sprintall (SIO), Arnold L. Gordon, Dwi Susanto (LDEO)
Australia - Susan Wijffels (CSIRO Marine Research)
France - Robert Molcard (LODYC)
Netherlands - Hendrik van Aken (Royal Netherlands Institute for Sea Research)
Indonesia - Indroyono Soesilo (Indonesian Agency for Marine and Fisheries)

INSTANT field activities include deployment cruises in August 2003 (East Timor), December 2004-January 2005 (Indonesia), a turnaround cruise in June 2005, and a recovery cruise in Dec 2006. All moorings have ADCPs, and discrete current meters, p, T and CTD sensors. A shallow pressure gauge array deployed on either side of Timor, Lombok and Ombai outflow passages allows the estimation of the across-strait pressure gradient and the velocity/transport through geostrophy.

Discussion on INSTANT addressed the following issues: (a) combining in situ observations with satellite altimetry, (b) including a modeling component, and (c) making the new observed data widely available.

7. Fukumori made a presentation on ENSO modeling and prediction. Many ENSO modeling studies concern ENSO prediction using data assimilation. Issues include: (a) Univariate vs multivariate optimal interpolation, (b) Ensemble forecasts and Kalman filters, (c) Assimilation of such different observations as temperature profiles, SST, altimetry, ARGO. Existing studies are mostly (all?) ocean only assimilation. Many coupled ocean-atmosphere models no longer employ "flux correction", i.e., there is less bias in model. This is largely due to isoneutral mixing parameterization. Many existing data assimilation studies employ model configurations that are 5~10 years old. Intercomparison of data assimilation products is urged to understand pros and cons of different analyses. GODAE is identifying various metrics to facilitate such comparisons.

The ongoing efforts of the ECCO group were summarized. ECCO's goal is to advance data assimilation into an operational tool to help understand ocean circulation. ECCO includes scientists from JPL, SIO, and MIT. ECCO has recently been renewed as a GODAE project. ECCO-GODAE includes additional members from GFDL, NCEP and GSFC. One of ECCO-GODAE's objectives is to implement the ECCO assimilation system with ocean models employed in operational seasonal-to-interannual climate forecasting models of NCEP and GSFC. This fall, a new proposal was submitted to NASA to further extend such implementation to a coupled ocean-atmosphere model.

8. Schneider made a presentation on PDV diagnosis. Of the many hypothesis that have been advanced, it appears that the observed PDO is a response of North Pacific SST to atmospheric forcing due to intrinsic changes of the extra-tropical atmosphere, changes in the tropics teleconnected in the ocean and atmosphere, and changes in the Kuroshio Extension due the delayed adjustment of the ocean gyres. The relative importance of these forcings for the PDO is frequency dependent, at yearly time scales intrinsic variability of the Aleutian Low dominating, at interannual time scales ENSO and Aleutian Low being of equal importance, while at decadal Aleutian Low, ENSO and the KOE ocean response are on par. This implies that the research

into PDV has to focus on the processes that determine the low frequency variations in the tropics, the feedback of the atmosphere to changes in the extra-tropics, and the precise dynamics of the SST response in the Kuroshio extension.

A number of challenges were discussed:

• Clarify the heat budget in Kuroshio-Oyashio and its Extension: The processes that communicate the perturbation in the thermocline to the surface in the eddy rich frontal region of the Kuroshio-Oyashio extension are poorly constrained, in particular in course resolution coupled models.

• Determine and understand the response of storm track to changes in the heat budget of the western boundary, and the role for PDV of the coupling between SST and the atmospheric boundary layer, that appears ubiquitous in recent observations in frontal regions.

• Determine and document Southern Hemisphere counterparts to the North Pacific Processes.

• Determine the role of intrinsic oceanic variability in in exciting PDV

• Determine the causes of tropical decadal variability and the decadal modulation of El Nino Existing hypotheses include: tropical air-sea decadal 'oscillator', modulation of mean state,nonlinear processes intrinsic to ENSO,intrinsic ocean variability in tropics, stochastic forcing.

Observations should be continued and strengthened to quantify processes governing equatorial pycnocline depth, sharpness, temperature (spiciness),intensity of the subtropical cell the impact of N/S extra-tropics, in particular the relative roles of diabatic (Q, E-P) and adiabiatic wind stress forcing, for example for spiciness.

The following write-up on PDV modelling was contributed by Zhengyu Liu.

Climate models should play a much more important role in the prediction and understanding of Pacific climate variability, especially for PDV. Here are several areas:

a) Model-Observation Comparison: Where we are?

It is important to have a systematic evaluation of the status of our current modeling capability of PDV against observations and other models, as in the case of ENSO and global warming studies. This will help us know: where we are now. This concern provides one motivation for a proposed workshop.

b) Model-Itself: Strategy for understanding PDV: What we can do?

Even for model PDVs, for which we have perfect “records”, our understanding is poor for both its mechanism and predictability. This is the area we can make substantial progresses, because a model has the distinctive advantage of being able to design sensitivity experiments that provide definite answers to some key questions. In the current situation of limited data, this modeling knowledge will provide great stimulations and challenging to our thinking of the real PDV, and provides perhaps the best hope to truly enhance our understanding and prediction capability of PDV in our career time. This model capability also provides a motivation for the proposed workshop in 3). More specifically,

i) Models can generate long (~1000-year) simulations such that the statistics of the model PDVs can be extracted with statistic significance. This is particularly serious problem for observations on PDV, whose time scale is comparable with most observed climate variables.

ii) Models can be used to perform sensitivity experiments, or "geophysical experiments". This is critical, because PDV are so complex that it is impossible to isolate the causality based on the observation alone.

iii) Predictability: The only possibility for the prediction of PDV, if any, is through climate modeling. This is because the data are so short and incomplete that no statistic prediction is possible in the foreseen future.

c) Decadal variability Modeling Intercomparison Project (DMIP) Workshop:
As a result of 1) and 2), a decadal variability modeling assessment workshop is desirable, or using familiar terms, as the DMIP workshop. The objectives are two-fold, which can be divided into two phases.

DMIP Phase I: Control Simulations: Where we are now?
As a first step, following the AMIP-type activity, we would like to perform a systematic model-model intercomparison of the control simulations of several state of art CGCMs (e.g. GFDL, NCAR, COLA, MPI, CAC, JAPAN, UK). The focus will be on the major features of the PDV (or other variability). The key question for this phase is: how well current model reproduce PDV modes?

DMIP Phase II: Standard Sensitivity Experiments
For a subset of models that pass DMIP I, we propose to go beyond the AMIP-type activity by perform key sensitivity experiments that are designed to isolate potential key mechanisms for the model PDV. For example, the source for the memory of PDV can be tested with proper modeling surgery approaches.

d) Model-Field Experiment:
While observations help to improve parameterizations and in turn models, it is equally important to recognize that current models are sufficiently sophisticated to help the design and interpretation of field experiments.

9. Kessler made a presentation on the Pacific Upwelling and Mixing Physics (PUMP) process study, whose implementation plan had been completed in May 2004. Nigam led a discussion of the plan. PIP strongly approved of the plan, at the same time offering constructive criticism. The following summary of the panel's criticisms was contributed by Kessler.

a. Why is PUMP only interested in the cooling times of year, when the restratification and warming processes may be as important? The failure of models to reproduce the meridional structure might equally be due to poor representation of restratification as to mixing. (This applies to El Nino warming as well as the annual cycle). What observations/model experiments could be done to address this? Will the moored measurements that will be in place through both

warming and cooling phases sample the restratification well enough to diagnose it? Or does PUMP need to consider another IOP during February? In that case what observations would be needed?

b. PUMP has not considered the large-scale controls on the cold tongue annual cycle. It is well-known that the annual cycle propagates west as a basin-scale phenomenon (Mitchell/Wallace, Nigam/Chao, Liu, Chang/Philander) but 140W is treated as if it can be considered in isolation. The large-scale must have something to do with the cooling mechanisms, but these are barely mentioned in the SIP. This probably involves air-sea interaction/propagation mechanisms (e.g. Lindzen/Nigam), and PUMP needs to recognize that the drivers of the micro-scale may have macro-scale controls. What about the role of stratus decks and the resulting air-sea feedbacks? Although the observations need not be modified, the basin-scale physics must be discussed in the introduction, at least to make sure that the atmospheric community can see how PUMP fits in with what is known about the cold tongue. Additionally, mixing is only one of the theories for why CGCMs have a poor annual cycle. Can PUMP justify the hypothesis that mixing is the most important target for investigation?

c. What has PUMP learned from EPIC? How does PUMP differ from and build on EPIC? What is the connection between the far eastern Pacific situation and the central Pacific? (especially given the westward propagation of the annual cycle).

d. The plan is not an experiment that tests a hypothesis, but is exploratory/expeditionary. It is driven by the need to know rather than designed to sort out well-formulated competing ideas, hypotheses, or model representations of physical processes. It was noted that several hypotheses are in the document, but these should be highlighted in the introduction. In light of this, Clara Deser commented that the new NCAR CCSM3 CGCM introduces diurnal solar forcing of the ocean that dramatically modifies the ocean mixing, producing downward-propagating mixing into the stratified region below the mixed layer. This improves Nino3 amplitude compared to CCSM2. Clara offered to let PUMP authors compare fields from these two models runs, which otherwise have only minor differences. This is a potential gold mine for PUMP, if it turns out that this additional mixing is a major piece of getting ENSO right in a very high-profile national modeling project (used for the US IPCC estimates). Such an experiment would certainly catch the attention of the climate community. Kessler will be contacting Clara to start this investigation.

e. PUMP need to be more concrete about how it will promote development of the new mixing parameterizations. Why will a 4th mixing experiment make more progress in this area than the first three? PUMP is designed to elucidate the conditions/regimes that foster the generation of internal waves, but it was still thought that the path to using this information in developing parameterizations useful in models was not convincingly-enough laid out. Stating that PUMP will be using LES models is not specific enough to justify spending $20M. Can the PUMP prospectus include a hypothesis about the parameterization (or at least about its pattern/structure) that would guide the investigation (see 2c above).

f. A variety of questions were raised about the adequacy of our sampling strategy, expecially given the huge velocities due to TIW that will probably be the largest signal measured (velocity

and, likely, mixing or apparent mixing). It was thought that careful OSSEs will be essential to justifying spending this amount of money. (Schopf and Kessler have a proposal in to OGP now to do such OSSEs). Such OSSEs were strongly supported by the panel. It was suggested that a stringent test of our sampling strategy would be to see if, given the variables PUMP will measure, can the eddy diffusivity profile/structure be determined from a model sampled the same way.

10. Rudnick presented an overview of the Subtropical Ocean-Atmosphere Processes (SOAP) study, in its early planning stages. The subtropical ocean is the site of the downward branch of shallow meridional overturning cell (MOC). Thus the oceanic focus of SOAP is the diabatic processes that set initial water properties in MOC. The subtropical atmosphere is a region where air/sea interaction is dominated by winter storms. The atmospheric focus of SOAP is then boundary layer processes under strong wind.

SOAP ocean observations and modeling would focus on the mixed layer and the transition zone just beneath the mixed layer. The transition zone has been identified by the Eddy Mixed-Layer Interactions (EMILIE) CPT (cpt-emilie.org) as a key poorly parameterized region in the ocean. Targets for investigation include lateral fluxes in the mixed layer, and restratification processes. In climate models, restratification in the interior is usually accomplished by a Gent-McWilliams (GM) parmeterization, but the extension of GM to the surface is problematic. A partnership with the EMILIE CPT would help to ensure that field observations are targeted to improve parameterizations.

The transition zone is notable for being the location of the deep chlorophyll maximum, (DCM) perhaps the most well-known and important feature of the oceanic ecosystem. SOAP could sensibly address the key question concerning the existence of the DCM: What regulates the diffusive supply of nutrients to the euphotic zone? A linkage with the Carbon Cycle Science Program is natural, and must be pursued.

SOAP atmospheric studies will focus on the boundary layer in winds greater than 15 m/s, where flux parameterizations must be improved. The effects of surface waves and sea spray are key in under these conditions. A special concern will be gas transfer including the roles of bubbles and turbulence (again connecting with the carbon cycle). SOAP will also concentrate on the effect of SST on storm tracks, with the goal of understanding the interaction of synoptic and climate-scale phenomena.

An interesting aspect of air-sea interaction in the gyre is that subducted ocean conditions are disproportionately affected by the strongest late winter storm, as opposed to mean winter fluxes. This suggest a connection between synoptic atmospheric variability and ocean climate. A collaborator may then be THORPEX whose goal is the prediction of storms over the Pacific.

A tentative site is the eastern north Pacific (20-40°N). Such a site is desirable because of its relevance to North American weather and climate. The oceanic component of SOAP requires a region of strong eddy variability. While, for example, the Kuroshio has stronger eddies than the proposed site, the ratio of eddy to mean variability is larger in the eastern north Pacific because

mean flows are weak.

PIP discussion of SOAP focused on the importance of the subtropical ocean on various time scales. It was agreed that the subtropical ocean is relevant to climate on time scales longer than 10 years, but effects on shorter time scales are controversial. PIP recognized the importance of the processes to be studied in SOAP. Future steps for SOAP in a newly configured CLIVAR are an open question.

11. The meeting concluded with a discussion of future Pacific CLIVAR activities. There was a desire to see the two Pacific process studies PUMP (equatorial) and SOAP (subtropical) move forward, with PUMP staged first and SOAP second. A meeting focusing on climate and ecosystems is envisioned for summer 2005. Decadal changes of fisheries was one of the earliest motivators of climate research on the US west coast. The proposed meeting would likely be well-attended, especially if the regional effects of climate were emphasized.