APPENDIX F: BASS/MODEL WORKSHOP ON *"PERTURBATION ANALYSIS" ON SUBARCTIC PACIFIC GYRE ECOSYSTEM MODELS USING ECOPATH/ECOSIM*

Background

At the PICES Sixth Annual Meeting (October 1997, Pusan, Republic of Korea) the BASS Task Team sponsored a symposium on *Ecosystem Dynamics in the Eastern and Western Subarctic Gyres*. The purpose was to bring together available information on the two gyres in a comparative framework. Topics included: 1) ocean responses to climate forcing, 2) nutrients and primary production, 3) structure of the lower trophic levels, mesozooplankton communities and epipelagic nekton, 4) mid-water fishes, and 5) the importance of these areas to marine birds and mammals. Papers presented at the meeting were published in 1999, in a special issue of *Progress in Oceanography* (Vol. 43, No. 2-4).

A series of follow-up workshops was convened to identify potential models which might have utility for examining gyre systems. This included: the BASS Workshop on *Development of a conceptual model of the subarctic Pacific basin ecosystem* (October 20-21, 2000, in conjunction with the PICES Ninth Annual Meeting in Hakodate, Japan), the BASS/MODEL Workshop on *Higher trophic level modeling* (March 5-6, 2001, in Honolulu, U.S.A.) and the BASS/MODEL

Participants of the PICES BASS/MODEL Workshop (left to right): Salvador Lluch-Cota (CIBNOR, Mexico, local host), Bernard Megrey (Alaska Fisheries Science Center, U.S.A.), Francisco Werner (University of North Carolina, U.S.A.), Gordon McFarlane, Jacquelynne King (Pacific Biological Station, Canada), Kerim Aydin (University of Washington, U.S.A.), Ian Perry (Pacific Biological Station, Canada) and Jeffrey Polovina (National Marine Fisheries Service, U.S.A.). Not in picture: Michio Kishi (Hokkaido University, Japan), Takashige Sugimoto, Ichiro Yasuda and Sachihiko Itoh (University of Tokyo, Japan).

Workshop to *Review ecosystem models for the Subarctic Pacific Gyres* (October 5, 2001, immediately preceding the PICES Tenth Annual Meeting in Victoria, Canada). At these workshops, the BASS and MODEL Task Teams examined the feasibility of using the ECOPATH/ECOSIM modelling approach as a means to organize our understanding of ecosystems of the subarctic gyres.

The BASS/MODEL Workshop to test the baseline models developed at the March 2001 workshop, and refined at the PICES Tenth Annual Meeting, was held April 21-22, 2002, in La Paz, Mexico (See Endnote F1 for attendance). Specific objectives of the workshop were:

- synthesize all trophic level data in a common format;
- examine trophic relations in both gyres using ECOPATH/ECOSIM; and
- examine methods of incorporating the PICES NEMURO lower trophic level model into the analysis.

Review of baseline models

ECOPATH baseline models and the NEMURO model have been previously reviewed (PICES Scientific Report Nos. 17 and 21). The two ECOPATH models produced at that workshop should be viewed as work in progress. Estimates of biomass, productivity to biomass, consumption rate to biomass and diet composition were compiled from the literature and from research data provided by PICES member countries. In general, information available for 1990 (or 1990-1993) was used such that the two models could be viewed as representative of the early 1990s conditions. In total, 56 species groups (with three detrital groups) were included in the models, however, some species were not common to both regions. For example, Minke whales, common dolphin, Japanese sardines and anchovies were present in the Western Subarctic Gyre (WSA) model but not in the Eastern Subarctic Gyre (ESA) model. Conversely, elephant seals were present in the ESA model only. Many of the estimates are at best only guesses. Some observations were derived from coastal ecosystems and therefore may not be applicable to gyre ecosystems.

In general, the total biomass estimated for the WSA was higher than for the ESA. Major differences between the two model regions include higher biomasses of flying squid and Pacific pomfret in the ESA, higher biomass of chaetognaths in the WSA, and higher salmon biomass in the WSA (pink salmon) than in the ESA (sockeye salmon). Marine mammal biomass estimates were identical for each region since they were derived from basic-scale North Pacific estimates. No biomass estimates of forage fish and micronektonic species groups were available from the literature or from research survey data, so these were evaluated by top-down balancing of each model. Biomass estimates for lower trophic level plankton groups were derived from outputs of the NEMURO model that had been calibrated for Ocean Station P in the ESA.

NEMURO is a lower trophic level model (LTL) developed by the PICES MODEL Task Team during a modelling workshop held in Nemuro, Japan, in January 2000 (for details see Eslinger *et al.* (2000) and Megrey *et al.* (2000)). NEMURO simulates the annual dynamics of phytoplankton, zooplankton and nutrient concentrations for two locations in the North Pacific, Ocean Station P (57.5°N, 175°W) and station A7 (41.30°N, 145.30°E) off the A-line, an oceanographic sampling line off Hokkaido Island, Japan.

Ten years of output from the NEMURO model was used to supply "bottom-up" forcing to the ECOPATH/ECOSIM models, configured for each subarctic gyre system. NEMURO output from Ocean Station P was used to force the ESA ECOPATH/ECOSIM model, and output from station A7 was used to force the ECOPATH/ECOSIM WSA model. The model connection was a static one-way linkage.

Hypothesis testing

The purpose of this approach was to provide a "picture" of the two subarctic gyres, and to facilitate our understanding of how these systems respond to natural and anthropogenic change. It is hoped that it will form the basis of future work which will attempt to link the subarctic gyre systems to coastal systems.

A number of hypotheses were discussed as appropriate proxies to test the response of the two gyres to various trophic level changes and climate change scenarios. These were further refined into "Perturbation analyses" and "Function fitting and forcing".

Perturbation analyses

- Bottom up pulse

  Rationale: Increasing primary production could elucidate any bottom-up effects.

- Removal of squid

  Rationale: There is considerable confidence in the salmon diet composition for both gyres and discernible differences in the relative proportion of micronecktonic squid, forage fish and mesopelagic fish between the two gyre models. Since neon flying squid and boreal clubhook are probably competitors for micronektonic squid and forage fishes, their removal may have implications for prey availability for salmonids.

- Removal of salmon

  Rationale: Assuming that salmon abundance is determined outside of the gyre system, changes in abundance will greatly affect other trophic levels if salmon is a driving force within the gyre system.

- Removal of sharks

  Rationale: Sharks were selected as representative of a higher trophic apex predator.

Function fitting and forcing

Rationale: We were interested in investigating the changes that were required in productivity in order to explain changes in salmon abundance. Forcing functions at different trophic levels could be calculated by fitting the function to known salmon abundance data. We selected three trophic levels for which to fit foraging efficiency functions to salmon abundance trends, and then using the function to perturb the models: small phytoplankton, neon flying squid and sharks.

The results of these analyses will be available shortly in a PICES Scientific Report.

Endnote F1

Participation List

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