Exhibit H.2.c
Supplemental CPSMT Report
September 2001

Recommendations for Market Squid Management and Research

Coastal Pelagic Species Management Team Supplemental Report

Pacific Fishery Management Council Meeting
DoubleTree Hotel-Columbia River
Portland, OR 97217

September 10-14, 2001

Preface

The Coastal Pelagic Species Management Team (CPSMT) convened from August 14-15, 2001 to address management and research issues associated with the market squid (*Loligo opalescens*) resource off the California coast. The overall goal of this CPSMT meeting was to review information generated from the recently conducted Stock Assessment Review (STAR) session for squid held in May 2001. Specifically, the CPSMT focused on the following objectives during the two-day meeting: (1) develop consensus regarding important points concluded in the STAR Panel's Report; (2) determine if the suite of model configurations based on the *Egg Escapement* (EE) method could be further reduced into a tractable subset (Maxwell 2001); (3) further evaluate important parameters of the EE approach (e.g., population 'threshold' levels) in efforts to establish maximum sustainable yield (MSY)-based management schemes; and (4) develop sampling, laboratory, and analysis schedules that support the EE approach in particular, and also discuss the merits of gathering auxiliary data that would improve understanding of squid population dynamics. The following synopsis presents the CPSMT's recommendations.

Summary

First and foremost, the CPSMT generally supports the findings of the STAR Panel and in particular, its conclusion that the EE method can provide an effective framework for monitoring/managing the squid population in the future (see objective (1) in Preface). That is, the current port sampling program implemented by the California Department of Fish and Game (CDFG), along with newly developed laboratory and analysis procedures conducted by the National Marine Fisheries Service (Southwest Fisheries Science Center, SWFSC), will provide an objective method for establishing Maximum Sustainable Yield (MSY)-based management goals for the squid resource, e.g., for developing biological reference points. In practical terms, the EE approach can be used to evaluate the effects of fishing mortality (F) on the spawning potential of the stock and in particular, to examine the relation between the stock's reproductive output and candidate proxies for the fishing mortality that results in MSY (F_{MSY}). However, it is important to note that this approach does not provide estimates of historical or current total biomass and thus, a definitive yield (i.e., quota or Acceptable Biological Catch) cannot be determined at this time. Ultimately, the EE approach can be used to assess whether the fleet is fishing above or below an a priori-determined sustainable level of exploitation and in this context, can be used as an effective management tool. Reasons for adopting the EE method for monitoring/managing the squid population, rather than other analytical approaches (e.g., surplus production and depletion models), are presented in STAR (2001).

A critical underpinning of this recommendation is that the fishery continues to concentrate strictly on squid spawning grounds–the fishing fleet attracts mature squid using lights deployed during the evening hours. This *spawning-grounds* squid fishery appears to have the following characteristics: (1) historically, harvests have consisted almost entirely of mature animals that have had an opportunity to spawn, i.e., lay some or all of their eggs before capture; (2) recruitment and future catches in each fishing season largely depend on successful and adequate spawning in the preceding season; (3) the squid are determinate spawners, with potential lifetime fecundity fixed at maturity; (4) the squid die soon after laying their full complement of eggs, i.e., semelparous reproduction; and (5) interpretable, anatomical evidence of spawning must be able to be estimated from commercial harvest data, which can be routinely collected through an ongoing port sampling program. The fact that evidence of spawning can be derived from commercially landed specimens offers a unique opportunity to implement an EE method for fishery monitoring/management. Ultimately, estimates of past spawning, coupled with per-recruit analysis

theory, can provide the necessary statistics for determining the relationships between important equilibrium-based fishery descriptors, e.g., for determining how fishing mortality (F) influences residual eggs at time of capture, eggs per recruit, and EE.

Although the CPSMT is supportive of such an approach for this fishery and recommends beginning efforts for its implementation, there still exist areas of uncertainty that would greatly benefit from further evaluation. In this regard, the following areas of squid biology are only generally understood at this time and thus, were treated through 'sensitivity' analysis at the modeling stage: (1) maturation rate; (2) duration of spawning; (3) egg-laying rate; and (4) natural mortality rate.

The CPSMT recommends that the squid resource be formally reviewed again in 2004. Thus, a research/management sequence should be started for completion by early 2004. Important areas of work include: (1) rigorous monitoring of the landed catch for the occurrence of immature squid; (2) collection of fishermen logbook data that will allow changes in fishing techniques and success to be accurately measured; and (3) initiating studies that shed light on areas of squid biology still unresolved (see above). An extensive research/management list is presented in Maxwell (2001) and summarized in STAR (2001).

Finally, the following discussion (see Additional Notes) addresses pertinent decisions made by the CPSMT to develop a workable monitoring/management plan for the squid fishery based on the EE method, i.e., the STAR Panel (STAR 2001) provided general recommendations regarding analytical methods and left determination of specific model configurations and other management-related parameters to the CPSMT.

Additional Notes

The following discussion briefly describes technical decisions made by the CPSMT regarding the squid stock assessment conducted in 2001 in general and the EE method in particular (see Maxwell 2001). The discussion is partitioned into four general areas: (1) selection of a 'preferred' model scenario; (2) selection of a 'threshold' level of egg escapement (EE value) that can be considered a warning flag when tracking the status of the population; (3) fishery operations in (and after) El Niño/Southern Oscillation (ENSO) events; and finally, (4) necessary management-related constraints.

Preferred Model Scenario

The CPSMT largely relied on researchers familiar with squid biology to identify a 'preferred' (most plausible) model scenario from the suite proposed in the overall analysis. First, given that *model version 1* was the more general of the two proposed versions and adequately captured what is known (at this time) regarding the maturation schedule of this species, the CPSMT recommended that this version be focused on when deriving final estimates. Further, two important areas of squid biology that were treated in sensitivity analysis during modeling exercises included hypothesized rates of natural mortality (M) and egg laying (v). The CPSMT recommended that the preferred model scenario be based on $M = 0.15$ and $v = 0.45$ (both are daily rates), given: (1) data on the energetics of egg production and longevity of sexually mature adults indicate higher values of M are more likely than lower values; and (2) anatomical examinations of reproductive organs of young spawning females support egg-laying rates that are roughly equivalent to $v = 0.45$. It is important to note that rates of natural mortality (M), as well as fishing mortality (F), are generally believed to be much higher for this marine animal than that estimated for species of fish; however, mortality associated with squid should be interpreted in the context of this

species' life history strategy, namely, it's relatively short life span and associated high productivity.

Threshold Level of Egg Escapement

A 'threshold' level of egg escapement can be practically interpreted as a level of 'reproductive' (egg) escapement (EE) that is believed to be at or near a minimum level that is considered necessary to allow the population to maintain it's level of abundance into the future (i.e., allow for 'sustainable' reproduction year after year). It is important to note that a threshold level of egg escapement applicable to this species is not known in strict terms at this time (and likely not a fixed value on an annual basis), but rather, determined from evaluating general patterns of harvest observed in the squid fishery off California, as well as examining similar reference points relied upon in other squid fisheries as approximate guidelines. The CPSMT recommended that a threshold value of 0.3 (30%) be used initially, given: (1) a reproductive escapement threshold of roughly 0.4 (40%) has been used effectively in other squid fisheries (e.g., Falkland Islands fishery)–keeping in mind that the Falkland Island fishery harvests primarily juveniles; (2) not all of the squid spawning grounds off the California coast are subject to fishing pressure; (3) an existing weekend closure allows two days per week for spawning in the absence of fishing; and (4) the daily mortality of females during spawning is likely quite high.

Given the reasons above, it is certainly possible that a more appropriate threshold level is even lower than 0.3; however, the CPSMT does not recommend a lower level of egg escapement, given: (1) this is a new approach that should be monitored for some time before adopting a lower threshold; (2) there are some uncertainties about the retention of eggs in the females after capture; (3) there may be unevaluated fishery-dependent sources of mortality after spawning, such as fishing gear destruction of egg beds; (4) squid are members of a lower animal trophic level of the marine ecosystem and thus, play an important role as a forage species utilized by animals at higher trophic levels; and (5) sample data indicate that it is not likely that the recommended threshold will hamper the operations of the fishery as observed since the mid 1990s.

ENSO Events

The CPSMT deferred consideration of the effects of ENSO conditions on the squid population and ultimately, the fishery itself, until studies that focus on the influence of such oceanographic phenomena on squid abundance and distribution generate useful management advice. A consistent observation during such events is a temporary cessation of availability to the fishery. Although researchers generally believe this 'disappearance' is due to both reduced reproduction by the population and movement out of the established spawning grounds and into favorable habitat, the extent and magnitude of each response are not clearly defined at this time. Most importantly, there is no indication from the post-ENSO landings of long-term detrimental damage to the population's ability to sustain itself, i.e., the population has recovered relatively quickly following El Niño events. Although catches by the fleet dramatically decline during such periods and in effect, 'self-regulate' the fishery, the CPSMT cautioned that further restrictions on catch may be warranted in the future, given the broad impact that these oceanographic conditions have on many marine animal populations distributed along the U.S. Pacific coast.

Monitoring and Management Issues

Most importantly, the CPSMT concurred with the STAR Panel that the current squid fishery should remain under the immediate jurisdiction of the state of California (i.e., CDFG)–keeping in mind the

federal-based policies inherently in place for all U.S.-based fisheries. The newly adopted EE method should be considered a joint effort between the CDFG and NMFS (see Summary above). Additionally, sample data (e.g., catch-related statistics) are currently being collected by the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW), with the possibility that in the future, ODFW and WDFW, along with CDFG, may assist in collection of information directly related to the EE method.

The CPSMT recognized that the management measures already in place by the CDFG for the squid fishery are effective tools for controlling the amount of fishing pressure exerted on the population, e.g., weekend closures and protected (no fishing) areas along the coast. In this regard, the CPSMT recommended that management-related exercises that may be needed in the future (via the EE method, e.g., falling below a threshold of 0.3) be implemented by the CDFG using similar, but somewhat more rigorous, regulations as those in place currently. Finally, the CPSMT strongly recommended that the recent CDFG-proposed annual landings cap on the total harvest of squid be supported. This management measure should not be considered a trivial constraint, given many of the conclusions drawn from the overall squid assessment were based on past fishing practices of the fleet and the dynamics of the population may indeed change if subjected to uncharacteristically high catches (also, see *spawning grounds* squid fishery in Summary above for related point).

References

Maxwell, M. R. 2001. Reproductive (egg) escapement model and management recommendations for the market squid fishery. Summary Paper from *Stock Assessment Review (STAR)* Meeting, NOAA/NMFS/SWFSC, May 14-17, 2001. 27 p.

Stock Assessment Review (STAR) Panel. 2001. Report of the Stock Assessment Review (STAR) panel for market squid. Panel Report from *Stock Assessment Review (STAR)* Meeting, NOAA/NMFS/SWFSC, May 14-17, 2001. 18 p.