ECOSYSTEM-BASED MANAGEMENT INDICES AND INFORMATION
Ecosystem Goal: Sustainability (for consumptive and non-consumptive uses)

Total annual surplus production and overall exploitation rate of groundfish
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Description of indices: Total annual surplus production (ASP) of groundfish on the Eastern Bering Sea (EBS) and Gulf of Alaska (GoA) shelfs was estimated by summing annual production across all commercial groundfish stocks for which assessments were available (excluding flathead sole and Dover sole in the GoA). These species represent at least 70-80% of the total catch retained in bottom trawl surveys. Assuming that all biomass estimates correspond to beginning of year estimates (prior to when the fishery occurs), annual surplus production in year *t* can be estimated as the change in total adult groundfish biomass across species from year *t* (B_t) to year *t*+1 (B_{t+1}) plus total catches in year *t* (C_t, All estimates of B and C are based on 2004 stock assessments):

$$ASP_t = \Delta B_t + C_t = B_{t+1} - B_t + C_t$$

An index of total exploitation rate within each region was estimated by dividing the total groundfish catch across the major commercial species by the combined biomass at the beginning of the year:

$$u_t = C_t / B_t$$

Status and trends: The resulting indices suggest high variability in groundfish production in the EBS (Figure 135) and a decrease in production between 1978 and 2004 (slope = - 76,500 mt / year, t = -1.70, p = 0.101). Production in the GoA was much lower on average, less variable, and decreased slightly from 1978 to 2004 (slope = - 15,900 mt/ year, t = -0.80, p = 0.429).

Total exploitation rates were generally much higher in the EBS than in the GoA and were highest in the early part of the time series due to high exploitation rates of walleye pollock (Figure 136). Total exploitation has remained relatively constant in both systems from the mid-1980s to the present. Exploitation rates in the EBS reached a low in 1999 and have increased since, while they are near their long-term minimum in the GoA.

Because trends in annual surplus production are largely driven by variability in walleye pollock in the EBS and variability in walleye pollock and arrowtooth flounder in the GoA we computed ASP_t without these stocks included (Figure 137). The results suggest a strong, significant decrease in aggregate surplus production of all non-pollock species from 1978 – 2004 in the Bering Sea (slope = -30,000 mt / year, t = -8.64, p < 0.0001) and a similar decrease in surplus production aggregated across stocks (excluding pollock and arrowtooth) in the GoA over this period (slope = -3,300 mt / year, t = -3.27, p = 0.0032). These trends reflect decreases across many species and are not driven by the next dominant species alone. In the Bering Sea, surplus production of all species except Atka mackerel and northern rockfish has decreased from 1978-2004. In the Gulf of Alaska, long-term trends in ASP were less pronounced but declines were evident for 5 out of the remaining 9 species, while three species showed no obvious long-term trends and (besides arrowtooth flounder) only thornyhead production increased notably from the late 1970s to the 1990s.

Factors causing trends: Annual Surplus Production is an estimate of the sum of new growth and recruitment minus deaths from natural mortality (i.e. mortality from all non-fishery sources) during a given year. It is highest during periods of increasing total biomass (e.g. 1978-1985 in the EBS) and lowest during periods of decreasing biomass (e.g. 1992-2000 in the GoA). In the absence of a long-term trend in

total biomass, ASP is equal to the long-term average catch. Long-term declines in ASP and low production in recent years in the EBS are a result of low recruitment, reduced growth, increased natural mortality or some combination thereof. These declining trends suggest that substantial reductions in total catches may be necessary in the near future. It is unclear whether existing levels of precaution implemented at the single-species level will be sufficient to deal with declines in overall system productivity when trying to meet multi-species or ecosystem objectives.

Exploitation rates are primarily determined by management and reflect a relatively precautionary management regime with rates that have averaged less than 10% across species over the last decade. Exploitation rates are much lower in the GoA because of the very limited exploitation of arrowtooth flounder, which currently make up the majority of the biomass in the GoA. If arrowtooth flounder is excluded, rates are comparable to those in the EBS.

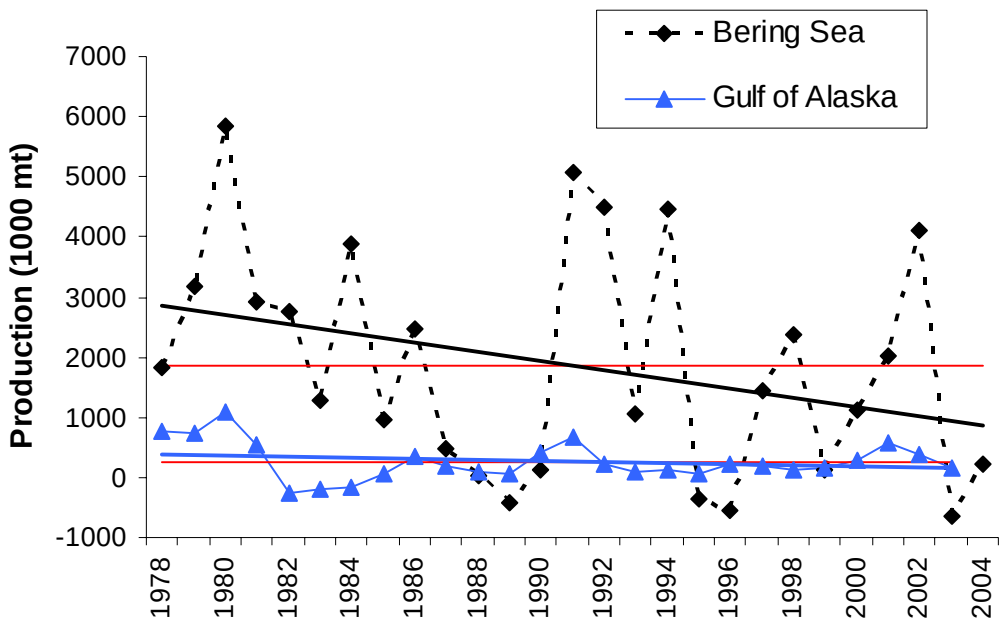

Figure 135. Total annual surplus production (change in biomass plus catch) across all major groundfish species in the Gulf of Alaska and Bering Sea with estimated linear trends (solid lines) and long-term means (red).

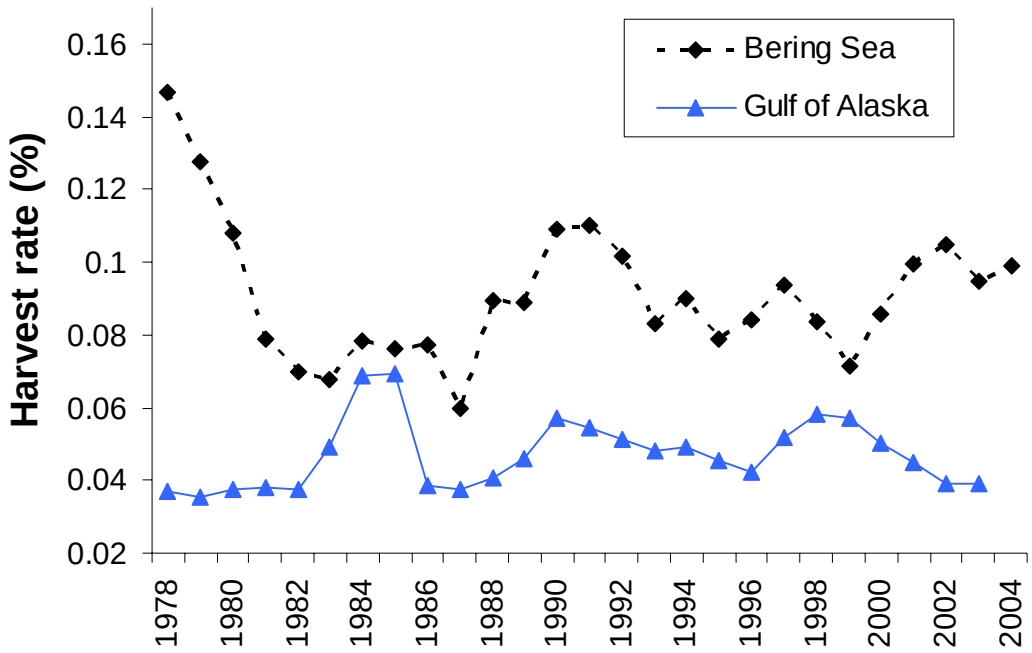

Figure 136. Total exploitation rate (total catch / total biomass) across all major groundfish species in the Gulf of Alaska and Bering Sea.

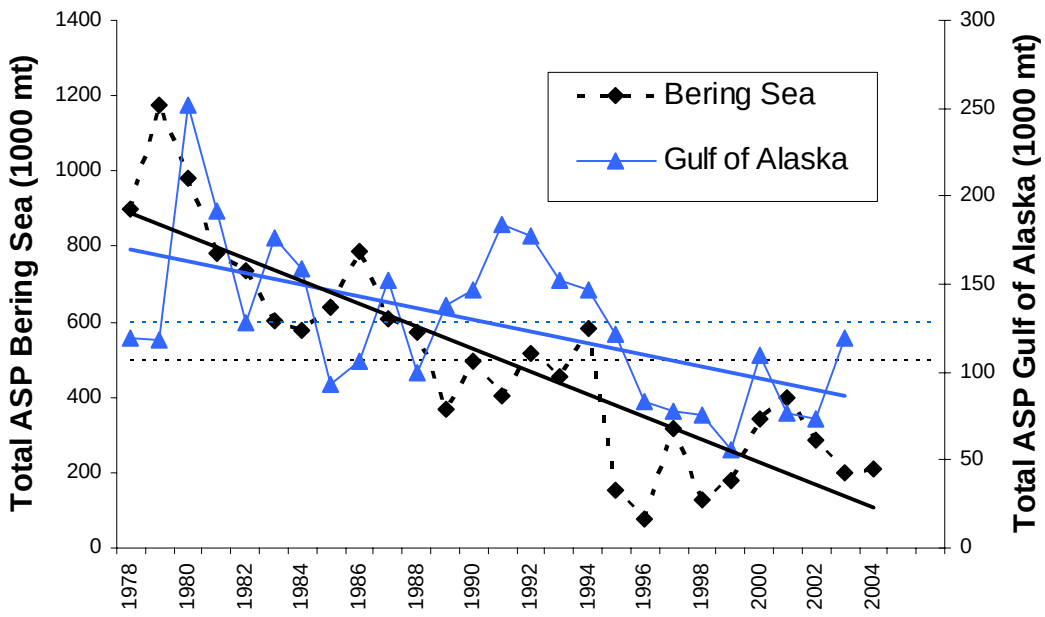

Figure 137. Total annual surplus production (change in biomass plus catch) across all major groundfish species excluding walleye pollock in the Bering Sea and excluding both walleye pollock and arrowtooth flounder in the Gulf of Alaska, with estimated linear trends (solid lines) and long-term means (dotted lines).