Unlike fish, crabs cannot be aged morphologically, and crab ages have to be approximated from growth information obtained from tagging data. Crab population abundances and catches in Alaska have fluctuated greatly over time (Zheng, Murphy & Kruse, 1995, 1996; Zheng, Kruse & Murphy, 1998; Kruse, Funk, Geiger, Mabry, Savikko & Siddeek, 2000). Commercial-sized red king crab (*Paralithodes camtschaticus*) population abundance in the Gulf of Alaska peaked in 1965 with a catch of 51,427 t. During the last 20 years, population size was a small fraction of abundances observed in the 1960s and 1970s, and fisheries on almost all Gulf of Alaska red king crab stocks have been closed since the early 1980s. Bristol Bay red king crab support the longest crab fisheries in Alaska with small commercial fisheries starting in the 1930s. Commercial-sized red king crab abundance in Bristol Bay peaked in 1979, and its fishery peaked in 1980, with a catch of about 59,000 t. Since 1982, annual catch of Bristol Bay red king crab has been less than 20% of its peak value. Adak red king crab produced an average annual catch of over 7,000 t from 1963 to 1972 and supported an average catch of less than 3% of that amount during the last 10 years. Tanner crab (*Chionoecetes bairdi*) catch in the Gulf of Alaska peaked in the 1970s with an average annual catch of 20,537 t, and most of these Tanner crab stocks have been closed for fishing since the early 1990s due to low population abundance. Eastern Bering Sea (EBS) Tanner and snow crab (*Chionoecetes opilio*) abundances and catches also experienced sharply up-and-down cycles, and both population abundances are currently at the low end of observed ranges.

Most crab population fluctuations are caused by recruitment variability. In a closed population, abundance increases through recruitment and decreases due to catch and natural mortality. When recruitment exceeds catch and natural mortality, the population abundance increases. If recruitment is periodic, as in Alaskan crab populations (Zheng & Kruse, 2000), population abundance increases quickly during a period of strong recruitment and peaks right after the poor recruitment period begins. Even without fishing, the population will decline if recruitment is less than natural mortality. Crab recruitment varies greatly over time. Among the crab recruitment indices calculated for 15 stocks in Alaska, corresponding to brood years 1963 to 1994, ratios of the highest to lowest recruitment for each stock ranged from 6 to 1697 and most ratios exceeded 29 (Zheng & Kruse, 2000). Periodic and variable recruitment causes fluctuating crab population abundances and creates unstable fisheries.

Most crab recruitment time series are not significantly correlated with each other (Table 1).

. Conclusions

Crab recruitment is likely to be a function of spawning biomass, fishing effects, larval survival, juvenile cannibalism, and predation. No single factor alone can consistently explain crab recruitment variation in the EBS, in part because most crab stocks have divergent recruitment patterns.

In this study, three climate forcing hypotheses on larval survival were addressed in relation to crab recruitment variation: (1) years of strong wind mixing associated with intensified Aleutian Lows may depress Bristol Bay red king crab larval survival and subsequent recruitment; (2) the shifts of spatial distributions of mature females of Bristol Bay red king and EBS snow crabs make it difficult to supply larvae to the southern ranges of their spatial distributions, affecting recruitment strength; and (3) winds from the northeast along the north side of the Alaska Peninsula promote coastal upwelling, serving to advect inshore-hatched Tanner crab larvae offshore in nursery areas of fine sediments. Support for the first hypothesis comes mainly from the general correspondence between strong red king crab year classes prior to the 1976/77 regime shift (period of weak Aleutian lows), and weak year classes since then (period of strong Aleutian lows) with the exception of a strong 1990 year class that also corresponded to a brief (1989-1991) period of weakened Aleutian low intensity. Support for the second hypothesis comes from the fact that snow and red king crab nursery areas (indexed by concentrations of juveniles) occur downstream of centers of distributions of adults and that, since the 1970s, adult red king crab shifted from southern to central Bristol Bay and adult snow crab shifted to the northwest along the middle and outer shelf; both shifts are downstream of prevailing currents in their respective regions. Finally, support for the last bottom-up hypothesis is attributable to a statistically significant relationship between the mean NE wind during the larval period (May-June) and subsequent Tanner crab recruitment, lagged 7 years corresponding to year of hatching.

Groundfish predation may play a very big role for crab recruitment success in the EBS. Yet, dynamic and divergent spatial distributions of groundfish and crabs over time may confound our ability to relate crab recruitment strength to groundfish biomass. Support for top-down control includes: (1) crab cohorts in the late 1960s were all strong for six stocks when groundfish biomass was low; (2) statistically significant relationships between Bristol Bay red king crab recruits and Pacific cod biomass and yellowfin sole biomass; and (3) large amounts of Tanner and snow crabs are consumed by groundfish. On the other hand, both snow and Tanner crabs had some strong year classes in the 1980s after groundfish abundance increased, and analyses of groundfish stomach indicate that too few red king crab are consumed to explain recruitment fluctuations. However, the former conflicting observation may relate to a lack of geographic overlap between groundfish predators and crab prey when groundfish initially increased (1980s) and the latter may relate to a lack of groundfish stomach collections in shallow nursery areas for red king crab.

Based on our exploratory data analyses, available evidence supports a mix of climate forcing and top-down control on EBS crab recruitment. However, these findings remain provisional until these hypotheses can be tested more comprehensively. To do so, we propose the following needed research. Field studies of groundfish predation on young juvenile king crabs are needed during spring in shallow waters of Bristol Bay and around St. Matthew and Pribilof Islands. Rather than additional correlation studies, computer simulations are needed to evaluate the role of ocean currents on crab larval distributions and settlement relative to nursery areas. Field studies are necessary to document relationships among climate indices, winds, *Thalassiosira* diatom abundance, and red king crab larval feeding success and survival and among surface temperature, abundance of *Pseudocalanus* copepod nauplii, and Tanner crab larval feeding success and survival in the Bering Sea to test the climate forcing hypotheses. Spatially explicit, multi-species models of groundfish predation effects on crabs based on their dynamic distributions may provide understanding of the top-down control on the crab recruitment in the EBS. Additional field studies on the location and habitat characteristics of crab nursery areas would strengthen the advection and predation modeling.

An expansion to previously low density habitat seems to be an important element of the population increase,

Recruitment Dynamics of Alaskan Crab Stocks

For more than three decades, population abundances and commercial catches of Alaskan crab stocks fluctuated widely, driven by highly variable recruitment. For most stocks, recent abundances are very low compared to historical levels. red king blue king Tanner (and snow (C. opilio) crabs in the eastern Bering Sea (EBS). Most crab recruitment time series are not significantly correlated with each other. Spatial distributions of three broadly distributed crab stocks (EBS snow and Tanner crabs and Bristol Bay red king crab) changed considerably over time, possibly related to shifts in regional climate and physical oceanography. Three climate forcing hypotheses on larval survival were proposed to explain crab recruitment variation of Bristol Bay red king crab and EBS Tanner and snow crabs. Some empirical evidence suggests that groundfish predation may play an important role in crab recruitment success. Environmental changes have caused major shifts in abundance and spatial distributions of groundfish predators, as well.

red king crab in Bristol Bay, Alaska. Estimated population abundance fluctuated greatly over time, increasing from the mid 1950s to the early 1960s, decreasing to the early 1970s, increasing to the peak at the late 1970s, and then falling off sharply in the early 1980s. The estimated abundance has stayed at a low level since the early 1980s and begun a slow recovery during the last few years. Natural mortality was estimated to be higher in the early 1980s than during other periods. High natural mortality coupled with high harvest rates and followed by low spawning biomass may have contributed to the collapse of the population in the early 1980s and its slow recovery. estimated that strong recruitment seems to be associated with intermediate levels of spawning biomass and extremely low recruitment related to low spawning stock. However, extremely strong and weak recruitment occurred successively over two separate periods.

From cold pools to cod: An environmental ratchet as cause of declines in Bering Sea Snow Crab

Authors: Armstrong, David; Ernst, Billy; Orensanz, Lobo; Livingston, Pat
Day: WednesdayTime: 11:00Room: Egan 5

Snow crab, opilio, comprise a major fishery in the Eastern Bering Sea (EBS) but have generally declined in abundance since the late 1970s. Prior to the major 1976 regime shift from a cold to warm stanza in the EBS, female snow crab were widely distributed and had very high abundance south of the Pribilof Islands (~ 57 N Lat). But over the period 1978-1985 centroids of female abundance propagated northward from about 58 to 60 N Lat (~220 km), and westward from 170 to 172 W Long and there is currently very little spawning biomass south of 58 N. To some extent, female snow crab distribution conforms to long-term spatial occurrence of the "cold pool" (bottom water < 2C) that seems to influence distribution of numerous species in the EBS community. Present circumstances imply a recruitment conundrum for EBS snow crab: given position of most female spawners and net direction of prevailing NW currents, there is little prospect for recolonization of the wider EBS south of 57 N. Concurrent to the northerly contraction of the female crab population (in response to warming bottom water?) has been expansion in distribution and biomass of cod (Gadus macrocephalus) and several flatfish species that are noted predators of very small (5-20 mm CW; age 1+) snow crab. Episodic recruitment of snow crab south of 58 N may be subject to intense fish predation until such time that abundance of those species declines or shifts farther south.

In estuaries of the Northeastern Pacific, Dungeness crab (Cancer magister) are abundant and compose a significant portion of estuarine biomass. The nursery role of complex littoral habitats for young-of-the-year C. magister is well documented, yet the ecology of subsequent age classes within coastal estuarine systems, and in littoral areas in particular, remains unclear. Anecdotal evidence suggests subadult C. magister (40 -130mm; 1+ and >1+ year classes) regularly utilize littoral habitats. subadult crab to make intertidal migrations y: Willapa Bay, WA. We found that subadult crabs undertake regular nighttime migrations into unstructured littoral habitats to forage and that energy derived from littoral sources subsidizes the large estuarine population of crab in Willapa Bay. Our results dramatically alter the perception of subadult C. magister as a predominantly sublittoral predator and underscore the significance of littoral habitats as important foraging areas.

sampled for Tanner and red king crabs throughout Glacier Bay Reserves in close proximity to each other were very different in the abundance of crabs. The majority of the Tanner crabs were in two reserves and most (73%) of the king crabs were in a small part of a single reserve. Both male and female Tanner crabs were widely distributed throughout Glacier Bay except for a large area at the entrance of Glacier Bay, which was devoid of Tanner crabs. this area is composed primarily of hard substrate. The lack of Tanner crabs in this area suggests that it might be a habitat barrier for adult Tanner crabs which could limit the exchange between Glacier Bay and nearby Icy Strait; connectivity between Icy Strait and Glacier Bay would be limited to the larval phase of their life cycle.

that Tanner crab demonstrate wide variation in movement patterns between individuals and some individuals move large distances. After two years, 29% of the tagged Tanner crabs had crossed the East Arm reserve boundary. In contrast, red king crab displayed coordinated movements on an annual cycle and, except for one individual, have not been found outside of the East Arm reserve.

Other presentations inclue shrimp in Florida, crabs in Bristol Bay, Chesapeak Bad n Californing and loster in the northeastern US, Florida and Hawaii.