Essential Fish Habitat project status report

Reporting date: 10/15/2010

Project number: 2010-05

Title: Productivity, habitat utilization and recruitment dynamics of Pacific cod

PIs: Laurel, Ryer, Stoner, Knoth, Parrish, Urban

Funding year: 2010

Funding amount: $42,800

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Project complete with manuscript in review:

Results: What is the most important result of the study?

Age-0 fish that successfully transition through early life stages may be the earliest reliable indicators of year class strength, yet few survey data are available to test these predictions for commercially important groundfish species in Alaska. Over the past five years, we examined trends in annual abundance, growth and mortality in age-0 Pacific cod (*Gadus macrocephalus*) across multiple fixed-site locations in two nursery embayments in Kodiak Island, Alaska, USA using beach seines (n=320 hauls) and baited cameras (n=410 deployments) (Fig. 1). The beach seine targeted age-0 fish in 2-4 m depth whereas the baited camera targeted older conspecifics (age 1 – 2) across a broader range of depths (2 – 20 m) adjacent to seine site locations. We used these survey data to address the following questions: (1) does post-settlement growth and mortality vary annually, and if so, (2) what processes control such variation? and (3) can bay-resident populations of age-1 and age-2 juvenile cod be predicted from age-0 abundance in the prior year or do post-settlement processes mask initial recruitment signals?

Question 1: The interannual abundance of age-0 recruiting to nurseries was highly variable, but variability was highly positively correlated among co-occurring gadids, age-0 saffron cod *Eleginus gracilis* (r^2 = 71%; Fig 2a) and age-0 walleye pollock *Theragra chalcogramma* (r^2 = 69%; Fig 2b). These patterns suggest a common mechanism regulates pre-settlement survival and/or successful delivery of larvae to coastal nurseries.

Question 2: Two notable trends emerged from the size and growth data. First, size-at-settlement was positively related to spring temperatures experienced by larvae, but more importantly, these differences in size were directly related to post-settlement mortality in the nursery (r^2 = 47%, p = 0.047; Fig. 3) i.e., larger fish in July were more likely to

survive to late Augusts in that year. Second, although age-0 density did not appear to impact mortality (Fig 4a) there was a negative impact on post-settlement growth (r^2 = 65%; Fig 4b), suggesting nurseries may have limited resources (e.g., habitat, food) and could be a population bottleneck in years of high age-0 abundance.

Question 3: The regression analysis of age-0 abundance on subsequent year class strength yielded mixed results. For Pacific cod, age-0 abundance significantly predicted age-1 and age-2 abundance ($p<0.05$ in all instances) and there was model improvement using late estimates of age-0 abundance from August compared to July. However, all the regressions were highly leveraged by the abundant 2006 year class in Anton Larsen Bay (h_{ii} = 0.76 – 0.93). The removal of this data point resulted in no significant relationship between age-0 and age-1 or age-0 and age-2 abundance ($p>0.05$). A more cautious interpretation is that age-0 estimates of low abundance (using beach seines) are reliable indicators of relatively low year class strength in subsequent years whereas abundant year classes may still be prone to high rates of mortality to be considered sound indicators of recruitment strength.

Conclusion: Collectively, these data suggest age-0 Pacific cod abundance is a reasonable predictor of year class strength of resident juveniles in nearshore habitats, but post-settlement sources of mortality (e.g., overwintering, predation, etc.) may be significant enough to consider the existence of additional critical periods in juvenile gadids resident to Kodiak coastal areas. Further studies will undoubtedly need to determine how the population dynamics of juvenile cod in coastal nurseries integrate with the broader population dynamics of the Gulf of Alaska. With additional time series data, an examination of parallels between coastal and offshore abundance data (e.g., age-0 seine data vs age-3 trawl data) will be one means of examining such links. In the mean time, the supporting vital rate information (derived in coastal nurseries) could be used for provisional estimates of growth and natural mortality where other such data are absent or assumed in the Gulf of Alaska stock assessment.

Associated manuscript:

Laurel BJ, Knoth B, Ryer CH (in review) Density-dependent growth, mortality and recruitment signals in age-0 gadids settling in coastal Alaskan nursery areas. Can J Fish Aquat Sci.

FIGURE CAPTIONS:

Figure 1: Sampling for juvenile Pacific cod caught by a) beach seine and b) baited camera across multiple fixed-site locations in Kodiak. The survey occurred over two sampling periods (mid-July and late-August) across 5 years (2006 – 2010).

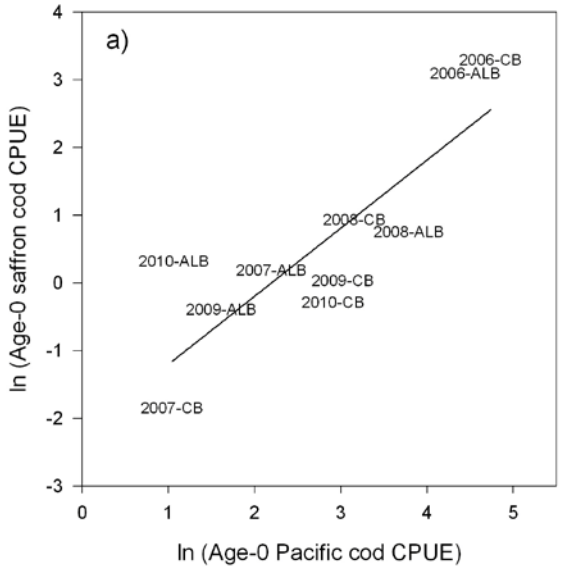
Figure 2: Interannual regional abundance of age-0 Pacific cod compared to a) age-0 saffron cod and b) age-0 walleye pollock during the same period and region. Data are based on seine catches of age-0 fish in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010).

Figure 3: Influence of settlement size on mortality in age-0 Pacific cod over a 6 wk period in two Kodiak nurseries areas. Size data (x-axis) are based on mean size of age-0 Pacific cod collected in mid-July in seines at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010). Mortality estimates are based on relative change in abundance (catch-per-haul) from mid-July to late August respectively

Figure 4: Influence of annual age-0 Pacific cod abundance on a) growth and b) mortality over a 6 wk period in two Kodiak nurseries areas. Abundance data (x-axis) are based on seine catches of age-0 Pacific cod in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010). Growth and mortality estimates are based on relative change mean length and abundance from mid-July to late August respectively.

Fig 1:

Fig 2:


a)
2006-CB
2006-ALB
2008-CB
2008-ALB
2010-ALB
2007-ALB
2009-CB
2009-ALB
2010-CB
2007-CB
ln (Age-0 saffron cod CPUE)
ln (Age-0 Pacific cod CPUE)

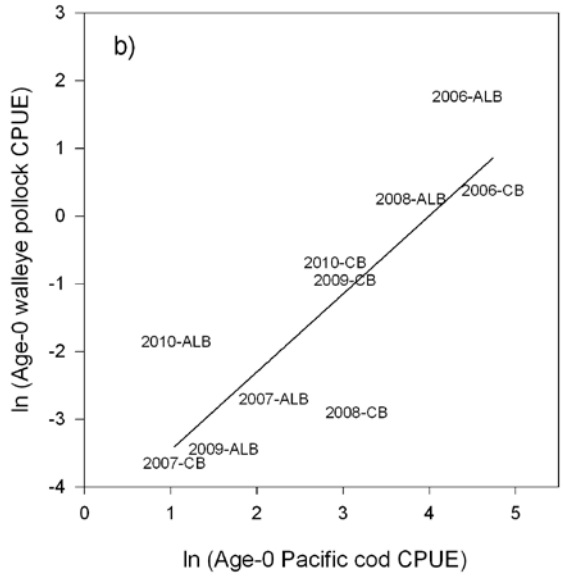

b)
2006-ALB
2008-ALB
2006-CB
2010-CB
2009-CB
2010-ALB
2007-ALB
2008-CB
2009-ALB
2007-CB
ln (Age-0 walleye pollock CPUE)
ln (Age-0 Pacific cod CPUE)

Fig 3:

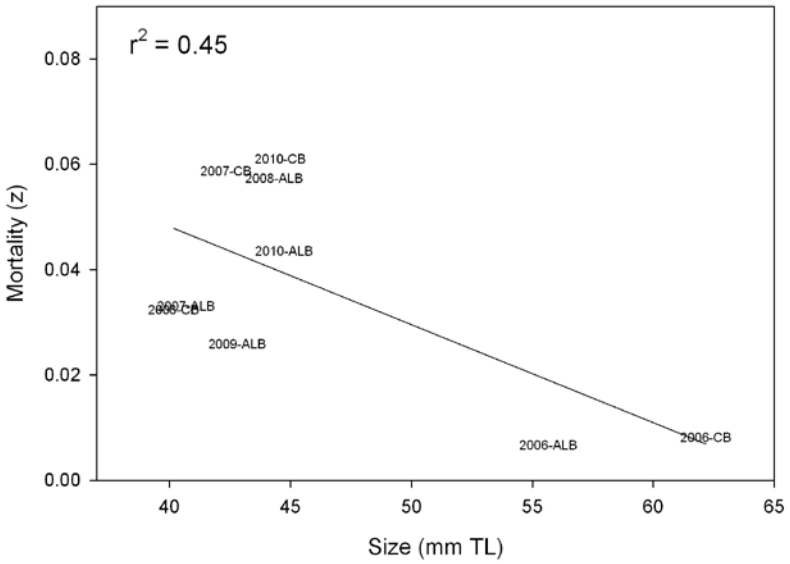
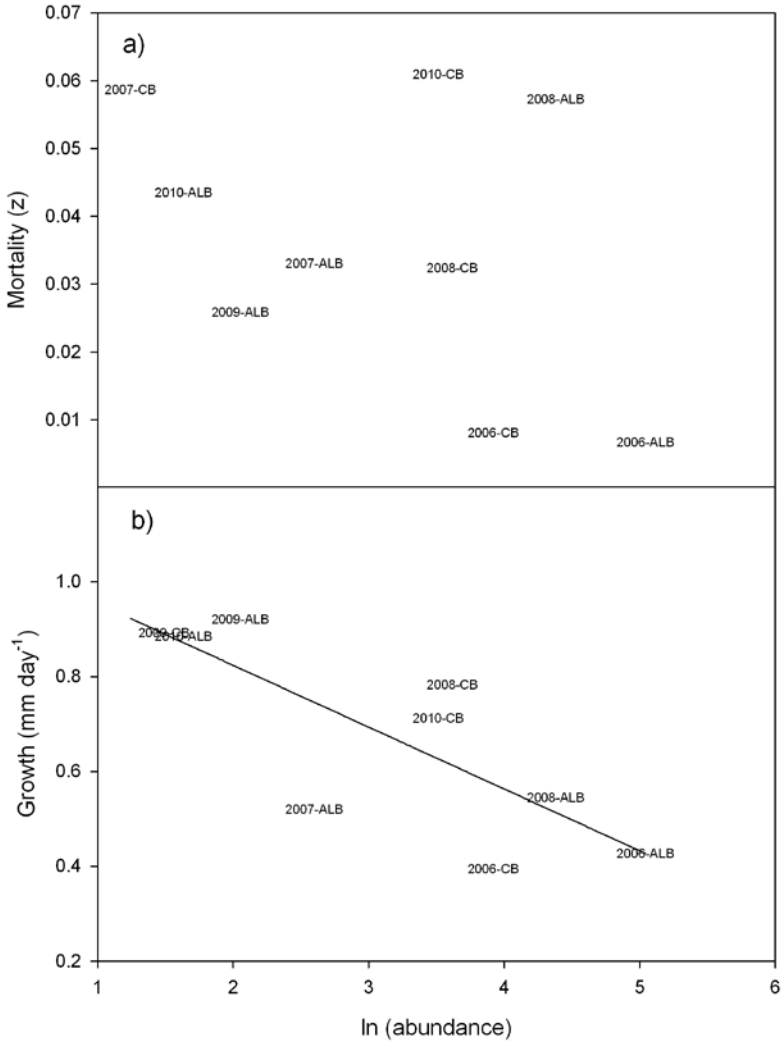

r^2 = 0.45
0.08
0.06
0.04
0.02
0.00
Mortality (z)
2010-CB
2007-CB
2008-ALB
2010-ALB
2007-ALB
2009-CB
2009-ALB
2006-ALB
2006-CB
40
45
50
55
60
65
Size (mm TL)

Fig 4:


a)
Mortality (z)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
2007-CB
2010-CB
2008-ALB
2010-ALB
2007-ALB
2008-CB
2009-ALB
2006-CB
2006-ALB
b)
Growth (mm day-1)
1.0
0.8
0.6
0.4
0.2
2009-ALB
2009-CB
2010-ALB
2008-CB
2010-CB
2008-ALB
2007-ALB
2006-ALB
2006-CB
1
2
3
4
5
6
ln (abundance)