NATIONAL MARINE FISHERIES SERVICE REPORT
FISHERIES SCIENCE CENTER ACTIVITIES

Update on Thiamine Deficiency Complex in California salmonids

TDC is an ongoing problem for Central Valley Chinook salmon. We documented some degree of thiamine deficiency in all CV Chinook salmon stocks in brood years 2020 and 2021. TDC was first detected by CV hatchery and fish health staff in January 2020 shortly after brood year 2019 fall-run eggs hatched, so this is the 3rd consecutive year that it has been an issue for Central Valley Chinook salmon. Samples from Trinity River and Iron Gate Hatcheries have not shown signs of thiamine deficiency in these years. The lowest egg thiamine values we have sampled came from brood year 2021 winter run Chinook salmon at Livingston Stone National Fish Hatchery. Based on a winter run survival study done by UC Davis on brood year 2020 winter run eggs and fry, we estimate a ~44% post-hatch fry mortality rate for naturally spawning brood year 2021 winter run Chinook salmon (adding to the already extreme temperature dependent egg mortality for this year class).

Multiple effective treatments for thiamine deficiency have been tested and are being used at varying rates at state-operated Chinook salmon hatcheries in the Central Valley and Livingston Stone National Fish Hatchery, but not at Coleman National Fish Hatchery, so impacts on hatchery populations should be partly mitigated. In contrast, treatment options for naturally-spawning populations may be limited to special cases where early migrating pre-spawn adults can be trapped, given thiamine injections, and then returned to the river as was done for Spring Run on the Feather River. We suspect that thiamine deficiency has negatively impacted early life stage survival rates for natural-origin Central Valley Chinook salmon from brood years 2020 and 2021.

Thiamine deficiency may be linked with the recent dominance of Northern Anchovy in the marine food-web that these salmon feed in. Our analysis found that anchovies have the highest lipid fraction and highest thiaminase activity level of five common prey items (krill, herring, market squid, juvenile rockfish, and Northern anchovy). Salmonid diets dominated by high lipid or high thiaminase activity prey have been linked with thiamine deficiency in salmon in the Great Lakes and Baltic Sea. Anchovy dominated gut contents of Chinook salmon caught in California's ocean fisheries in 2019, 2020, and 2021. The lack of other prey items (like krill, juvenile rockfish, squid, and herring) in salmon diets may be as important as the dominance of anchovy for accounting for thiamine deficiency.

Ocean surveys documented a dramatic increase in the Central California Northern anchovy stock from 2014-2021, with record high biomass estimated from Coastal Pelagic Species (CPS) surveys in 2019 and 2021. The NMFS summer CPS survey found that the spatial extent of the Central CA anchovy stock also expanded northward from 2017-2021, with the northern boundary near Monterey in 2017, San Francisco in 2018, Point Arena in 2019, and Cape Mendocino in 2021.

We have funding through 2022 for limited sampling and analysis of salmon eggs, salmon tissues for salmon diet reconstructions, and prey nutrition. With existing data and planned sampling in 2022, we hope to learn:

1. If naturally spawned eggs can be "rescued" from thiamine deficiency by taking in dissolved thiamine from water in natural spawning areas.
2. Whether some spawning streams/reaches are producing more or less thiamine than others.
3. If we can use adult salmon diet reconstruction through stable-isotope analysis of salmon tissues (muscle and eye lenses) to explain the observed patterns of variation in egg thiamine concentrations.
4. If different stocks of Central Valley salmon have different critical thiamine egg concentrations for impacting early life stage survival rates. We need to know this in order to translate egg thiamine concentration samples from hatchery stocks (where we can get egg samples) into predictions for population-level impacts on early life stage survival rates for hatchery and natural spawning populations.
5. If there is evidence for thiamine deficient water masses in the coastal ocean, and if we can connect dissolved thiamine concentrations to microbial communities in the ocean.

For more information, see:

Mantua, N., R. Johnson, J. Field , S. Lindley , T. Williams , A. Todgham , N. Fangue , C. Jeffres, H. Bell, D. Cocherell, J. Rinchard, D. Tillitt, B. Finney, D. Honeyfield, T. Lipscomb, S. Foott, K. Kwak, M. Adkison, B. Kormos, S. Litvin, and I. Ruiz-Cooley. 2021. Mechanisms, Impacts, and Mitigation for Thiamine Deficiency and Early Life Stage Mortality in California's Central Valley Chinook Salmon. North Pacific Anadromous Fish Commission Technical Report No. 17: 92–93, 2021. Available at https://npafc.org/wp-content/uploads/technical-reports/Tech-Report-17-DOI/28_Mantua-et-al.pdf

https://www.fisheries.noaa.gov/west-coast/science-data/monitoring-thiamine-deficiency-california-salmon
https://www.fisheries.noaa.gov/feature-story/researchers-probe-deaths-central-valley-chinook-possible-ties-ocean-changes

NMFS SWFSC Application for a MSA Scientific Research Permit

NMFS SWFSC is collaborating with UC Santa Cruz on a project to quantify thermal thresholds of Central Valley salmon. The scope of this research project encompasses developing a better understanding of how exposure to different water temperatures affects the survival of adult Chinook Salmon migrating to spawning grounds in the Central Valley of California. How thermal exposure affects the probability of mortality for salmon migrating to spawning grounds, the location and timing of exposure risk, and how additional environmental conditions influence the susceptibility of salmon being negatively impacted by thermal stress are important unanswered questions that will benefit fisheries management.

An important component of this project consists of capturing, tagging and releasing up to 200 adult Chinook salmon in the Pacific Ocean near the entry to the San Francisco Estuary at the Golden Gate Bridge. We will collect scales for age determination and fin clips for stock identification. Each fish will be measured for energy content with a microwave device, have a nonlethal gill tissue biopsy taken, then surgically implanted with an acoustic tag with a unique tag-code for each fish. The acoustic tag will allow for tracking individuals on their return migration from the Golden Gate Bridge, through the Delta and the Sacramento or San Joaquin River system. Acoustic tag detections will provide migration data that will be combined with high resolution flow and temperature data to allow for migration cost model simulations, building on earlier work we have done in this area (Martin et al. 2015)

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Martin, B. T., R. M. Nisbet, A. Pike, C. J. Michel, and E. M. Danner. 2015. Sport science for salmon and other species: ecological consequences of metabolic power constraints. Ecology Letters. doi: 10.1111/ele.12433

Concerns regarding Central Valley spring-run Chinook salmon status and response to drought effects

Multiple lines of evidence point to the potential for very low abundance for brood year (BY) 2020 Central Valley Spring Chinook (CVSC), which are listed as threatened under both the federal and California Endangered Species Acts. Natural-area spawning escapement of CVSC in 2020 was the third lowest since 2001 (PFMC 2021, Table B-3). Due to 2021 drought conditions, temperatures experienced during incubation by fall run stocks in the Central Valley were high and conditions during juvenile outmigration were very poor (C. Greene pers. comm., see Table J.2.2 of the CCIEA Report when available); CVSC were also very likely negatively impacted by these conditions. Survival estimates for tagged CVSC outmigrating in 2021 were lower than any of the other eight years available, worse than the 2015 drought year associated with very poor 2017 returns (C. Michel pers. comm., see https://oceanview.pfeg.noaa.gov/CalFishTrack/pageSEASON_2021.html). Ocean indicators for BY 2020 Central Valley Chinook were mixed (C. Greene pers. comm., see Table J.2.2 of the CCIEA Report when available). Therefore, it appears that 2023 fisheries (and to a lesser extent fisheries late in the 2022 management year) are likely to encounter a very weak BY 2020 CVSC cohort.

Due to a combination of data limitations and limited analytical capacity, fishery impacts on CVSC cannot be routinely estimated and therefore are managed using harvest management frameworks for proxy salmon stocks. Given patterns in ocean spatial distributions and run timing, age-specific ocean fishery impacts on CVSC are likely higher than those experienced by Sacramento River Winter Chinook (SRWC) but lower than those experienced by Sacramento River Fall Chinook (SRFC, Satterthwaite et al. 2018). Therefore, it is reasonable to assume that ocean fishery impacts on CVSC will covary with the planned ocean fishery impacts on SRFC and SRWC.

For salmon fisheries in the 2023 management year, allowable impacts on SRWC and SRFC will be driven by forecasts for BY 2021 SRWC and BY 2020 SRFC. The BY 2021 SRWC forecast will likely be higher than it otherwise would have been under similar conditions because Livingston Stone Hatchery targeted 2021 production of 550,000 fish versus its usual production of 200,000-250,000 fish to offset poor anticipated survival. In addition, the BY 2020 SRFC forecast will likely reflect all CDFW hatcheries transporting all of their BY 2020 fall Chinook production downstream before release, which is intended to avoid in-river mortality, and Coleman National Fishery Hatchery trucking approximately one million fish for the same purpose. In addition, hatchery-spawning fish from these two stocks were treated for potential thiamine deficiency (NMFS SWFSC 2021) whereas naturally spawning fish in the basin did not receive this treatment.

This creates the risk that the SRWC and SRFC forecasts informing 2023 salmon management will not reflect the impacts of poor environmental conditions on natural-origin productivity that CVSC are likely to experience. To better assess the likely magnitude of this risk, there is some technical work that could be done over the next year that could provide useful information to the Council for its 2023 deliberations. Information on the separate contribution of hatchery- versus natural-origin fish to both the SRWC and SRFC forecasts for 2023 compared to earlier years would be valuable in assessing the impact of atypical hatchery practices on the forecasts and resultant allowable exploitation rates. Refined ecosystem indicators specific to CVSC (including the yearling life history that may be more important for spring-run in drought years, Cordoleani et al. 2021) might better inform the incubation and ocean survival expected for BY 2020 CVSC, and provide a further refined sense of likely cohort strength when paired with information on parent spawner abundance and downstream migration survival.

References cited

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