NANCY LO RETIRES AFTER 38 YEARS

Processing samples aboard the *R/V Jordan* in the early 1980's.

Nancy C. H. Lo retired from Southwest Fisheries Science Center, National Marine Fisheries Service at the end of 2011 after 38 years of working as a biometrician in marine fishery science. CalCOFI has no greater friend or advocate. After receiving her PhD in statistics from Oregon State University in 1972, she worked as a statistical method analyst with the California Department of Fish and Game (CDFG), Menlo Park, California from 1973–76. In 1976, she and her family moved to San Diego to join the Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service as the mathematical statistician in the Marine Mammal Division even though she had never heard of La Jolla and knew nothing about porpoises. In 1980, she transferred to the Coastal Fishery Division (presently the Fisheries Resources Division), where she remained for the rest of her career. The Fisheries Resources Division is the federal partner in the CalCOFI program. The Division has the responsibility of ensuring that the information collected by the CalCOFI surveys is in a form that can be used directly in the management of fishery stocks. Consequently much of her work was closely tied to CalCOFI, focusing on analysis of plankton survey data and quantification of new survey methodologies so that fish egg and larval data could be more effectively used to monitor the relative abundance of commercial species, and interpret their life history. Her research included application of statistical techniques to fishery and marine mammal biology: sampling schemes of fishery-independent sea surveys; estimation of biological parameters; and spawning biomass estimates, in particular using the daily egg production method (DEPM) for coastal pelagic species (CPS), which has been an input time series to the stock assessments of northern anchovy and Pacific sardine.

To improve survey efficiency, Nancy developed an adaptive allocation survey design for Pacific sardine DEPM-ichthyoplankton-trawl surveys, using the Continuous Underway Fish Egg Sampler (CUFES) developed by David Checkley. This design requires only a fraction of the ichthyoplankton tows that would be required by the traditional fixed-station design to achieve the same precision of the estimates of parameters used in the DEPM spawning biomass. Data from CUFES provide an instant spatial map of CPS eggs during the survey.

In addition to DEPM spawning biomass of CPS, she collaborated with other scientists to estimate vital rates of anchovy and sardines: mortality, growth rates of each life stage, fecundity rates, and to evaluate the sensitivities of changes in vital rates on the population growth of anchovy and sardines using the stage-specific matrix model. She strongly believes that through the vision of CalCOFI and it's founding ecosystem and oceanographic principles, the CPS populations of the California Current are now monitored to prevent population collapses, like Pacific sardines in the late 1950s, that led to the formation of CalCOFI. Nancy Lo had also constructed long time series of daily larval production for other species, like hake and Pacific mackerel.

At the SWFSC, laboratory experiments have been conducted for CPS, primarily for anchovy and sardine prior to the 1990s. Nancy developed automation procedures for temperature-dependent stage-to-age and yolk-sac larval growth for anchovy based on data collected from laboratory experiments conducted in 1981. These new methodologies attracted international attention, particularly in countries where monitoring sardines and anchovy stocks had a high priority. This stage-to-age model is now being used and/or modified for sardine and anchovy in other parts of the world, e.g., Korea, Mexico, Peru, Chile, Australia, Spain, Portugal, and Greece. Lo also found that the early larvae of anchovy do not have constant instantaneous mortality rates. As a result, the exponential survival curve was not applicable and an age-dependent survival curve has since been used.

Nancy Lo on the balcony of the original SWFSC building in 2012.

Nancy explored methods other than plankton-based surveys for monitoring the relative abundance of fishes. In 1995, working with Jim Churnside and John Hunter, she explored the feasibility of an aerial survey using lidar (light detecting and ranging) by developing a model to evaluate such a survey approach. She also developed time series data from aerial surveys from com-

mercial spotter pilot logbooks for anchovy, sardine, and Pacific mackerel to construct long time series of relative abundance from 1963-early 2000s. This survey was not statistically designed but has been very useful as a population index. Another area of survey science where Nancy made major contributions was the rescue of long-term time series. Such work involves extending present time series accurately into the past through all the changes in equipment, methodology, and survey pattern that inevitably occur, e.g., extrusion and avoidance of fish eggs and larvae for bongo nets which replaced the 1-m ring nets used by CalCOFI surveys prior to 1978.

Nancy has consistently demonstrated that fishery-independent ichthyoplankton surveys like the CalCOFI surveys are a treasure of information, often on topics that were not part of the original goals, and she has been an advocate and leader over the years to promote the Cal-COFI approach worldwide, e.g., the around-Taiwan ichthyoplankton surveys (aka TaiCOFI) from 2003–present, DEPM sardine and anchovy surveys from 1996–2006 in Chile, the ichthyoplankton survey in Ireland in early 2000s, and the Korea-U.S. ichthyoplankon sea surveys (KISS) from 2004–08.

While the CalCOFI ichthyoplankton survey is one of the longest time series in the world, budget reductions have resulted in reductions of areal coverage from central or southern Baja California through central or northern California from 1951–84 to only southern Califor-

nia since then, and a reduction in sampling frequency from monthly to quarterly after 1984. Luckily, the IME-COCAL (Investigaciones Mexicanas de la Corriente de California) survey has been conducted quarterly since October 1997, similar to the current CalCOFI survey schedule and covers the area from the U.S.-Mexican border to Punta Eugenia. Data from IMECOCAL will fill some gaps of the current CalCOFI data. Regardless, the time series from the CalCOFI survey can serve as indices of abundance of fish populations.

Nancy indicated that retirement was a hard decision. She will miss her statistical applications to fishery problems and interactions with staff members of SWFSC and scientists around the world. In addition, she noted she will miss the white-water, oceanfront office that has been her home for over 30 years. However, she feels strongly about passing the baton to the younger generation to carry out projects with new statistical approaches to long-standing fisheries problems. Nancy's greatest contribution will always remain her integrity and fierce defense of quality science as embodied in the CalCOFI program. She has been a role model and an inspiration to several generations of young scientists. As Nancy once noted, being an Asian woman working in statistics and fisheries science, she is an outlier in every respect, and it is the outlier that has the disproportionate influence in most analyses! Nancy will be greatly missed by the CalCOFI community.