INTRODUCTION: An Egg Production Method for Anchovy Biomass Assessment

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Fishery scientists engaged in estimating the size of free-swimming populations have never had a technique available to them whereby all the parameters could be estimated from a resource survey and where no parameter values need to be assumed. Recognizing the need for a technique of this kind, the staff of the Coastal Fisheries Resources Division of the Southwest Fisheries Center (SWFC) devised an egg production method for anchovy biomass assessment. Previously, anchovy biomass was estimated by approximate methods derived from a long-time series and anchovy larval abundance, which required about 5 mo of shiptime each year to integrate the area under a seasonal spawning curve. One major assumption used in the larval abundance census method is that there is constant proportionality between larval numbers and spawning biomass. This has now proved to be erroneous.

The chief advantages of this egg production method are: 1) it yields an instantaneous estimate of egg production and spawning biomass requiring a single cruise with one or two ships, and 2) each factor in the biomass estimate is formally derived with estimates of precision. The major disadvantage of the method is that eggs are patchier and represent a shorter time period than larvae. This requires that numerous samples be taken to improve precision. Each sample must be small to reduce variance and to limit the time needed to sort out the eggs, and the entire spawning area should be encompassed by the cruise to detect the geographic edge of spawning.

This egg production method is based on an original finding by Moser (1967) that postovulatory follicles can be seen and used to determine time of spawning in rockfish. Hunter and Goldberg (1980) and Hunter and Macewicz (1980), following upon this suggestion, developed criteria for ageing postovulatory follicles in anchovy and hence the frequency of spawning of natural populations. This was confirmed in the SWFC aquarium using Leong's (1971) laboratory breeding anchovies. Thus incidence of females with postovulatory follicles or hydrated eggs could be used as a measure of spawning frequency. Parker's (1980) model, in which all parameters can be estimated, uses an estimate of egg production divided by the product of batch fecundity and the proportion of females in the mature stock, and accounts for the fact that spawning in anchovies is relatively continuous. Estimates of egg production are derived from direct plankton net sampling using a net designed by Smith and modified by Flerx (see Smith et al. 1985). Smith conceived the idea of sampling small numbers of eggs, and guided the procedure at sea each year since its inception, 1980-84, at the SWFC. Lo (1985) developed analytical procedures to estimate the natural mortality and the contagious distribution of the eggs. Moser and Ahlstrom (1985) developed the criteria for staging the eggs.

Besides an estimation of biomass, the application of this technique provides a great deal of information heretofore unobtainable on the natural history of anchovy populations. For example, we now can determine the mortality rates of eggs and early larvae and we have shown that multiple spawners can spawn as many as 20-30 times in a season. The biological rates we measure appear to be much more dynamic than we had supposed; egg mortality has differed greatly from year to year as has fecundity and spawning frequency. Together these new findings have given us an insight we did not have before into the potential for recruitment in fish populations.

It is our belief that the egg production method may also be the technique of choice for determining the spawning biomass of other multiple spawning pelagic fish, particularly clupeoids, (e.g., sardine, anchovy, and menhaden). Thus this volume is intended to be a guide to fishery scientists in applying the method to their own species. We have provided the theoretical basis and described the

operational aspects of the method as we have used it to determine the spawning biomass of the northern anchovy, *Engraulis mordax*, for the last 5 yr in the waters off California and Baja California, Mexico.

There are several important criteria which must be met before this egg production method for biomass estimation can be used. The fish must be a multiple spawner, and its eggs must be pelagic. The eggs must be caught by a plankton net in the upper layers of the ocean without significant losses by extrusion. Spawning and nonspawning adults must be equally available to a trawl or similar sampler. Application of this technique to other fish may require modification to fit the biology of the species and circumstances of sampling and capture.

This manual provides a description of the biomass model and its mathematical parameters; a physical description of the parameters themselves, e.g., eggs and spawning adults; and information on the field methods as we have applied them to determining the spawning biomass of the northern anchovy.

The various steps of the egg production method for determining northern anchovy biomass, as they are done at La Jolla, are charted in Figure 1.

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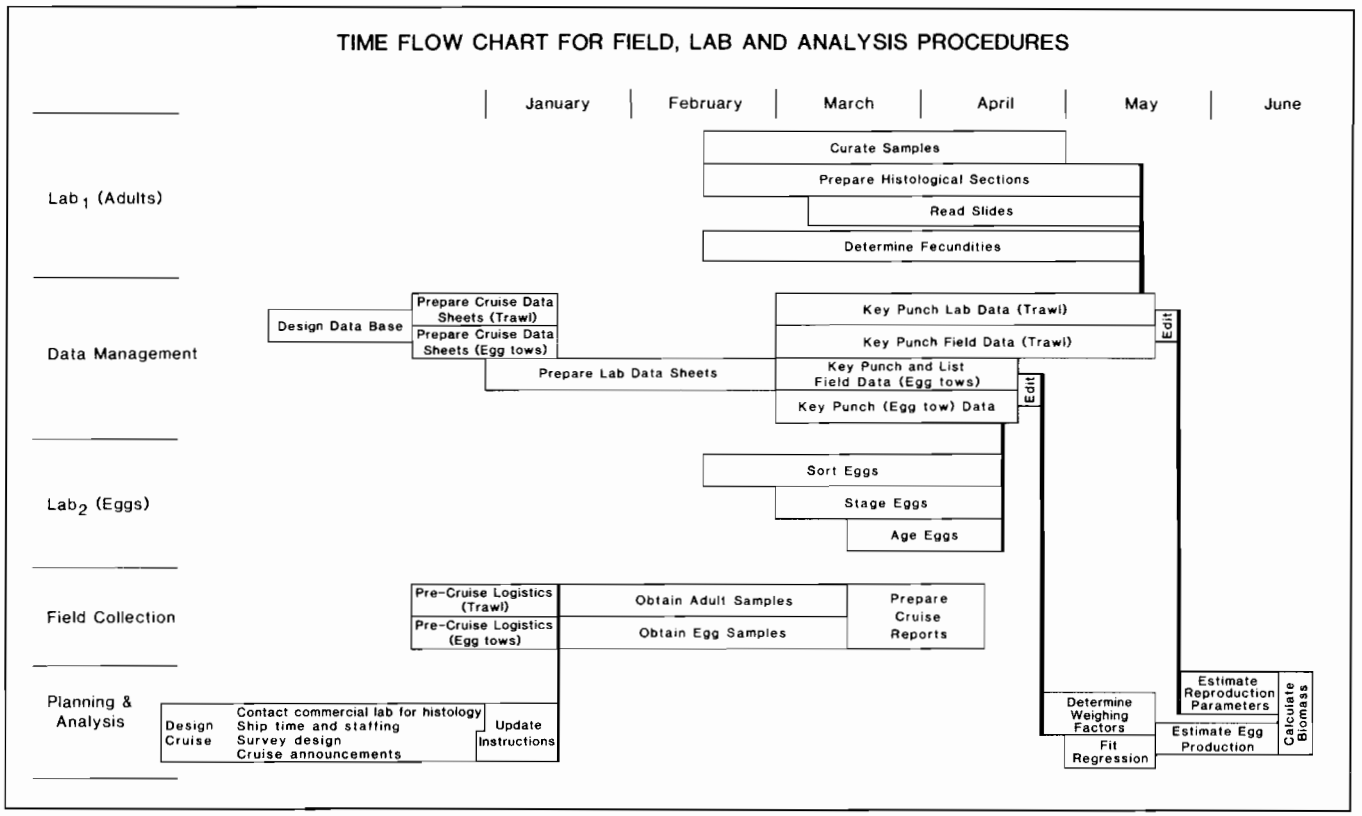

Figure 1.—Time flow chart for field, laboratory, and analysis procedures.