A Model for Temperature-Dependent Northern Anchovy Egg Development and an Automated Procedure for the Assignment of Age to Staged Eggs

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ABSTRACT

A functional relationship between age and developmental stage of northern anchovy, *Engraulis mordax*, eggs for various temperatures was determined based upon data collected in two laboratory experiments. The age of an egg was found to be a mixed exponential and power function of temperature and stage. An automated procedure was also developed using a reference table to assign age to staged eggs for any given time of tow and sea temperature ranging from 10° to 22°C. A comparison between the manual system and the automated procedure was made based on 1980-83 data, and the difference was found to be minimal.

INTRODUCTION

In the first section of this paper, I discuss the modelling of temperature-dependent anchovy egg development based on data from two laboratory experiments conducted at the Southwest Fisheries Center (SWFC). This temperature-dependent egg development curve is used to assign ages to the field-collected eggs after they are staged according to their anatomical development. In the second section, I discuss an automated procedure for accomplishing the assignment of ages.

TEMPERATURE AND DEVELOPMENT

Both laboratory and field-collected anchovy egg data indicate that the developmental rate of eggs is temperature-dependent. The higher the temperature, the shorter the time required to reach a given stage. The relationship between the age of eggs and temperature for a given stage has been studied in the past (Zweifel and Lasker 1976; Zweifel pers. comm.[1]) and a Gompertz growth curve fitted to the laboratory egg development data of both anchovy and sardine.

To improve our knowledge of the relationship between temperature and development of anchovy eggs and yolksac larvae, in 1981 a laboratory experiment was conducted at three temperatures (13.5°, 15.0°, and 16.5°C) using eggs from a captive brood stock (Lo 1983). These egg data were used along with those collected at temperatures ranging from 13.8° to 20.8°C for stages III, VI, VIII, IX, and XI in an earlier experiment to develop a revised model for expressing the development of anchovy eggs at a given temperature (Table 1). Stages are described by Moser and Ahlstrom (1985), and procedures for sorting and staging eggs by Stauffer and Picquelle (1985).

Table 1.—Average age (in hours.minutes) of northern anchovy eggs for each of 10 developmental stages (Stage I not observed) at various temperatures (°C) from laboratory experiments conducted at the SWFC.

	Temperature (°C)								
	(Lo 1983)			Zweifel and Lasker (1976)					
Stage	13.9	15.2	16.2	13.8	15.2	16.6	18.0	19.4	20.8
II	6.82	6.42	6.40						
III	16.36	13.55	13.14	20	15	10	9	8	6
IV	24.91	21.12	20.18						
V	35.88	30.7	25.56						
VI	44.63	39.24	33.20	42	35	26	24	21	9
VII	49.64	47.13	38.56						
VIII	52.5	52.07	43.64						
IX	61.1	56.28	50.48	58	50	39	35	33	28
X	66.09	62.63	54.78						
XI	69.79	65.65	56.10	78	65	55	44	39	35

MODEL DEVELOPMENT AND RESULTS

To choose an appropriate model for the relationship between age and temperature for a particular stage, I examined the age-temperature relationship empirically for stages III, VI, VIII, IX, and XI, because data on these stages were available for a wide temperature range (data for stages VIII and IX were combined to increase the sample size).

[1] J. R. Zweifel, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149, pers. commun. July 1983.

In: R. Lasker (editor), An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36. U.S. Dep. Commer., Wash., D.C., 99 p.

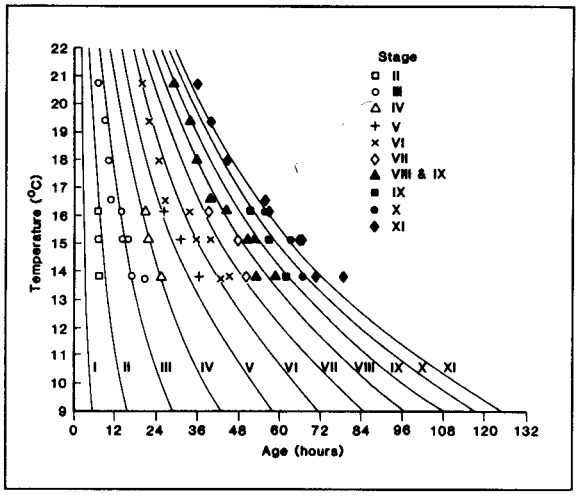

Figure 1.—Observed (denoted by various symbols) and predicted ages (smooth lines) of time to the *i*th stage as a function of temperature (°C) based on egg development data collected from two laboratory experiments conducted at SWFC. The predicted values are computed from Equation (4).

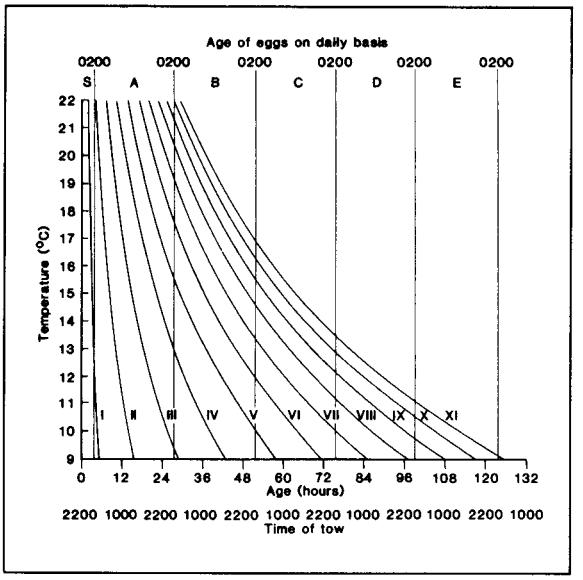

Figure 2.—Function relationship of average age of eggs for the *i*th stage based upon time of tow and sea surface temperature (°C).

For all four stages, the exponential function fitted the data well, i.e.,

$$y_{i,t} = a_i e^{b_i t} \quad (1)$$

where $y_{i,t}$ is the average age of the *i*th-stage anchovy eggs at temperature t°C. The coefficients ($a_i b_i$) are for the *i*th stage only. The initial fitting of the model was accomplished by linear regression of the natural logarithm of the ages on the temperatures ($\ln y_{i,t} = \ln a_i + b_i t$). The coefficient of determination (R^2) ranges from 0.82 to 0.98:

Stage	$\ln a_i$	b_i	R^2
III	5.02	−0.155	0.95
VI	5.50	−0.126	0.82
VIII, IX	5.54	−0.107	0.95
XI	5.88	−0.113	0.98

Next, the development data were examined for a given temperature where ages were available for most of the stages. In this analysis, only the latest laboratory data were included because the other data set had only four or five egg stages. The temperatures used were 13.9°, 15.2°, and 16.2°C (mean temperature experienced by all egg stages). For each of the three temperatures, the development curves were more complicated than time-to-stage curves described above. A simple exponential function was not sufficient. Instead, the function was a combination of an exponential and a power function:

$$y_{i,t} = a_t e^{b_t i} (i)^{c_t} \quad (2)$$

All the coefficients are temperature specific; a_t, b_t, and c_t are for temperature t°C. Linear regressions of the natural logarithms of average age on stage ($\ln y_{i,t} = \ln a_t + b_t \cdot i + c_t \ln(i)$) show an excellent fit with R^2 ranging from 0.96 to 0.99 for each of the three temperatures:

Temperature (°C)	$\ln a_t$	b_t	c_t	R^2
13.9	0.717	−0.206	2.4	0.96
13.5	0.731	−0.153	2.13	0.96
16.2	0.793	−0.206	1.94	0.99

In order to include all the existing data on anchovy egg development in a single model, Equations (1) and (2) were combined into one equation:

$$y_{i,t} = a\ e^{(bt+ci)} i^d \quad (3)$$

where the coefficients a, b,c, and d were common for all stages and all temperatures. Equation (3) was then fitted to all temperature-specific egg development data (Table 1). The resulting model is:

$$y_{i,t} = 16.07\ e^{-(0.1145t+0.0098i)} i^{1.74}. \quad (4)$$

The observed and predicted ages of anchovy eggs were plotted in Figure 1.

For each of the 11 stages, the average age of anchovy eggs can be estimated from Equation (4) for a given temperature. A family of 11 temperature-age curves was used as the key to determine the ages of anchovy eggs collected in the field in conjunction with the time of tow and sea surface temperature, assuming 1800-0200 was the spawning time with 2200 as the peak (Fig. 2).

To use Figure 2 to assign age to anchovy eggs after they are staged, the following is done. First, time zero was assumed to be 2200, the midpoint of the daily spawning period. All the eggs observed between 1800 and 0200 were classified as newly spawned eggs (S). Eggs that fall in the consecutive 24-h intervals from 0200 to 0200 are classified as day 0, day 1, day 2, and day 3 eggs (or A-day, B-day, C-day, D-day eggs), depending on the time of tow and the sea surface temperature. For example, the eggs collected from a tow taken at 1800 h at 16°C should have the age assignment as below (theoretically no stage II should be observed):

Stage	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Age	S	—	A	A	A	B	B	B	B	B	B,C

The above assignment of ages to staged eggs is on a daily basis. With the information of time of tow, the age of eggs can be expressed in hours, e.g., A-day eggs are 20 h old (20 h from 2200) and B-day eggs are 44 h old in this example.

AN AUTOMATED PROCEDURE

The automated procedure for assigning an age to a staged anchovy egg is a FORTRAN computer program (STAGEAGE) coded for VAX[2] computer. It takes input data of staged eggs along with sea temperature and time of tow and assigns ages to eggs according to a reference table (see Table 3). This reference table contains the estimated ages of eggs for each of the 11 egg stages (see Moser and Ahlstrom 1985) at temperatures ranging from 10° to 22°C for any time throughout a day. In the following paragraphs, I describe the construction of the reference table.

The estimated ages ($y_{i,t,k}$) in the reference table are the average ages ($y_{i,t}$) computed from Equation (4) adjusted for the time of tow (k) assuming that the peak spawning time is 2200. If the eggs are observed before their expected time, an age younger than $y_{i,t}$ will be assigned. Otherwise, an older age will be assigned. The basic formula of determining the age of eggs ($y_{i,t,k}$) is

$$y_{i,t,k} = y_{i,t} + k - \hat{T} \qquad (5)$$

[2]VAX is a trademark of Digital Equipment Corporation.

where $y_{i,t}$ is from Equation (4), k is time of tow, and $\hat{T}$ is the expected time of observing stage i eggs. $\hat{T}$ is obtained from the peak spawning time (st) (=2200 for northern anchovy) and average age ($y_{i,t}$):

$$\hat{T} = \text{remainder of } (y_{i,t} + st)/24.$$

The basic formula is used for samples taken between $\hat{T}$-G and $\hat{T}$+G h. The quantity G is chosen to be 2× the standard deviation of ages within stage (sd). If $y_{i,t,k}<2\times sd$, G is set to be equal to $y_{i,t,k}$, or

$$G = \begin{cases} 2\times sd & \text{if } y_{i,t,k}>2\times sd \\ y_{i,t,k} & \text{otherwise.} \end{cases}$$

The average standard deviation over three temperatures (13.9°, 15.2°, 16.2°C) is between 2 and 5 h.

Stage	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
sd (h)	—	2	4	4	4	4	3	3	5	3	3

The average age ($y_{i,t}$) and the expected time of tow ($\hat{T}$) for each stage and temperature combination are given in Table 2. The assignment of ages of eggs as a function of the time of tow (k) and sea surface temperature (t) is computed as below:

$$y_{i,t,k} = \begin{cases} y_{i,t}-G & \text{if } k<\hat{T}-G \\ y_{i,t}+k-\hat{T} & \hat{T}-G<k<\hat{T}+G \\ y_{i,t}+G & \hat{T}+G<k. \end{cases} \qquad (7)$$

Notice Equation (7) is a modified version of Equation (5).

Table 2.—Average age and expected time of tow for each combination of stages (i) and temperatures (t) ranging from 10° to 22°C.

Temp. (°C)	Stage I	II	III	IV	V	VI	VII	VIII	IX	X	XI
	Average ($y_{i,t}$) (in hours.minutes)										
10	4.23	13.16	24.21	36.25	48.40	60.36	71.51	82.11	91.27	99.36	106.36
11	3.54	11.50	21.43	32.28	43.24	54.03	64.05	73.17	81.34	88.50	95.04
12	3.29	10.33	19.22	28.57	38.43	48.12	57.09	65.22	72.44	79.13	84.47
13	3.06	9.24	17.16	25.50	34.31	42.59	50.58	58.17	64.52	70.39	75.36
14	2.46	8.23	15.24	23.02	30.47	38.20	45.27	51.59	57.51	63.00	67.26
15	2.28	7.29	13.44	20.32	27.27	34.11	40.32	46.22	51.36	56.11	60.08
16	2.12	6.40	12.15	18.19	24.29	30.29	36.09	41.21	46.01	50.07	53.38
17	1.58	5.57	10.55	16.20	21.50	27.11	32.14	36.52	41.02	44.41	47.49
18	1.45	5.18	9.44	14.34	19.28	24.15	28.45	32.53	36.36	39.51	42.39
19	1.34	4.44	8.41	13.00	17.22	21.38	25.38	29.19	32.38	35.32	38.02
20	1.24	4.13	7.45	11.35	15.29	19.17	22.52	26.09	29.06	31.42	33.55
21	1.15	3.46	6.55	10.20	13.49	17.12	20.23	23.19	25.57	28.16	30.15
22	1.06	3.21	6.10	9.13	12.19	15.20	18.11	20.48	23.09	25.13	26.59
	Expected time of tow ($\hat{T}$) (in hours.minutes)										
10	2.23	11.16	22.21	10.25	22.40	10.36	21.51	8.11	17.27	1.36	8.36
11	1.54	9.50	19.43	6.28	17.24	4.03	14.05	23.17	7.34	14.50	21.04
12	1.29	8.33	17.22	2.57	12.43	22.12	7.09	15.22	22.44	5.13	10.47
13	1.06	7.24	15.16	23.50	8.31	16.59	0.58	8.17	14.52	20.39	1.36
14	0.46	6.23	13.24	21.02	4.47	12.20	19.27	1.59	7.51	13.00	17.26
15	0.28	5.29	11.44	18.32	1.27	8.11	14.32	20.22	1.36	6.11	10.08
16	0.12	4.40	10.15	16.19	22.29	4.29	10.09	15.21	20.01	0.07	3.38
17	23.58	3.57	8.55	14.20	19.50	1.11	6.14	10.52	15.02	18.41	21.49
18	23.45	3.18	7.44	12.34	17.28	22.15	2.45	6.53	10.36	13.51	16.39
19	23.34	2.44	6.41	11.00	15.22	19.38	23.38	3.19	6.38	9.32	12.02
20	23.24	2.13	5.45	9.35	13.29	17.17	20.52	0.09	3.06	5.42	7.55
21	23.15	1.46	4.55	8.20	11.49	15.12	18.23	21.19	23.57	2.16	4.15
22	23.06	1.21	4.10	7.13	10.19	13.20	16.11	18.48	21.09	23.13	0.59

Thus, the age for eggs of stage i observed at temperature t is always within $y_{i,t} \pm G$ (i.e., between two standard deviations of age within a stage). Equation (7) eliminates the possibility of assigning either too young or too old an age to eggs that were sampled at the time which is more than G hours before or after the expected time of tow. Occasionally, the eggs are taken 12 h away from the expected time of spawning. These eggs can be either the youngest or the oldest eggs for that stage. In this case, the maximum and minimum ages are then randomly assigned to those eggs because there is no way of distinguishing eggs between the young and old ages within stage.

The reference table for stage IV anchovy eggs is given (Table 3). In the table, the first column is the time of tow (01-24 h). The rows corresponding to 25 h are the maximum ages used for random selection of ages for eggs observed at 12 h away from the expected time. Row 1 contains temperatures ranging from 10° to 22°C. Each entry from row 2 and on is the estimated age for a combination of time of tow and sea temperature. For a given temperature, and time of tow, ages are assigned to each stage according to the reference table. The reference table for all stages is included in FORTRAN program STAGEAGE (Hewitt et al. 1984).

Use of Computer Program STAGEAGE

Input Data File—The input data file of eggs should include tow identification (ID) information, e.g., cruise number, location (line and station for CalCOFI survey), stratum, weighting factor (Hewitt et al. 1984), tow number, tow time, sea surface temperature, number of eggs for each stage, and total number of eggs. Variables in tow ID and total eggs are useful for data checking. The other variables are essential for estimating the ages of eggs (Table 4).

Output Data Files—Several output data files are available from STAGEAGE. STAGEAGE can be used not only to assign ages to staged eggs, but also to stratify the survey area into regions as desired. Regions are defined as area between line numbers. The user can choose output data file(s) and the number of regions in the execution instructions (see next section). The major output data file names in logic unit numbers are FOR026.DAT, FOR029.DAT, FOR036.DAT, FOR037.DAT, FOR038.DAT (Tables 5a-e).

Table 3.—Partial listing of the reference table. Estimated age (in hours.minutes) for stage IV for each combination of time of tow (1-24 h) and temperature (10°-22°C). Asterisks (*) indicate the estimated age corresponding to expected time of tow ($\hat{T}$) (see Tables 2a, b). Row 25 is for random assignment of ages for eggs observed at 12 h before or after expected time of tow.

Time of tow (k)	Temperature (°C)												
	10	11	12	13	14	15	16	17	18	19	20	21	22
1	28.25	27.28	27.57	27.50	27.02	27.32	26.19	24.20	6.34	4.60	3.35	3.20	3.13
2	28.25	28.28	28.57*	28.50	28.02	28.32	26.19	8.20	6.34	4.60	4.35	4.20	4.13
3	29.25	29.28	29.57	29.50	29.02	28.32	26.19	8.20	6.34	5.60	5.35	5.20	5.13
4	30.25	30.28	30.57	30.50	30.02	28.32	10.19	8.20	6.34	6.60	6.35	6.20	6.13
5	31.25	31.28	31.57	31.50	31.02	28.32	10.19	8.20	7.34	7.60	7.35	7.20	7.13
6	32.25	32.28*	32.57	32.50	31.02	12.32	10.19	8.20	8.34	8.60	8.35	8.20	8.13
7	33.25	33.28	33.57	33.50	31.02	12.32	10.19	9.20	9.34	9.60	9.35	9.20	9.13*
8	34.25	34.28	34.57	33.50	31.02	12.32	10.19	10.20	10.34	10.60	10.35	10.20*	10.13
9	35.25	35.28	35.57	33.50	15.02	12.32	11.19	11.20	11.34	11.60	11.35*	11.20	11.13
10	36.25*	36.28	36.57	33.50	15.02	12.32	12.19	12.20	12.34	12.60*	12.35	12.20	12.13
11	37.25	37.28	36.57	17.50	15.02	13.32	13.19	13.20	13.34	13.60	13.35	13.20	13.13
12	38.25	38.28	36.57	17.50	15.02	14.32	14.19	14.20	14.34*	14.60	14.35	14.20	14.13
13	39.25	39.28	36.57	17.50	15.02	15.32	15.19	15.20	15.34	15.60	15.35	15.20	15.13
14	40.25	40.28	20.57	17.50	16.02	16.32	16.19	16.20*	16.34	16.60	16.35	16.20	16.13
15	41.25	40.28	20.57	17.50	17.02	17.32	17.19	17.20	17.34	17.60	17.35	17.20	17.13
16	42.25	40.28	20.57	18.50	18.02	18.32	18.19*	18.20	18.34	18.60	18.35	18.20	17.13
17	43.25	40.28	20.57	19.50	19.02	19.32	19.19	19.20	19.34	19.60	19.35	18.20	17.13
18	44.25	24.28	20.57	20.50	20.02	20.32*	20.19	20.20	20.34	20.60	19.35	18.20	17.13
19	44.25	24.28	21.57	21.50	21.02	21.32	21.19	21.20	21.34	20.60	19.35	18.20	1.13
20	44.25	24.28	22.57	22.50	22.02	22.32	22.19	22.20	22.34	20.60	19.35	2.20	1.13
21	44.25	24.28	23.57	23.50	23.02*	23.32	23.19	23.20	22.34	20.60	3.35	2.20	1.13
22	28.25	24.28	24.57	24.50	24.02	24.32	24.19	24.20	22.34	4.60	3.35	2.20	1.13
23	28.25	25.28	25.57	25.50*	25.02	25.32	25.19	24.20	22.34	4.60	3.35	2.20	1.13
24	28.25	26.28	26.57	26.50	26.02	26.32	26.19	24.20	6.34	4.60	3.35	2.20	2.13
25	44.25	40.28	36.57	33.50	31.02	28.32	26.19	24.20	22.34	20.60	19.35	18.20	17.13

FOR026.DAT contains tow ID, region, tow time, temperature, and number of eggs and age grouped by 24-h increments: 0-3, 4-27, 28-51, 52-75, and 76-99 as S, A, B, C, and D-day categories for each tow. The program assigns number 0 to an age if it is impossible to observe eggs that belong to such a day category for a given time of tow. For example, S-day eggs are never observed at 1200 (Table 5a).

FOR029.DAT contains the same data as FOR026.DAT except the age is not included and this file was formatted for the CalCOFI data base for the SWFC (Table 5b).

FOR036.DAT contains tow ID, region, tow time, temperature, and number of eggs and age for each stage by tow (Table 5c).

FOR037.DAT contains records in which at least one stage was observed outside the normal range of expected time, i.e., $\hat{T} \pm G$. This file is useful for double-checking the accuracy of data on eggs observed at unusual times (Table 5d).

FOR038.DAT contains tow ID and two variables: number of eggs and age for A, B, and C-day eggs. The day categories with age >2.5 d are excluded. Therefore, the total number of records is <3× the number of tows. This file can be used directly for regression estimates of egg production and egg mortality rates (Table 5e).

Execution Instructions—The program may be executed interactively or as a batch job. An example of a set of commands for VAX is given below with input data file FILENAME:

$ASSIGN FILENAME FOR025
$RUN STAGEAGE
(. . .enter 1 for each of the output files needed:FOR026,028,029, 036,037, and 038. Enter 2, otherwise.)
1 2 1 2 1 1
(enter number of regions)
3
(enter max (CalCOFI) line number for each region, separated by space.)
826 950 1500

This set of commands takes FILENAME as the input file and asks for output files FOR026, 029, 037, and 038. Commands in parentheses are prompted by the machine. Other lines are inputs by the user. The input and output data files for 1983 anchovy eggs are listed in Tables 4 and 5 for illustration.

Table 4.—Partial listing of input data file for 1983 northern anchovy eggs (N8302.DAT) for the computer program STAGEAGE. (Cruise no. is 8302; 8 was deleted from printout.)

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Stratum	Weighting factor	Date	Tow time (h)	Temp. (°C x 10)	Egg stages I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Disintegrated eggs	Total no eggs/tow
302	1	733	500	0	1.000	830205	408	150	0	0	0	0	0	0	0	0	0	0	0	0	0
302	2	733	510	0	1.000	830205	545	149	0	0	0	0	0	0	0	0	0	0	0	0	0
302	3	733	520	0	1.000	830205	631	149	0	0	0	0	0	0	0	0	0	0	0	0	0
302	4	733	530	0	1.000	830205	837	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	5	733	540	0	1.000	830205	1028	146	0	0	0	0	0	0	0	0	0	0	0	0	0
302	6	733	550	1	1.000	830205	1113	148	0	0	0	0	0	0	0	0	0	1	0	0	1
302	7	733	560	0	1.000	830205	1159	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	8	733	570	0	1.000	830205	1245	150	0	0	0	0	0	0	0	0	0	0	0	0	0
302	9	733	580	0	1.000	830205	1328	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	10	733	590	0	1.000	830205	1416	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	11	733	600	0	1.000	830205	1633	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	12	741	600	0	1.000	830205	1831	146	0	0	0	0	0	0	0	0	0	0	0	0	0
302	13	741	590	0	1.000	830205	2035	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	14	741	580	0	1.000	830205	2109	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	15	741	570	0	1.000	830205	2144	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	16	741	560	0	1.000	830205	2231	147	0	0	0	0	0	0	0	0	0	0	0	0	0
302	17	741	550	1	1.000	830205	2328	146	0	0	0	0	1	0	0	0	0	0	0	0	1
302	18	741	540	1	1.000	830206	20	146	0	0	0	0	0	0	0	1	0	0	0	0	1
302	19	741	530	1	1.000	830206	113	146	0	0	0	0	0	0	0	3	0	0	0	0	3
302	20	741	520	0	1.000	830206	151	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	21	741	510	0	1.000	830206	228	149	0	0	0	0	0	0	0	0	0	0	0	0	0
302	22	741	500	0	1.000	830206	312	149	0	0	0	0	0	0	0	0	0	0	0	0	0
302	23	741	492	0	1.000	830206	417	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	24	750	485	1	1.000	830206	619	146	0	0	0	0	0	0	0	0	0	0	0	0	0
302	26	750	500	1	1.000	830206	1539	151	0	0	0	0	0	0	0	0	0	2	0	0	2
302	27	750	510	1	1.000	830206	1717	151	0	0	0	0	0	0	0	0	0	0	0	0	0
302	29	750	520	1	1.000	830206	2232	151	0	0	0	0	0	0	0	0	0	0	0	0	0
302	30	750	530	1	1.000	830206	2311	148	0	0	0	0	0	0	0	0	0	0	0	0	0
302	31	750	540	1	1.000	830207	8	143	0	0	0	0	0	0	0	0	0	2	0	1	3
302	32	750	550	1	1.000	830207	49	143	0	0	0	0	0	0	0	0	0	2	0	0	2
302	33	750	560	1	1.000	830207	147	144	0	0	0	0	0	0	0	0	0	2	0	0	2
302	34	750	570	1	1.000	830207	231	145	0	0	0	0	0	0	0	0	0	1	0	0	1
302	35	750	580	0	1.000	830207	309	144	0	0	0	0	0	0	0	0	0	0	0	0	0
302	36	750	590	0	1.000	830207	350	146	0	0	0	0	0	0	0	0	0	0	0	0	0
302	37	750	600	0	1.000	830207	441	146	0	0	0	0	0	0	0	0	0	0	0	0	0
302	38	758	600	1	1.000	830207	616	146	0	0	0	0	0	0	0	2	0	0	0	0	2
302	39	758	590	1	1.000	830207	720	146	0	0	0	0	0	0	0	2	0	0	0	0	2
302	40	758	580	1	1.000	830207	807	146	0	0	0	0	0	0	0	0	2	0	0	0	2
302	41	758	570	1	1.000	830207	852	144	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5a.—Partial listing of output data file (FORO26.DAT) for 1983: Number of northern anchovy eggs and estimated ages (in hours) grouped by S(0-3 h), A(4-27 h), B(28-51), C(52-75 h), D(76-99 h). Disintegrated eggs are obtained by subtraction. E-day eggs (100-123 h) are not observed for northern anchovy and thus are not included in the output. (Cruise no. is 8302.)

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Stratum	Weighting factor	Date	Region	Tow time (h)	Temp. (°C)	No. eggs and ages (h)/day catagories										Total
										S		A		B		C		D		
										N	h	N	h	N	h	N	h	N	h	
302	17	741	550	1	1.000	830205	1	23 28	14	0.	1.	1.	25.	0.	48.	0.	71.	0.	0.	1.
302	18	741	540	1	1.000	830206	1	24 20	14	0.	2.	0.	20.	1.	50.	0.	71.	0.	0.	1.
302	19	741	530	1	1.000	830206	1	1 13	14	0.	3.	0.	20.	3.	51.	0.	65.	0.	0.	3.
302	24	750	485	1	1.000	830206	1	6 19	14	0.	0.	0.	7.	0.	37.	0.	58.	0.	0.	0.
302	26	750	500	1	1.000	830206	1	15 39	15	0.	0.	0.	16.	0.	41.	2.	62.	0.	0.	2.
302	27	750	510	1	1.000	830206	1	17 17	15	0.	2.	0.	19.	0.	43.	0.	64.	0.	0.	2.
302	29	750	520	1	1.000	830206	1	22 32	15	0.	2.	0.	24.	0.	48.	0.	66.	0.	0.	2.
302	30	750	530	1	1.000	830206	1	23 11	14	0.	1.	0.	19.	0.	48.	0.	71.	0.	0.	1.
302	31	750	540	1	1.000	830207	1	24 8	14	0.	2.	0.	20.	2.	50.	0.	71.	0.	0.	3.
302	32	750	550	1	1.000	830207	1	24 49	14	0.	2.	0.	20.	0.	49.	2.	69.	0.	0.	3.
302	33	750	560	1	1.000	830207	1	1 47	14	0.	3.	0.	20.	0.	46.	2.	57.	0.	0.	3.
302	34	750	570	1	1.000	830207	1	2 31	14	0.	0.	0.	5.	0.	34.	1.	57.	0.	0.	1.
302	38	758	600	1	1.000	830207	1	6 16	14	0.	0.	0.	7.	0.	37.	2.	56.	0.	0.	2.
302	39	758	590	1	1.000	830207	1	7 20	14	0.	0.	0.	7.	0.	34.	2.	57.	0.	0.	2.
302	40	758	580	1	1.000	830207	1	8 7	14	0.	0.	0.	8.	0.	35.	2.	58.	0.	0.	2.
302	41	758	570	1	1.000	830207	1	8 52	14	0.	0.	0.	8.	0.	35.	0.	59.	0.	0.	0.
302	42	758	560	1	1.000	830207	1	9 34	14	0.	0.	0.	10.	0.	36.	0.	59.	0.	0.	0.
302	43	758	550	1	1.000	830207	1	10 39	14	0.	0.	0.	11.	0.	37.	2.	60.	0.	0.	2.
302	44	758	540	1	1.000	830207	1	11 22	14	0.	0.	0.	11.	0.	38.	2.	61.	0.	0.	2.
302	45	758	530	1	1.000	830207	1	12 0	15	0.	0.	0.	13.	1.	38.	1.	62.	0.	0.	3.
302	46	758	520	1	1.000	830207	1	12 35	15	0.	0.	0.	13.	0.	38.	3.	61.	0.	0.	3.
302	47	758	510	1	1.000	830207	1	13 16	15	0.	0.	0.	15.	0.	40.	0.	63.	0.	0.	0.
302	49	758	495	1	1.000	830207	1	14 30	15	0.	0.	0.	16.	0.	40.	0.	63.	0.	0.	0.
302	50	767	480	1	1.000	830207	1	17 9	15	0.	0.	0.	17.	0.	43.	0.	64.	0.	0.	0.
302	51	767	490	1	1.000	830207	1	18 28	15	0.	2.	0.	20.	1.	44.	0.	64.	0.	0.	1.
302	52	767	500	1	1.000	830207	1	20 46	15	0.	2.	0.	23.	0.	47.	0.	66.	0.	0.	0.
302	53	767	510	1	1.000	830207	1	22 25	15	0.	2.	3.	24.	1.	48.	0.	66.	0.	0.	4.
302	54	767	520	1	1.000	830208	1	24 43	15	0.	3.	0.	21.	0.	49.	0.	54.	0.	0.	0.
302	55	767	530	1	1.000	830208	1	1 31	15	0.	3.	0.	22.	0.	50.	0.	54.	0.	0.	0.
302	56	767	540	1	1.000	830208	1	2 17	15	0.	0.	0.	4.	1.	28.	0.	53.	0.	0.	1.
302	57	767	550	1	1.000	830208	1	3 6	15	0.	0.	1.	5.	1.	29.	0.	53.	0.	0.	2.
302	58	767	560	1	1.000	830208	1	5 28	15	0.	0.	0.	6.	1.	31.	0.	54.	0.	0.	1.
302	59	767	570	1	1.000	830208	1	6 22	14	0.	0.	0.	7	1.	32.	0.	58.	0.	0.	1.
302	64	775	590	1	1.000	830208	1	14 14	14	0.	0.	0.	15	1.	38.	0.	64.	0.	0.	1.
302	65	775	580	1	1.000	830208	1	14 53	14	0.	0.	0.	15.	0.	41.	0.	64.	0.	0.	0.
302	66	775	570	1	1.000	830208	1	15 29	15	0.	0.	0.	16	0.	41	1.	62.	0.	0.	1.
302	67	775	560	1	1.000	830208	1	16 15	15	0.	0.	0.	17	1.	42.	1	66.	0.	0.	2.
302	68	775	550	1	1.000	830208	1	17 3	14	0.	0.	0.	18.	0.	44.	0.	67.	0.	0.	0.

Table 5b.—Partial listing of output data file (FORO29.DAT). Number of northern anchovy eggs grouped by S(0-3 h), A(4-27 h), B(28-51 h), C(52-75 h), D(76-99 h), and E(100-123 h).

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Stratum	Weighting factor	Date	Tow time (h)	Temp. (°C x 10)	No. eggs/ day categories						Disintegrated eggs	Total no. eggs in tow
									S	A	B	C	D	E		
8302	19	741	530	1	1.00	830206	113	146	0	0	3	0	0	0	0	3
8302	24	750	485	1	1.00	830206	619	146	0	0	0	0	0	0	0	0
8302	26	750	500	1	1.00	830206	1539	151	0	0	0	2	0	0	0	2
8302	27	750	510	1	1.00	830206	1717	151	0	0	0	0	0	0	0	0
8302	29	750	520	1	1.00	830206	2232	151	0	0	0	0	0	0	0	0
8302	30	750	530	1	1.00	830206	2311	148	0	0	0	0	0	0	0	0
8302	31	750	540	1	1.00	830207	24 8	143	0	0	2	0	0	0	1	3
8302	32	750	550	1	1.00	830207	2449	143	0	0	0	2	0	0	0	2
8302	33	750	560	1	1.00	830207	147	144	0	0	0	2	0	0	0	2
8302	34	750	570	1	1.00	830207	231	145	0	0	0	1	0	0	0	1
8302	38	758	600	1	1.00	830207	616	146	0	0	0	2	0	0	0	2
8302	39	758	590	1	1.00	830207	720	146	0	0	0	2	0	0	0	2
8302	40	758	580	1	1.00	830207	8 7	146	0	0	0	2	0	0	0	2
8302	41	758	570	1	1.00	830207	852	144	0	0	0	0	0	0	0	0
8302	42	758	560	1	1.00	830207	934	144	0	0	0	0	0	0	0	0
8302	43	758	550	1	1.00	830207	1039	149	0	0	0	2	0	0	0	2
8302	44	758	540	1	1.00	830207	1122	149	0	0	0	2	0	0	0	2
8302	45	758	530	1	1.00	830207	12 0	151	0	0	0	1	0	0	0	1
8302	46	758	520	1	1.00	830207	1235	151	0	0	0	3	0	0	0	3
8302	47	758	510	1	1.00	830207	1316	153	0	0	0	0	0	0	0	0
8302	49	758	495	1	1.00	830207	1430	150	0	0	0	0	0	0	0	0
8302	50	767	480	1	1.00	830207	17 9	150	0	0	0	0	0	0	0	0
8302	51	767	490	1	1.00	830207	1828	151	0	0	1	0	0	0	0	1
8302	52	767	500	1	1.00	830207	2046	152	0	0	1	0	0	0	0	1
8302	53	767	510	1	1.00	830207	2225	151	0	3	1	0	0	0	0	4
8302	54	767	520	1	1.00	830208	2443	152	0	0	0	0	0	0	0	0
8302	55	767	530	1	1.00	830208	131	152	0	0	0	0	0	0	0	0
8302	56	767	540	1	1.00	830208	217	151	0	0	1	0	0	0	0	1
8302	57	767	550	1	1.00	830208	3 6	151	0	1	1	0	0	0	0	2
8302	58	767	560	1	1.00	830208	528	151	0	0	1	0	0	0	0	1
8302	59	767	570	1	1.00	830208	622	143	0	0	1	0	0	0	0	1
8302	64	775	590	1	1.00	830208	1414	145	0	0	1	0	0	0	0	1
8302	65	775	580	1	1.00	830208	1453	145	0	0	0	0	0	0	0	0
8302	66	775	570	1	1.00	830208	1529	153	0	0	0	1	0	0	0	1
8302	67	775	560	1	1.00	830208	1615	151	0	0	1	1	0	0	0	2
8302	68	775	550	1	1.00	830208	17 3	148	0	0	0	0	0	0	0	0
8302	69	775	540	1	1.00	830208	1824	148	0	0	0	0	0	0	0	0
8302	70	775	530	1	1.00	830208	2044	152	0	0	1	0	0	0	0	1
8302	71	775	520	1	1.00	830208	2121	152	0	0	0	0	0	0	0	0
8302	72	775	510	1	1.00	830208	2315	152	0	0	0	0	0	0	0	0
8302	73	775	500	1	1.00	830209	2410	151	0	2	2	0	0	0	0	4
8302	74	775	495	1	1.00	830209	150	149	0	7	1	0	0	0	0	8
8302	75	783	510	1	1.00	830209	314	151	0	0	1	0	0	0	0	1

Table 5c.—Partial listing of output data file (FORO36.DAT). Number of northern anchovy eggs and estimated ages (in hours) are grouped by developmental stages I-XI. (Cruise no. is 8302.)

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Stratum	Weighting factor	Date	Region	Tow time (h)	Temp. (°C)	No. eggs and ages (h)/egg stages										
										I	II	III	IV	V	VI	VII	VIII	IX	X	XI
302	19	741	530	1	1.000	830206	1	113	14	0. 3.	0 4.	0 23.	0 27.	0 27.	0 30.	0 51.	3 51.	0 51.	0 57.	0 73.
302	24	750	485	1	1.000	830206	1	2119	14	0. 4.	0. 8.	0. 8.	0. 17.	0. 19.	0. 41.	0. 41.	0. 41.	0. 41.	2. 62.	0. 65.
302	26	750	500	1	1.000	830206	1	1539	13	0. 0.	0. 0.	0. 3.	0. 19.	0. 19.	0. 42.	0. 43.	0. 43.	0. 43.	0. 62.	0. 66.
302	27	750	510	1	1.000	830206	1	1717	15	0. 0.	0. 0.	0. 3.	0. 19.	0. 19.	0. 42.	0. 43.	0. 43.	0. 43.	0. 62.	0. 66.
302	29	750	520	1	1.000	830206	1	2232	15	0. 0.	0. 0.	0. 3.	0. 21.	0. 24.	0. 25.	0. 46.	0. 48.	0. 48.	0. 50.	0. 66.
302	30	750	530	1	1.000	830206	1	2311	14	0. 1.	0. 4.	0. 4.	0. 23.	0. 25.	0. 25.	0. 46.	0. 49.	0. 49.	0. 49.	0. 73.
302	31	750	540	1	1.000	830207	1	24 8	14	0. 2.	0. 4.	0. 4.	0. 23.	0. 26.	0. 26.	0. 46.	0. 49.	0. 49.	0. 69.	0. 73.
302	32	750	550	1	1.000	830207	1	2449	14	0. 2.	0. 4.	0. 4.	0. 23.	0. 26.	0. 26.	0. 46.	0. 50.	0. 50.	0. 69.	0. 73.
302	33	750	560	1	1.000	830207	1	147	14	0. 3.	0. 4.	0. 4.	0. 23.	0. 26.	0. 26.	0. 46.	0. 50.	0. 50.	0. 69.	0. 73.
302	34	750	570	1	1.000	830207	1	231	14	0. 3.	0. 4.	0. 4.	0. 23.	0. 27.	0. 27.	0. 30.	0. 51.	0. 51.	0. 51.	0. 73.
302	38	758	600	1	1.000	830207	1	616	14	0. 4.	0. 4.	0. 4.	0. 7.	0. 28.	0. 28.	0. 30.	0. 51.	0. 52.	0. 52.	1. 57.	0. 73.
302	39	758	590	1	1.000	830207	1	720	14	0. 4.	0. 4.	0. 8.	0. 8.	0. 31.	0. 32.	0. 38.	0. 51.	0. 56.	0. 56.	0. 57.	0. 61.
302	40	758	580	1	1.000	830207	1	847	14	0. 4.	0. 4.	0. 9.	0. 9.	0. 31.	0. 33.	0. 39.	0. 51.	0. 57.	0. 57.	0. 57.	0. 61.
302	41	758	570	1	1.000	830207	1	857	14	0. 4.	0. 10.	0. 10.	0. 31.	0. 34.	0. 34.	0. 39.	0. 52.	0. 57.	0. 57.	0. 58.	0. 61.
302	42	758	560	1	1.000	830207	1	853	14	0. 4.	0. 10.	0. 10.	0. 31.	0. 34.	0. 34.	0. 39.	0. 52.	0. 57.	0. 57.	0. 58.	0. 61.
302	43	758	550	1	1.000	830207	1	934	14	0. 4.	0. 11.	0. 11.	0. 15.	0. 35.	0. 35.	0. 39.	0. 52.	0. 57.	0. 57.	0. 59.	0. 61.
302	44	758	540	1	1.000	830207	1	1039	14	0. 4.	0. 12.	0. 12.	0. 15.	0. 35.	0. 36.	0. 39.	0. 52.	0. 57.	0. 57.	0. 59.	0. 61.
302	45	758	530	1	1.000	830207	1	1122	14	0. 4.	0. 12.	0. 12.	0. 13.	0. 15.	0. 37.	0. 37.	0. 39.	0. 57.	2. 60.	0. 60.	0. 61.
302	46	758	520	1	1.000	830207	1	1235	15	0. 0.	0. 11.	0. 14.	0. 14.	0. 35.	1. 38.	0. 38.	0. 40.	2. 61.	1. 62.	0. 62.	0. 62.
302	47	758	510	1	1.000	830207	1	1316	15	0. 0.	0. 11.	0. 14.	0. 14.	0. 35.	0. 38.	0. 38.	0. 40.	2. 61.	1. 62.	0. 62.	0. 62.
302	49	758	495	1	1.000	830207	1	1430	15	0. 0.	0. 11.	0. 15.	0. 15.	0. 15.	0. 39.	0. 39.	0. 40.	2. 61.	0. 62.	0. 63.	0. 63.
302	50	767	480	1	1.000	830207	1	1639	15	0. 0.	0. 11.	0. 16.	0. 16.	0. 19.	0. 40.	0. 40.	0. 40.	0. 41.	0. 62.	0. 64.	0. 64.
302	51	767	490	1	1.000	830207	1	17 9	15	0. 0.	0. 11.	0. 19.	0. 19.	0. 19.	0. 42.	0. 43.	0. 43.	0. 43.	0. 62.	0. 66.	0. 66.
302	52	767	500	1	1.000	830207	1	1828	15	0. 0.	0. 3.	0. 20.	0. 20.	0. 20.	0. 42.	1. 44.	0. 44.	0. 44.	0. 62.	0. 66.	0. 66.
302	53	767	510	1	1.000	830207	1	2046	15	0. 0.	0. 3.	0. 21.	0. 22.	0. 22.	0. 26.	0. 46.	0. 46.	0. 46.	0. 62.	0. 66.	0. 66.
302	54	767	520	1	1.000	830208	1	2225	15	0. 0.	0. 3.	0. 21.	0. 24.	0. 24.	0. 26.	0. 46.	1. 48.	0. 48.	0. 50.	0. 66.	0. 66.
302	55	767	530	1	1.000	830208	1	2443	15	0. 2.	0. 3.	0. 5.	0. 26.	0. 26.	0. 26.	0. 46.	0. 50.	0. 50.	0. 50.	0. 66.	0. 66.
302	56	767	540	1	1.000	830208	1	131	15	0. 3.	0. 4.	0. 5.	0. 27.	0. 27.	0. 27.	0. 46.	0. 51.	0. 51.	0. 51.	0. 54.	0. 54.
302	57	767	550	1	1.000	830208	1	217	15	0. 4.	0. 5.	0. 5.	0. 28.	1. 28.	0. 28.	0. 34.	0. 52.	0. 52.	0. 52.	0. 54.	0. 54.
302	58	767	560	1	1.000	830208	1	3 6	15	0. 4.	1. 5.	0. 5.	0. 28.	1. 29.	0. 29.	0. 34.	0. 52.	0. 53.	0. 53.	0. 54.	0. 54.
302	59	767	570	1	1.000	830208	1	528	15	0. 4.	0. 7.	0. 7.	0. 28.	1. 31.	0. 31.	0. 34.	0. 52.	0. 55.	0. 55.	0. 55.	0. 55.
302	64	775	590	1	1.000	830208	1	622	14	0. 4.	0. 8.	0. 8.	0. 31.	1. 32.	0. 32.	0. 51.	0. 56.	0. 56.	0. 57.	0. 61.	0. 61.
302	65	775	580	1	1.000	830208	1	1414	14	0. 0.	0. 12.	0. 16.	0. 16.	1. 38.	0. 40.	0. 40.	0. 45.	0. 64.	0. 64.	0. 64.	0. 64.
302	66	775	570	1	1.000	830208	1	1453	14	0. 0.	0. 12.	0. 16.	0. 16.	0. 38.	0. 40.	0. 40.	0. 45.	0. 64.	0. 64.	0. 64.	0. 64.
302	67	775	560	1	1.000	830208	1	1529	15	0. 0.	0. 11.	0. 17.	0. 17.	0. 19.	0. 41.	0. 41.	0. 41.	0. 41.	1. 62.	0. 65.	0. 65.
302	68	775	550	1	1.000	830208	1	1615	15	0. 0.	0. 11.	0. 18.	0. 18.	0. 19.	0. 42.	0. 42.	0. 42.	0. 43.	0. 62.	1. 66.	0. 66.
302	69	775	540	1	1.000	830208	1	17 3	14	0. 0.	0. 12.	0. 19.	0. 19.	0. 22.	0. 42.	0. 43.	0. 45.	0. 45.	0. 67.	0. 67.	0. 67.
302	70	775	530	1	1.000	830208	1	1824	14	0. 0.	0. 12.	0. 20.	0. 20.	0. 22.	0. 44.	0. 44.	0. 45.	0. 47.	0. 67.	0. 68.	0. 68.
302	71	775	520	1	1.000	830208	1	2044	15	0. 0.	0. 3.	0. 21.	0. 22.	0. 22.	0. 42.	0. 46.	1. 46.	0. 46.	0. 50.	0. 66.	0. 66.
302	72	775	510	1	1.000	830208	1	2121	15	0. 0.	0. 3.	0. 21.	0. 22.	0. 22.	0. 42.	0. 46.	0. 46.	0. 46.	0. 50.	0. 66.	0. 66.
302	73	775	500	1	1.000	830208	1	2315	15	0. 1.	0. 3.	0. 21.	0. 25.	0. 25.	0. 26.	0. 46.	0. 49.	0. 49.	0. 50.	0. 66.	0. 66.
302	74	775	495	1	1.000	830209	1	2410	15	0. 2.	0. 3.	0. 5.	0. 26.	0. 26.	0. 26.	0. 46.	0. 50.	2. 50.	0. 50.	0. 54.	0. 54.
302	75	783	510	1	1.000	830209	1	150	14	0. 3.	0. 4.	0. 23.	0. 27.	0. 27.	0. 30.	0. 51.	0. 51.	1. 51.	0. 57.	0. 73.	0. 73.
302	75	783	510	1	1.000	830209	1	314	15	0. 4.	0. 5.	0. 5.	0. 28.	0. 29.	0. 29.	1. 34.	0. 52.	0. 53.	0. 53.	0. 54.	0. 54.

Table 5d.—Partial listing of the output data file (FORO37.DAT): estimated age (h) and number of northern anchovy eggs for those egg stages observed within or beyond the normal ranges of expected tow time ($\hat{T}\pm G$, see text). (Cruise no. is 8302.)

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Stratum	Weighting factor	Date	Region	Tow time (h)	Temp. (°C)	Est. age (h)	Lower limit of age	Upper limit of age	Egg stage	No. of eggs	Expected tow time (h)
302	26	750	500	1	1.000	830206	1	15	15	62	50	62	10	2.	6.
302	32	750	550	1	1.000	830207	1	24	14	69	37	69	10	2.	13.
302	33	750	560	1	1.000	830207	1	1	14	37	37	69	10	2.	13.
302	34	750	570	1	1.000	830207	1	2	14	37	37	69	10	1.	13.
302	39	758	590	1	1.000	830207	1	7	14	37	43	57	8	2.	2.
302	45	758	530	1	1.000	830207	1	12	15	62	50	62	10	1.	6.
302	46	758	520	1	1.000	830207	1	12	15	61	41	61	9	2.	1.
302	46	758	520	1	1.000	830207	1	12	15	62	50	62	10	1.	1.
302	64	775	590	1	1.000	830208	1	14	14	38	22	38	3	1.	6.
302	66	775	570	1	1.000	830208	1	15	15	62	50	62	10	1.	4.
302	67	775	560	1	1.000	830208	1	16	15	66	54	66	11	1.	6.
302	74	775	495	1	1.000	830209	1	1	14	4	4	12	2	1.	10.
302	75	783	510	1	1.000	830209	1	3	14	34	34	46	7	2.	6.
302	76	783	520	1	1.000	830209	1	4	15	34	34	46	7	1.	14.
302	86	791	590	1	1.000	830209	1	12	13	62	50	62	10	1.	14.
302	92	791	530	1	1.000	830209	1	16	15	42	26	42	6	2.	6.
302	92	791	530	1	1.000	830209	1	16	15	62	50	62	10	3.	8.
302	98	800	540	1	1.000	830210	1	4	12	4	0	4	1	3.	6.
302	98	800	540	1	1.000	830210	1	4	12	52	40	52	8	3.	24.
302	100	800	560	1	1.000	830210	1	9	0	11	3	11	2	2.	20.
302	100	800	560	1	1.000	830210	1	9	0	35	19	35	5	3.	5.
302	102	800	580	1	1.000	830210	1	11	30	11	3	11	2	1.	1.
302	100	808	570	1	1.000	830210	1	19	53	66	54	66	11	1.	5.
302	133	817	580	1	1.000	830214	1	2	33	4	0	4	1	1.	10.
302	133	817	580	1	1.000	830214	1	2	33	28	12	28	4	10.	24.
302	133	817	580	1	1.000	830214	1	2	33	34	34	46	7	3.	18.
302	133	817	580	1	1.000	830214	1	2	33	52	40	52	8	1.	14.
302	134	817	590	1	1.000	830214	1	3	10	4	0	4	1	1.	20.
302	139	825	570	1	1.000	830214	1	7	20	4	0	4	1	2.	24.
302	146	825	490	1	1.000	830214	1	12	32	4	0	4	1	1.	24.
302	155	833	406	1	1.000	830214	2	19	36	61	41	61	9	1.	1.
302	155	833	406	1	1.000	830214	2	19	36	0	0	4	1	10.	24.
302	165	841	450	1	1.000	830215	2	9	20	3	3	11	2	4.	5.
302	165	841	450	1	1.000	830215	2	9	20	16	10	22	3	11.	4.
302	165	841	450	1	1.000	830215	2	9	20	16	56	44	56	10	5.	24.
302	166	841	410	1	1.000	830215	2	10	5	16	59	47	59	11	3.	3.
302	172	850	410	1	1.000	830215	2	16	0	16	42	30	42	7	3.	3.
302	173	850	420	1	1.000	830215	2	16	35	16	42	30	42	7	2.	10.
302	178	850	470	1	1.000	830215	2	20	54	15	0	0	4	1	4.	10.
302	178	850	470	1	1.000	830215	2	20	54	15	3	3	11	2	1.	24.
302	178	850	470	1	1.000	830215	2	20	54	15	3	3	11	2	1.	5.
302	179	850	480	1	1.000	830215	2	22	20	15	66	54	66	11	2.	10.
											0	0	4	1	2.	24.

Table 5e.—Partial listing of data file (FORO38.DAT): Number of eggs and age (in days) excluding eggs >2.5 d old. (Cruise no. is 8302.)

Cruise no.	Tow no.	CalCOFI line	CalCOFI stn.	Date	Number of eggs	Age (in days)
302	6	0733	0550	830205	0.0000	0.4583
302	6	0733	0550	830205	0.0000	1.3694
302	6	0733	0550	830205	1.0000	2.5417
302	17	0741	0550	830205	1.0000	1.0417
302	17	0741	0550	830205	0.0000	2.0104
302	17	0741	0550	830205	0.0000	2.9583
302	18	0741	0540	830206	0.0000	0.8229
302	18	0741	0540	830206	1.0000	2.0833
302	18	0741	0540	830206	0.0000	2.9583
302	19	0741	0530	830206	0.0000	0.8438
302	19	0741	0530	830206	3.0000	2.1250
302	19	0741	0530	830206	0.0000	2.7083
302	24	0750	0485	830206	0.0000	0.2778
302	24	0750	0485	830206	0.0000	1.5208
302	24	0750	0485	830206	0.0000	2.3958
302	26	0750	0500	830206	0.0000	0.6667
302	26	0750	0500	830206	0.0000	1.7083
302	26	0750	0500	830206	2.0000	2.5833
302	27	0750	0510	830206	0.0000	0.7917
302	27	0750	0510	830206	0.0000	1.7813
302	27	0750	0510	830206	0.0000	2.6667
302	29	0750	0520	830206	0.0000	0.9896
302	29	0750	0520	830206	0.0000	2.0000
302	29	0750	0520	830206	0.0000	2.7500
302	30	0750	0530	830206	0.0000	0.8021
302	30	0750	0530	830206	0.0000	2.0104
302	30	0750	0530	830206	0.0000	2.9583
302	31	0750	0540	830207	0.0000	0.8229
302	31	0750	0540	830207	2.0000	2.0833
302	31	0750	0540	830207	0.0000	2.9583
302	32	0750	0550	830207	0.0000	0.8229
302	32	0750	0550	830207	0.0000	2.0417
302	32	0750	0550	830207	2.0000	2.8750
302	33	0750	0560	830207	0.0000	0.8438
302	33	0750	0560	830207	0.0000	1.9063
302	33	0750	0560	830207	2.0000	2.3750
302	34	0750	0570	830207	0.0000	0.2083
302	34	0750	0570	830207	0.0000	1.4271
302	34	0750	0570	830207	1.0000	2.3750
302	38	0758	0600	830207	0.0000	0.2778
302	38	0758	0600	830207	0.0000	1.5208
302	38	0758	0600	830207	2.0000	2.3333
302	39	0758	0590	830207	0.0000	0.3056
302	39	0758	0590	830207	0.0000	1.4167
302	39	0758	0590	830207	2.0000	2.3750
302	40	0758	0580	830207	0.0000	0.3333
302	40	0758	0580	830207	0.0000	1.4375

Table 6.—Number of northern anchovy eggs per tow grouped by days S(0-3 h), A (4-27 h), B (28-51 h), C (52-75 h), and D (76-99 h) from the manual system (m) and the proposed automated system (a) for each year in 1980-83.

		No. eggs/day categories					Disintegrated		No.
		S[1]	A	B	C	D	eggs	Total[2]	tows[3]
1980	m	2.72	13.65	8.86	4.91	0.16	0.82	31.14	312
	a	2.61	13.74	9.78	4.08	0.03		30.24	
1981	m	2.76	12.32	10.33	6.91	0.47	0.85	33.72	564
	a	1.81	13.86	12.00	4.98	0.13		32.78	
1982	m	2.49	9.00	7.00	4.44	0.31	0.89	24.23	308
	a	1.13	10.50	7.77	3.78	0.16		23.34	
1983	m	1.95	9.16	8.42	2.88	0.002	0.67	23.07	482
	a	2.01	9.31	8.51	2.61			22.44	

[1]S eggs from manual system (m) include some disintegrated eggs.
[2]Difference between "m" and "a" is the disintegrated eggs which were included in "m," but not in "a."
[3]Positive tows only.

DISCUSSION

The automated procedure should be fully tested before being implemented. For the anchovy egg data, 1980-83 data of aged eggs from both manual and automated procedures were compared based upon positive tows (tows with at least one egg sampled) (Table 6). Although there were some differences between the results of these two procedures, the results from the automated procedure are encouraging. The differences are due to different methods of age assignment and to subjective elements in the manual age assignment method. In the manual system, day category (S, A, B, C, D, and E) was first assigned to eggs (Stauffer and Picquelle 1985). An actual age was then computed based upon the time of tow (k) and day category:

$$\text{age} = k+2+24\times f \qquad (8)$$

where f = 0,1,2,... for A,B,C,...-day eggs. In the automated system, the age was assigned according to Equation (7) before the day category was assigned. Equation (8) yields a range of ages larger than that from Equation (7) and thus gives larger values for maximum ages. This difference affects the ages of older eggs, particularly in the case where eggs older than 2.5 d are excluded in computation of egg mortality. For example, at temperature 15°C, the maximum age for stage XI is 66 h using Equation (7), and the maximum age is 72 h using Equation (8) for eggs that were sampled at 0100. Thus, more eggs would be assigned to older age groups when Equation (8) was used rather than Equation (7). The subjectivities of human judgment or human errors of the manual system are evident in several steps in the manual methods. These include 1) misassignment of age from the key structure due to inexperience or the fatigue of the worker; 2) determination of age for eggs which were observed at a time significantly different from the expected time (Table 2); and 3) assignment of age to eggs observed around 0200 which is the break point of A, B, C, D, and E-day categories (Fig. 2).

To adopt the program for other species would require 1) a model for the temperature-dependent egg development, e.g., Equation (4); 2) the distribution of age within each egg stage to obtain G in Equation (6); and 3) the peak spawning time (st) for Equation (5), so that a reference table can be constructed which is the base of the automated procedure.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

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April 16, 1987

MEMORANDUM FOR: USERS OF THE EGG PRODUCTION METHOD FOR ESTIMATING SPAWNING BIOMASS OF PELAGIC FISH.

FROM: REUBEN LASKER

SUBJECT: ERRATA FOR NOAA TECHNICAL REPORT NMFS 36; "AN EGG PRODUCTION METHOD FOR ESTIMATING SPAWNING BIOMASS OF PELAGIC FISH: APPLICATION TO THE NORTHERN ANCHOVY".

A number of printing errors have been discovered by Dr. Sachiko Tsuji in the published account of the egg production method. These are important and warrant this memo. Please make these corrections in your copy.

p. 5, Abstract, 4th line should read:
"be estimable and spawning rate constant over the field sampling interval."

p. 12, in equation 8, $\hat{\beta}$ should be β.

p. 17, Table 1. on the January line +3.5 should be -3.5.

p. 20, two lines under the formula in the second column, "sample size" should be "sample scale" and σ_i should read σ_{ij}^2. Five lines under the formula "larger observations" should be "bigger scales."

p. 22, 1st para., No. 3 last line should be simulation, not stimulation.

p. 23. 1st para., line 7. "Table 9" should read "Table 6."

p. 44. Temperature table in second column on the page.

The temperatures read	13.9
	13.5
	16.2
The correct temperatures are	13.9
	15.2
	16.2.

p.45. Second column, $y_{i,t,k}$ should read $y_{i,t}$.

p.46 1st Para., line 7, change the word "spawning" to "tows, $\hat{T}$".

p.49. Table 5d. Strike out the words "within or" in the second line of the heading.

p.55. 9th line from the bottom, x_1 should be x_i.

p.56. First. para. second column, sixth line, 26 should read 25.

p.63. Under "Preservation" $Na_2H_2PO_4$ should be Na_2HPO_4.

p.93. In table 1, atretic state e, change > to <.

p.97. In the! formula after the second para. change < to >.

p.98. In the formula in the first column change -Zt to $-Zt_h$.