Draft

Relative gear efficiency of the 20 mm survey for delta smelt

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Summary

This method of estimating relative gear efficiency is applicable in any case where successive surveys are conducted when fish are not being recruited to that portion of the population whose size is being sampled.

I estimated the relative gear efficiency for the 20 mm survey for larval and juvenile delta smelt. I assumed a relative efficiency of 1.0 for 20 mm smelt. This method will accommodate a different assumption about the size at which relative efficiency is 1.0. I also assumed that relative efficiency would decrease for sizes smaller and larger than 20 mm and that the relative efficiency would change in a smooth fashion (i.e., no stepwise changes) with the size of delta smelt.

This method involved numerically defining a smooth curve that satisfied the above assumptions using four parameters. These parameters were adjusted until a range of each was found that produced a declining population of delta smelt over successive surveys in the same year. The resulting family of relative efficiency curves is shown in Figure 1.

Background

The 20 mm survey is carried out by the California Department of Fish and Game (http://www.delta.dfg.ca.gov/data/20mm/). The survey begins in the spring and samples at about 45 stations in the Bay-Delta system (east San

Pablo Bay to Stockton). Each survey takes about five days to complete. Surveys occur every two weeks. Barring unusual circumstances, at least eight surveys are conducted each year. The surveys catch delta smelt from sizes 5 mm and up, although few of the smaller sizes are caught.

Sometime, supplemental surveys are carried out at stations where delta smelt are especially abundant. None of the supplemental surveys were used in these estimates of relative gear efficiency.

The 20 mm surveys began in 1995. At the time this paper was prepared, 10 years of survey had occurred with at least eight surveys in all 10 years.

Delta smelt spawn in the late winter and almost all adults die after spawning (Bennett 2005). Eggs are attached to substrate such as rocks and, for that reason, cannot be sampled. Eggs hatch into 5 to 6 mm larvae in about two weeks (Bennett 2005). Larvae increase in length more or less linearly with time (Feyrer, 2004). Once all eggs have hatched, the 20 mm surveys sample the entire population. After all smelt have hatched, the size of the population must be declining with each survey as mortality occurs among all sizes of fish.

Method

I examined the surveys from all years and eliminated the surveys for which all delta smelt had not hatched. I assumed that all delta smelt had hatched when no 5 or 6 mm smelt were caught in a survey or in any following survey for that year. From the remaining surveys I discarded those in which very few delta smelt were caught and in which there were obvious discrepancies

in the catch of successive surveys (8,400 to 11,200 to 1,100, for example) The remaining catch data used in this analysis are shown in Table 1.

I assumed that the curve describing relative gear efficiency would be of the form shown in Figure 2, that is, a smooth curve with a value 1.0 at 20 mm and lower values at greater and lesser lengths. I defined this curve by four parameters, the relative efficiencies at 5 mm, 10 mm, 15 mm, and 60 mm. I originally used only three parameters, the values at 5 mm, 15 mm, and 60 mm. However, this produced a change in relative efficiency from 5 mm to 6 mm that was unrealistically high. I realized that the curve had to begin with a gentler slope at the smaller sizes, so I inserted a fourth parameter, the relative efficiency at 10 mm.

I assumed that the slope of this curve varied with the distance from the size with lower slope. An example can best describe the specifics of this method.

Assume that the relative efficiency at 5 mm is assumed to be 0.10 and the relative efficiency at 10 mm is assumed to be 0.25. There are five size steps from 5 to 10, that is, 1 step to 6 mm, 2 steps to 7 mm, and so forth. The sum of the step values is 15, that is, 1+2+3+4+5. The change in relative efficiency over the five steps from 5 mm to 10 mm is 0.25 - 0.10 = 0.15. This change of 0.15 is distributed over the sizes from 5 to 10 mm in proportion to the sum of step values from 5 mm. For example, the relative efficiency at 6 mm would be 0.10 + (1/15)*0.15 = 0.11, and the value at 7 mm would be 0.10 + (3/15)*0.15 = 0.13, and so forth.

This interpolation between parameters made it possible to define numerically the relative efficiency at any size and to make the relative efficiency at any size dependent only on the values of the four parameters. Other assumptions could have been made about how the slope varied from one size to the next, For example, the step values could have first been raised to some power. However, the approach I used was simple, and from the small differences in sizes it was apparent that a more complicated method was not justified.

Then, it was a matter of trial and error to find the ranges in curve-defining parameters that produced a family of curves that, when applied to the actual catch data, produced estimates of total population that decreased in each successive survey in the same year. This simple test, declining population in successive surveys, turned out to be surprisingly limiting given the number of surveys to which it was applied. The resulting curve and values of curve-defining parameters are shown in Figure 1.

Additional, more sophisticated tests could be devised to further refine the estimates. For example, another test would be a continually declining population of a size range from 5 mm to a value less than maximum. However, this single-test method seemed adequate for the data.

The results indicate that the 20 mm survey is highly inefficient for early life stage delta smelt. In fact, the relative efficiencies at small sizes are so small and variable that we can conclude that the survey is unreliable for estimates of abundance of delta smelt less than 10 or 15 mm in length. It might still be used cautiously for describing the distribution of delta smelt.

Figures and Table

Figure 1
Family of relative efficiency curves

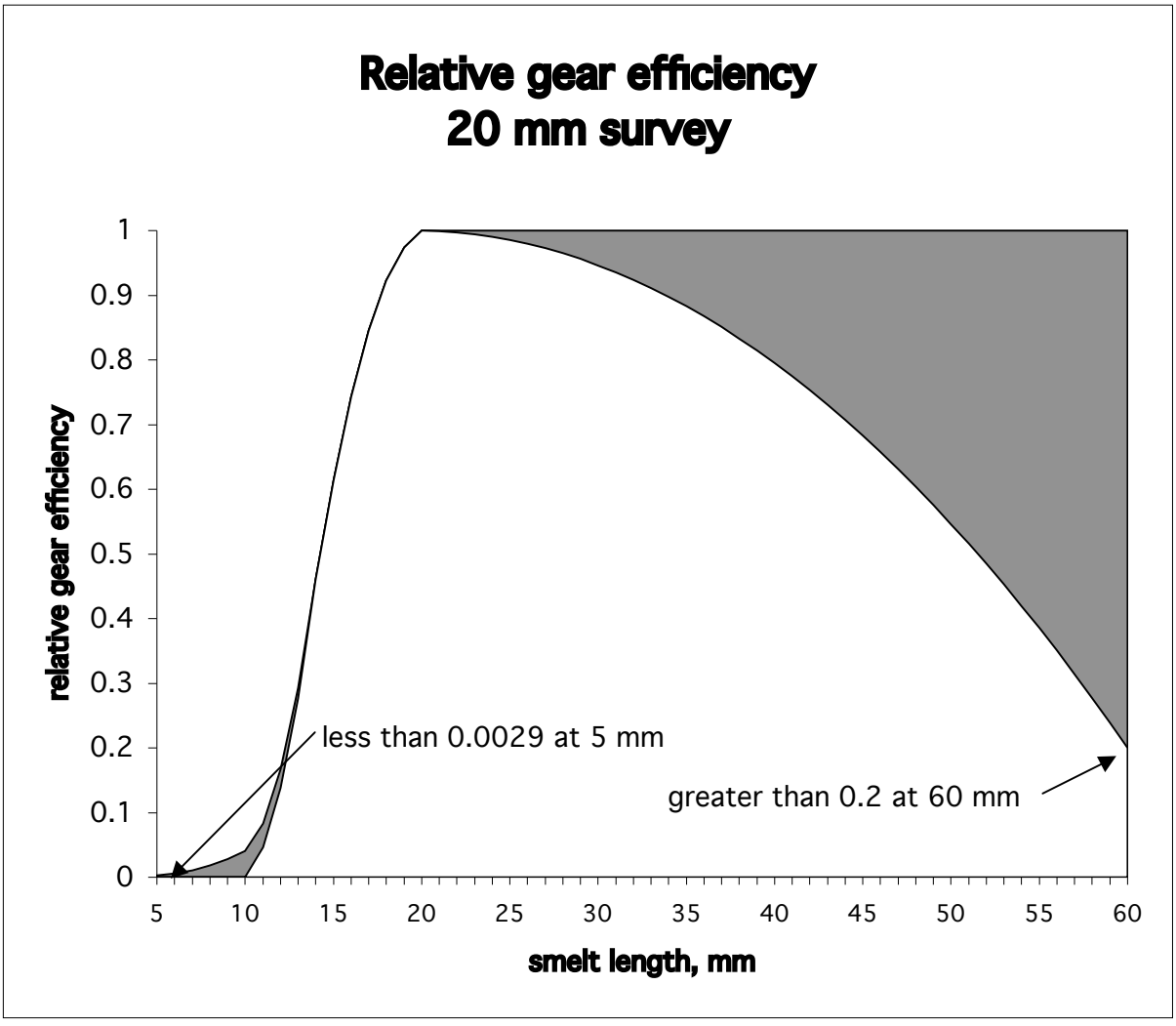

Table 1

20 mm survey catch data used in estimating relative gear efficiency

1996					1997					1998					1999					2000		2001				2003					2004		
survey #					survey #					survey #					survey #					survey #		survey #				survey #					survey #		
4	5	6	7	8	4	5	6	7	8	4	5	6	7	8	4	5	6	7	8	7	8	5	6	7	8	4	5	6	7	8	5	6	7
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6	0	0	0	8	0	0	0	0	0	0	0
4	0	0	0	0	5	0	0	0	0	0	0	0	0	0	6	1	2	0	0	0	0	18	0	0	0	1	4	3	1	0	0	0	0
7	1	2	0	0	7	0	0	0	0	0	0	0	0	0	10	7	1	0	0	2	0	12	1	0	0	1	3	1	0	1	0	0	0
3	3	2	0	0	14	1	0	0	0	3	0	0	0	0	8	6	3	0	0	2	0	13	2	0	0	0	1	2	1	0	0	0	0
10	13	0	0	0	29	4	0	0	0	1	2	1	0	0	9	11	9	0	0	3	1	13	3	0	0	1	2	4	3	0	1	1	0
21	24	5	0	0	14	5	0	0	0	3	1	0	0	0	11	11	17	2	0	2	1	13	1	1	0	0	6	10	3	1	0	0	0
30	43	3	0	0	16	14	1	0	0	6	2	0	0	0	10	15	11	2	0	6	1	9	4	0	0	1	4	5	2	4	1	0	0
33	52	3	1	0	20	15	1	0	0	3	3	0	0	0	9	14	14	2	1	15	2	9	8	2	0	1	11	2	3	2	2	0	0
30	39	2	5	1	17	32	0	0	0	1	2	0	0	0	22	18	22	8	0	30	3	16	5	0	0	0	6	5	13	0	2	2	0
37	39	3	1	0	20	81	1	0	0	1	3	4	0	0	14	15	20	15	1	62	2	13	9	6	0	3	2	1	12	1	3	3	0
31	18	2	2	2	15	139	8	0	0	2	6	4	0	0	18	13	17	20	0	93	5	10	13	1	0	2	1	4	9	3	8	3	0
44	32	4	12	1	17	121	14	0	0	6	6	3	0	0	9	21	17	23	2	128	9	10	8	9	1	0	3	8	11	1	13	2	1
58	19	6	6	2	8	117	28	2	0	7	5	2	0	1	17	13	6	25	1	175	6	6	13	9	0	3	2	13	17	3	17	0	1
50	26	22	6	4	10	81	37	1	0	2	6	2	1	0	24	27	12	16	3	154	12	6	16	16	2	3	1	11	9	5	19	4	2
85	33	18	8	7	11	52	37	3	1	8	9	8	1	1	21	33	12	12	5	109	34	3	9	23	0	0	3	8	10	5	19	0	1
61	39	8	7	4	4	29	37	2	0	5	5	0	0	1	25	23	13	22	9	40	39	1	13	19	1	2	4	5	5	2	12	6	0
49	40	13	9	3	2	23	16	5	0	2	10	5	3	0	25	19	22	10	6	37	37	2	10	18	2	1	4	3	7	2	12	8	6
35	35	13	16	9	1	28	15	11	1	2	3	3	0	0	32	20	23	15	6	15	26	4	14	26	3	0	2	2	9	2	17	8	2
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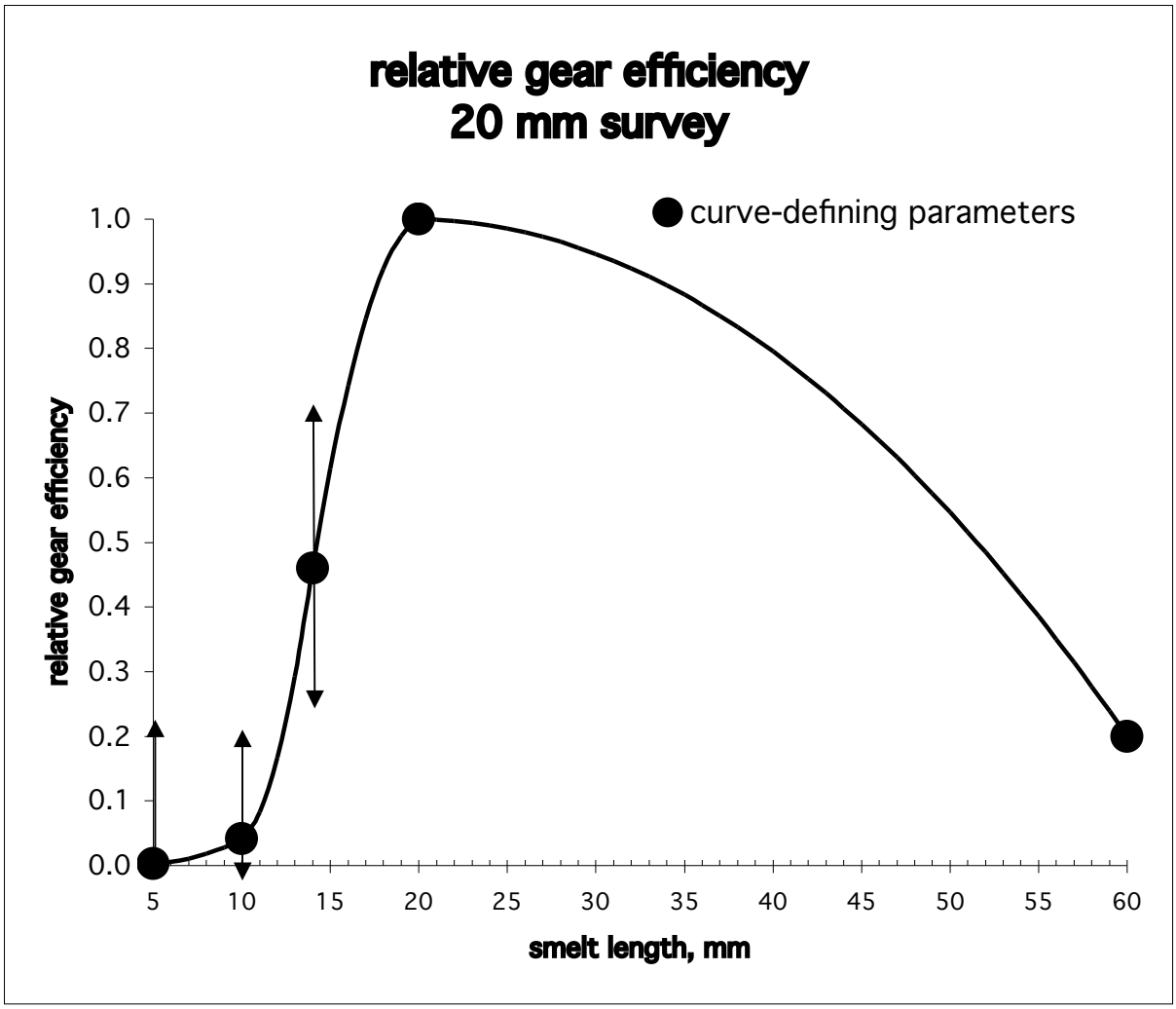
Figure 2
Trial relative efficiency curve and curve-defining parameters



References

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