

International Consultations on the Establishment of the
South Pacific Regional Fisheries Management Organisation

Effect of Reducing Fishing Mortality on Immature Jack Mackerel

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Evaluating Effects of Minimum Size Limits

The revised interim measures for pelagic fisheries adopted in November 2009 required that:

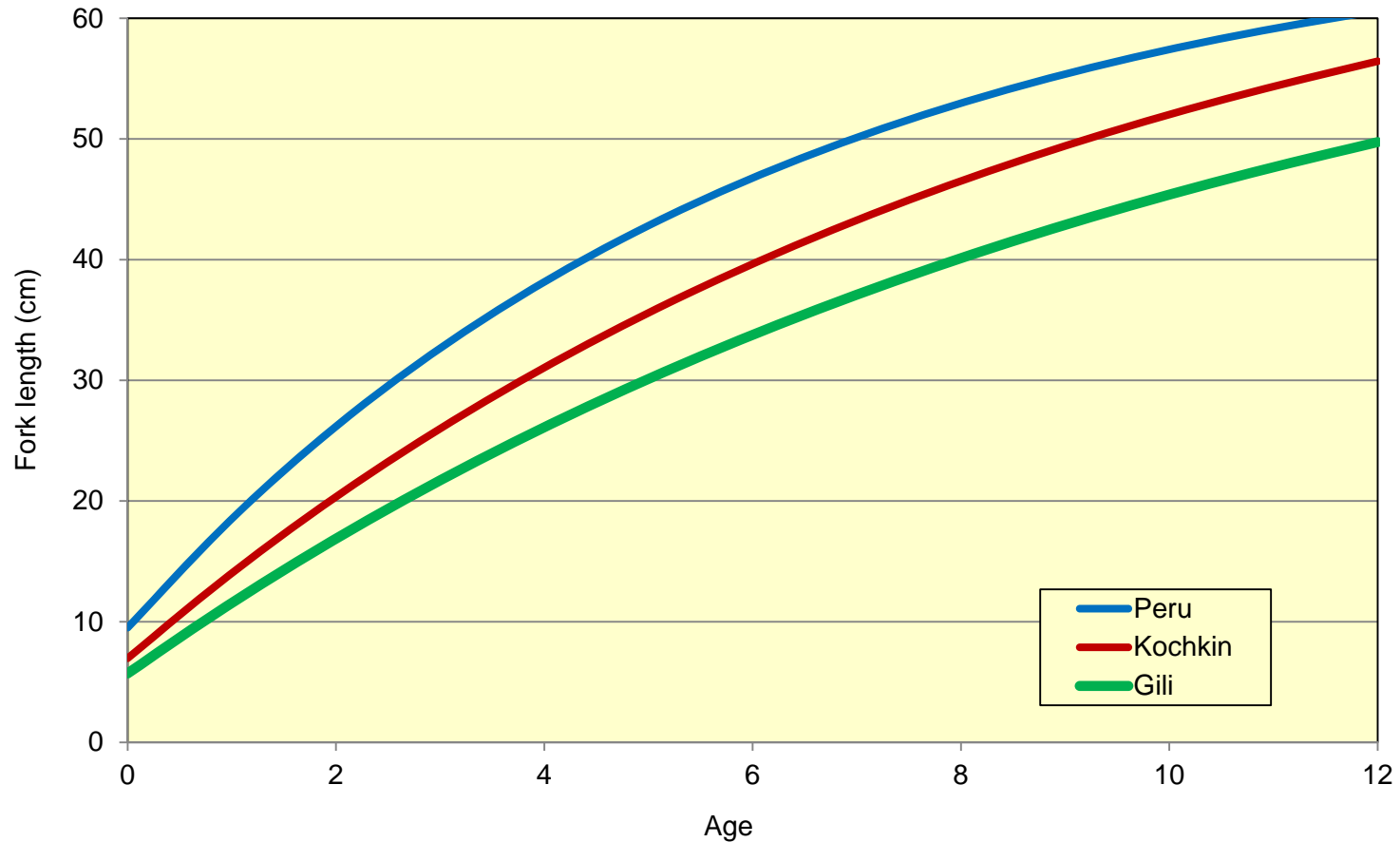
- *"In 2010, the SWG will conduct the necessary analysis and assessment to provide advice on stock status and recovery. If possible, based on the information available, this advice will include projections of stock status associated with the impact of a range of possible management measures, including minimum size lengths for Trachurus species and minimum fishery specific net mesh sizes."*

There two separate and very different questions that need to be answered when evaluating the effect of minimum size limits and net mesh sizes:

1. What would the potential benefits be of reducing catch / fishing mortality on small fish?
2. How effective would a minimum size limit or minimum net mesh size actually be in reducing catch / fishing mortality on small fish?

Of these two questions, the latter is the more important, and the most difficult to answer. Essentially the second question can only be properly answered by means of fishing experiments at sea. The first question is relatively easy to answer from results of stock assessments.

Jack Mackerel Growth Curves



Using the Gili (1995) growth formula, as used in the jack mackerel assessment base case (model 4), a 3 year old (immature) fish would be 22cm fork length, a 4-year old (maturing) fish would be 26cm fork length and 5+ (mature) fish would be >30cm fork length.

Current Fishing Mortality by Age - Northern Fisheries

Age	2	3	4	5	6	7	8	9	10	11	12
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1975	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
1977	0.01	0.02	0.04	0.06	0.05	0.03	0.05	0.05	0.05	0.05	0.05
1978	0.00	0.01	0.03	0.05	0.04	0.03	0.04	0.04	0.04	0.04	0.04
1979	0.00	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1980	0.00	0.01	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
1981	0.00	0.01	0.02	0.04	0.03	0.02	0.03	0.03	0.03	0.03	0.03
1982	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1983	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1984	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1985	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
1986	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1989	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1990	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1991	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1992	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1993	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1994	0.00	0.01	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.02
1995	0.01	0.03	0.05	0.09	0.07	0.05	0.07	0.07	0.07	0.07	0.07
1996	0.01	0.03	0.06	0.09	0.07	0.05	0.07	0.07	0.07	0.07	0.07
1997	0.01	0.04	0.08	0.13	0.10	0.07	0.10	0.10	0.10	0.10	0.10
1998	0.01	0.04	0.08	0.13	0.10	0.07	0.10	0.10	0.10	0.10	0.10
1999	0.00	0.01	0.02	0.04	0.03	0.02	0.03	0.03	0.03	0.03	0.03
2000	0.01	0.02	0.04	0.06	0.05	0.03	0.05	0.05	0.05	0.05	0.05
2001	0.02	0.07	0.14	0.22	0.17	0.12	0.17	0.17	0.17	0.17	0.17
2002	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
2003	0.00	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2004	0.00	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
2005	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2006	0.01	0.02	0.05	0.08	0.06	0.04	0.06	0.06	0.06	0.06	0.06
2007	0.01	0.02	0.04	0.07	0.06	0.04	0.06	0.06	0.06	0.06	0.06
2008	0.01	0.02	0.04	0.07	0.05	0.04	0.05	0.05	0.05	0.05	0.05
2009	0.00	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
2010	0.00	0.02	0.03	0.05	0.04	0.03	0.04	0.04	0.04	0.04	0.04

Fishery 3: Far North: Max F = 0.22 (2001 age 5)

Age	2	3	4	5	6	7	8	9	10	11	12
1970	0.00	0.01	0.01	0.03	0.06	0.10	0.10	0.03	0.01	0.01	0.01
1971	0.00	0.01	0.01	0.03	0.05	0.10	0.09	0.03	0.01	0.01	0.01
1972	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.01	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.01	0.00	0.00	0.00
1974	0.00	0.00	0.01	0.02	0.03	0.06	0.06	0.02	0.01	0.01	0.01
1975	0.00	0.00	0.01	0.02	0.03	0.06	0.06	0.02	0.01	0.01	0.01
1976	0.00	0.00	0.01	0.02	0.03	0.06	0.06	0.02	0.01	0.01	0.01
1977	0.00	0.00	0.01	0.02	0.03	0.06	0.06	0.02	0.01	0.01	0.01
1978	0.00	0.01	0.01	0.03	0.06	0.11	0.10	0.04	0.01	0.01	0.01
1979	0.00	0.00	0.01	0.02	0.04	0.08	0.08	0.03	0.01	0.01	0.01
1980	0.00	0.00	0.01	0.01	0.03	0.06	0.05	0.02	0.00	0.00	0.00
1981	0.00	0.00	0.01	0.02	0.04	0.08	0.07	0.03	0.01	0.01	0.01
1982	0.00	0.01	0.02	0.04	0.08	0.14	0.13	0.05	0.01	0.01	0.01
1983	0.00	0.00	0.01	0.01	0.02	0.04	0.04	0.01	0.00	0.00	0.00
1984	0.00	0.01	0.01	0.03	0.06	0.11	0.10	0.04	0.01	0.01	0.01
1985	0.00	0.00	0.01	0.02	0.04	0.07	0.07	0.02	0.01	0.01	0.01
1986	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
1987	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1988	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1989	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1990	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1991	0.01	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00
1992	0.01	0.04	0.04	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00
1993	0.01	0.05	0.06	0.04	0.04	0.02	0.02	0.01	0.01	0.01	0.01
1994	0.01	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
1995	0.01	0.04	0.04	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00
1996	0.01	0.06	0.06	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.01
1997	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2001	0.01	0.04	0.04	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00
2002	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2003	0.01	0.03	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
2004	0.01	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
2005	0.01	0.04	0.04	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00
2006	0.01	0.04	0.05	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01
2007	0.02	0.07	0.07	0.05	0.05	0.03	0.02	0.01	0.01	0.01	0.01
2008	0.03	0.11	0.12	0.09	0.07	0.05	0.03	0.02	0.01	0.01	0.01
2009	0.03	0.12	0.13	0.10	0.08	0.06	0.04	0.02	0.01	0.01	0.01
2010	0.04	0.16	0.18	0.13	0.11	0.07	0.05	0.03	0.02	0.02	0.02

Fishery 1: North Chile: Max F = 0.18 (2010 age 4)

The potential benefit of reducing F on small fish is directly related to the current impact on small fish. In the northern fisheries over 2006-2010, F on immature fish (ages 2 - 4) averaged 0.10; F on mature fish (ages 5 - 12) averaged 0.08

Current Fishing Mortality by Age - Southern Fisheries

Age	2	3	4	5	6	7	8	9	10	11	12
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.01	0.04	0.08	0.10	0.07	0.02	0.02	0.02
1980	0.00	0.00	0.00	0.01	0.03	0.05	0.07	0.05	0.01	0.01	0.01
1981	0.00	0.00	0.00	0.01	0.03	0.07	0.08	0.06	0.01	0.01	0.01
1982	0.00	0.00	0.01	0.02	0.05	0.11	0.14	0.10	0.02	0.02	0.02
1983	0.00	0.00	0.01	0.02	0.06	0.13	0.17	0.12	0.03	0.03	0.03
1984	0.00	0.00	0.01	0.03	0.07	0.15	0.19	0.14	0.03	0.03	0.03
1985	0.00	0.00	0.01	0.02	0.05	0.11	0.14	0.10	0.02	0.02	0.02
1986	0.00	0.00	0.00	0.02	0.04	0.09	0.12	0.08	0.02	0.02	0.02
1987	0.00	0.00	0.00	0.02	0.05	0.09	0.12	0.08	0.02	0.02	0.02
1988	0.00	0.00	0.00	0.02	0.04	0.09	0.11	0.08	0.02	0.02	0.02
1989	0.00	0.00	0.00	0.01	0.04	0.08	0.10	0.07	0.02	0.02	0.02
1990	0.00	0.00	0.00	0.01	0.04	0.07	0.09	0.07	0.02	0.02	0.02
1991	0.00	0.00	0.00	0.01	0.02	0.05	0.06	0.04	0.01	0.01	0.01
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2002	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.03	0.03	0.03
2003	0.00	0.00	0.01	0.02	0.04	0.06	0.08	0.07	0.05	0.05	0.05
2004	0.00	0.00	0.01	0.04	0.07	0.11	0.13	0.12	0.09	0.09	0.09
2005	0.00	0.00	0.01	0.03	0.06	0.08	0.10	0.09	0.07	0.07	0.07
2006	0.00	0.00	0.02	0.05	0.09	0.13	0.16	0.15	0.11	0.11	0.11
2007	0.00	0.01	0.03	0.08	0.14	0.21	0.25	0.23	0.17	0.17	0.17
2008	0.00	0.01	0.03	0.10	0.19	0.28	0.34	0.31	0.23	0.23	0.23
2009	0.00	0.01	0.05	0.14	0.26	0.39	0.48	0.44	0.32	0.32	0.32
2010	0.00	0.01	0.06	0.18	0.33	0.49	0.60	0.55	0.40	0.40	0.40

Fleet 4: Offshore Trawl: Max F = 0.60 (2010 age 8)

Age	2	3	4	5	6	7	8	9	10	11	12
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1977	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1978	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
1979	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1980	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
1981	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.04
1982	0.00	0.00	0.01	0.03	0.05	0.08	0.06	0.06	0.06	0.06	0.06
1983	0.00	0.00	0.01	0.02	0.04	0.06	0.05	0.05	0.05	0.05	0.05
1984	0.00	0.00	0.01	0.02	0.04	0.07	0.06	0.06	0.06	0.06	0.06
1985	0.00	0.00	0.02	0.03	0.05	0.09	0.07	0.07	0.07	0.07	0.07
1986	0.00	0.00	0.02	0.03	0.06	0.09	0.07	0.07	0.07	0.07	0.07
1987	0.00	0.01	0.02	0.04	0.07	0.11	0.09	0.09	0.09	0.09	0.09
1988	0.00	0.01	0.02	0.05	0.09	0.14	0.11	0.11	0.11	0.11	0.11
1989	0.00	0.01	0.03	0.05	0.09	0.14	0.12	0.12	0.12	0.12	0.12
1990	0.00	0.01	0.03	0.05	0.09	0.14	0.12	0.12	0.12	0.12	0.12
1991	0.00	0.01	0.04	0.07	0.13	0.21	0.17	0.17	0.17	0.17	0.17
1992	0.00	0.02	0.05	0.11	0.19	0.30	0.25	0.25	0.25	0.25	0.25
1993	0.00	0.02	0.06	0.12	0.21	0.33	0.27	0.27	0.27	0.27	0.27
1994	0.00	0.03	0.09	0.18	0.32	0.51	0.42	0.42	0.42	0.42	0.42
1995	0.01	0.04	0.15	0.30	0.53	0.85	0.70	0.70	0.70	0.70	0.70
1996	0.01	0.05	0.17	0.34	0.60	0.95	0.78	0.78	0.78	0.78	0.78
1997	0.01	0.07	0.26	0.52	0.92	1.46	1.20	1.20	1.20	1.20	1.20
1998	0.01	0.07	0.24	0.46	0.82	1.31	1.08	1.08	1.08	1.08	1.08
1999	0.01	0.05	0.17	0.34	0.61	0.97	0.79	0.79	0.79	0.79	0.79
2000	0.00	0.04	0.13	0.25	0.45	0.71	0.58	0.58	0.58	0.58	0.58
2001	0.00	0.03	0.12	0.23	0.41	0.65	0.54	0.54	0.54	0.54	0.54
2002	0.00	0.03	0.11	0.22	0.39	0.61	0.50	0.50	0.50	0.50	0.50
2003	0.00	0.03	0.09	0.18	0.33	0.52	0.43	0.43	0.43	0.43	0.43
2004	0.00	0.02	0.09	0.17	0.30	0.48	0.39	0.39	0.39	0.39	0.39
2005	0.00	0.02	0.08	0.15	0.28	0.44	0.36	0.36	0.36	0.36	0.36
2006	0.00	0.02	0.08	0.16	0.29	0.46	0.38	0.38	0.38	0.38	0.38
2007	0.00	0.03	0.10	0.20	0.35	0.56	0.46	0.46	0.46	0.46	0.46
2008	0.00	0.03	0.10	0.19	0.34	0.54	0.45	0.45	0.45	0.45	0.45
2009	0.00	0.04	0.15	0.29	0.52	0.82	0.67	0.67	0.67	0.67	0.67
2010	0.00	0.03	0.12	0.23	0.41	0.65	0.54	0.54	0.54	0.54	0.54

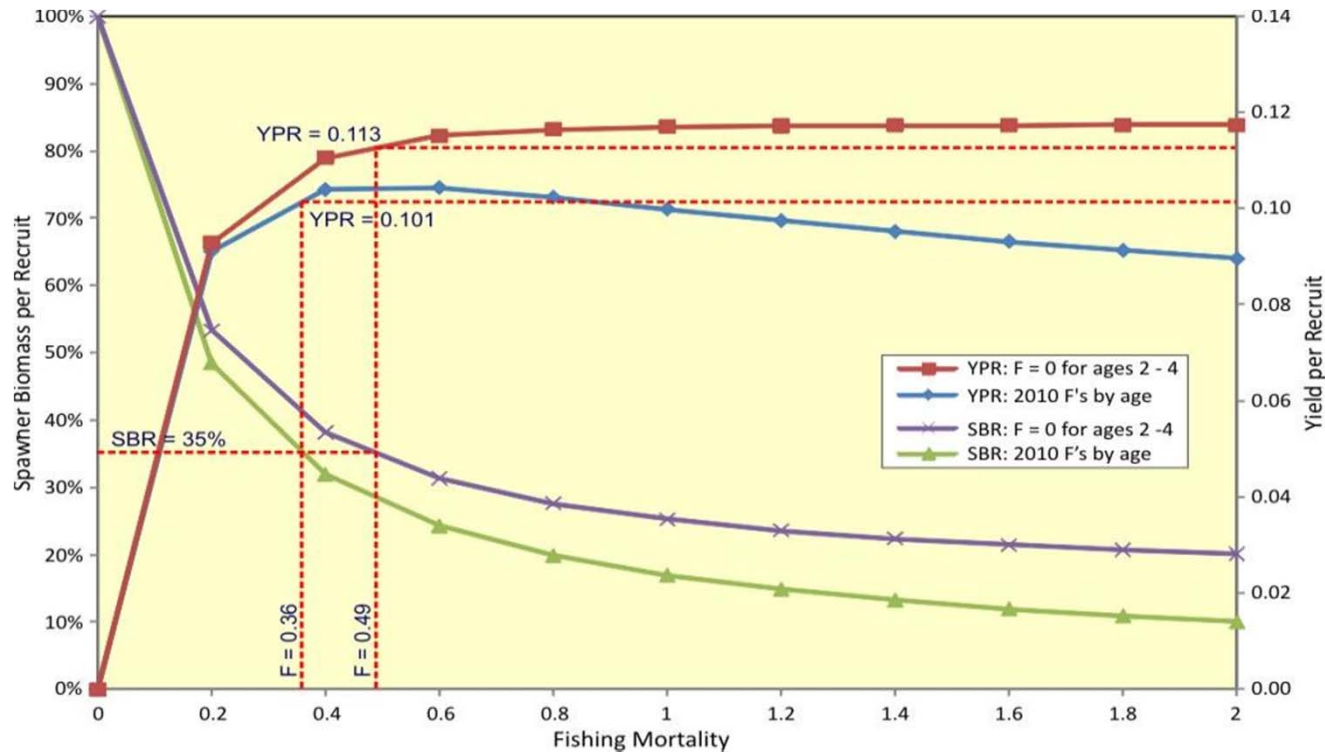
Fishery 2: SC Chile PS: Max F = 1.46 (1997 age 7)

In contrast, in the southern fisheries over 2006-2010, F on immature fish (ages 2 -4) averaged 0.06; F on mature fish (ages 5 - 12) averaged 0.72

Effect of Reducing F on Immature Fish

For a hypothetical minimum size limit of 28cm Lf that is 100% effective in preventing catches of immature fish ages 0-4:

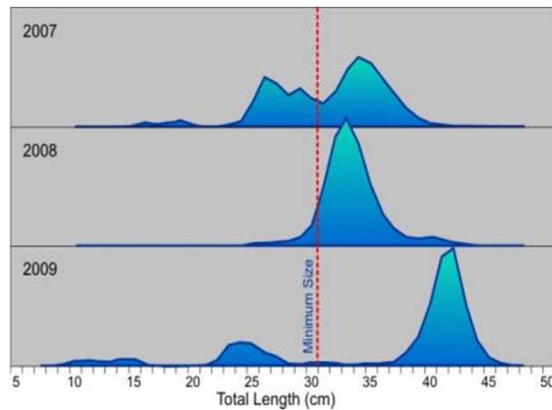
Size Limit Effectiveness	100%												Average F is reduced from 0.79 to 0.73 (exploitation reduced from 50% to 47%)	
Age	2	3	4	5	6	7	8	9	10	11	12	Avg F	μ	
2010 F's by Age	0.05	0.22	0.39	0.59	0.89	1.24	1.22	1.16	0.99	0.99	0.99	0.79	50%	
F ages 2-4 = 0	0.00	0.00	0.00	0.59	0.89	1.24	1.22	1.16	0.99	0.99	0.99	0.73	47%	



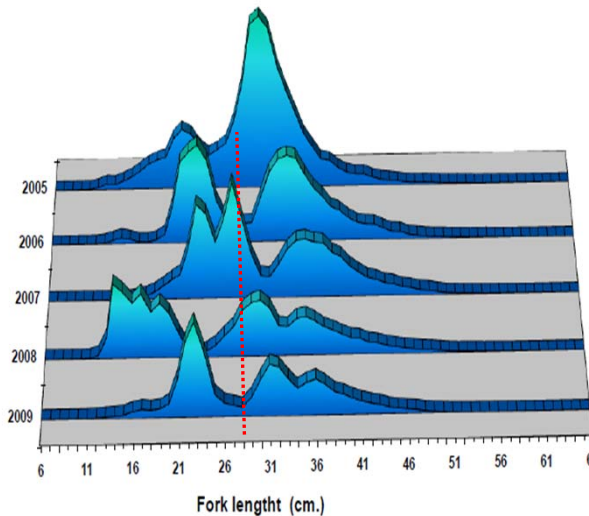
For a SBR reference level of 35%, reduction in fishing mortality to zero for fish age 0 - 4 could potentially result, over the long-term, in a 12% increase in YPR, and allow sustainable fishing mortality on the remaining age classes to increase from 0.36 to 0.49 (exploitation rate increase from 27% to 35%). This would still require at least a 30% reduction in exploitation of the remaining age classes.

Jack Mackerel Length Frequencies

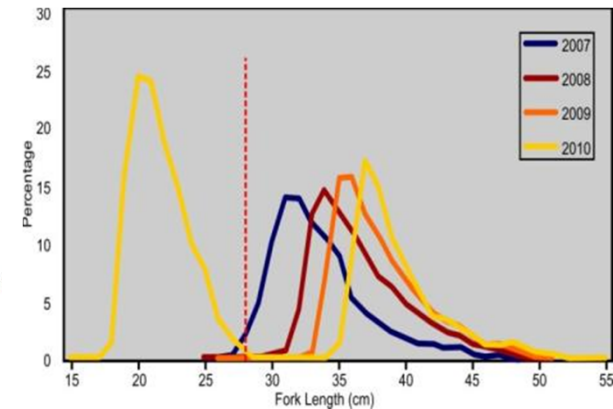
So there are some moderate potential benefits to be gained from reducing F on immature fish, but only if the measures implemented are genuinely effective in preventing or substantially reducing the catch of young fish.



Peruvian Fishery 2007 to 2009
Purse-seine fishery, mesh size 38m,
size limit 31cm total length



Chilean Fishery 2005 - 2009
Purse-seine fishery, various
mesh sizes, no size limit



EU PFA Fleet 2007 - 2010
Pelagic trawl fishery, cod-end mesh
size 53mm - 60mm, no size limit

However, fish smaller than 28cm fork length (31cm total length) are currently caught in all of the different fisheries when they are available, with different gear types and mesh sizes, whether there is currently a size limit in place or not. (2010 National Reports)

Limitations on Effectiveness of Minimum Size Limits

Conclusions

- While there are moderate potential benefits to be gained from preventing or substantially reducing F on immature fish, this would not greatly reduce the need for reduction in F on adult fish. Even if size limits were 100% effective in preventing catch of fish smaller than 28cm fork length, this would only reduce F from ~ 0.79 to ~ 0.73 . F needs to be reduced to ~ 0.4
- It is clear that all current gear types and net mesh sizes are capable of catching fish smaller than 28cm fork length, with even the largest pelagic trawl cod-end mesh size of 60mm being capable of targeting fish smaller than 20cm if available. A minimum size or mesh size limit would therefore not be 100% effective in preventing catch of small fish.
- There would also be substantial observer and compliance monitoring requirements to ensure that adoption of a minimum size or mesh size limit did not simply result in discarding of small fish.