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DOCUMENT SARM-9-06c**EVALUATION OF THE EFFECT OF RESOLUTIONS C-04-09 AND
C-06-02**

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1. INTRODUCTION

Resolution C-04-09 on the conservation of tuna in the eastern Pacific Ocean called for restrictions on purse-seine effort and longline catches for 2004 to 2006: a 6-week closure during the third or fourth quarter of the year for purse-seine fisheries, and for limits on the longline catches of each country equal to their 2001 longline catches or, in the case of Japan, 34,076 metric tons (t). Resolution C-06-02 extended the measures into 2007. We investigate the effectiveness of this management measure, first by examining the changes in purse-seine fishing effort (measured by days fishing) and the longline catches of bigeye, and then with a simulation of the effect of assumed purse-seine effort and longline catch in the absence of the resolutions.

2. PURSE-SEINE EFFORT

In this section the effort by purse-seine vessels, in number of days fished, is compared with the effort by purse-seine vessels in 2003. Previous analyses had suggested that the conservation measures in that year had little effect on the purse-seine fishery.

In 2004 there was a reduction of effort in the floating-object fisheries, particularly in the third quarter (Tables 1 and 2). Overall, there was a 22% reduction in days fished, with a 46% reduction in the third quarter. However, in 2005, 2006, and 2007, respectively, the third-quarter effort was only 26%, 8%, and 27% less, and the total effort was 6%, 21%, and 7% greater than in 2003.

Effort in the fisheries for unassociated fish was reduced by 16% in the fourth quarter of 2004, but this was more than offset by increased effort in the second and third quarters, resulting in 6% more days fished for the year (Tables 3 and 4). In 2005, 2006, and 2007, the number of days fished in the fourth quarter was 37% greater, 42% less, and 27% less, respectively, than in 2003; the annual totals were 17%, 8%, and 19% greater, respectively, than in 2003.

Effort in the dolphin-associated fisheries fell by 25% in the fourth quarter of 2004, but increases in the first through third quarters resulted in an overall 15% increase in days fished in 2004 (Tables 3 and 4). Dolphin-associated effort in the second quarter was again greater in 2005 than in 2003, but in all other quarters was lower, resulting in 2% less effort than in 2003. The effort, compared to that in 2003, in 2006 was lower in all but the first quarter, and the annual total was 10% lower, and in 2007 was lower in all but the second quarter, and the annual total was 11% lower.

3. LONGLINE CATCH

Data for longline catch are provided to the IATTC staff on a monthly basis. The data from the most recent years are not complete, but, due to the monthly reporting, the majority of the catch is accounted for. The longline catch of bigeye has decreased substantially since 2001 (Table 5); in 2006 it was only 51% of that in 2001 and 62% of the combined catch limit for Chinese Taipei, China, Korea, and Japan. The data for 2007 are too incomplete to make any comparisons, but the catches reported for the major fishing nations are lower than in 2006.

4. SIMULATION OF EFFECTS OF MEASURES

4.1. Methods

To assess the utility of these management actions, we projected the population forward through 2012, assuming that the conservation measures were not implemented, as described below. We started the projections in 2004, to include the first year of the management measure. To approximate the choice of closure period made by the fishing nations, it was assumed that the 6-week closure occurred in the third and fourth quarters for bigeye and yellowfin, respectively, and that the effect of the closure was to reduce fishing effort by about 12%. For the longline fisheries whose catches were restricted in 2004, the ratio of catch in 2003 to catch in 2004 was used to increase the effort to represent no restrictions; the actual reduction of catches of bigeye in 2004 compared to 2003 was used as the basis for the simulation of fishing with restrictions. This was a greater reduction than that required by the resolutions. It was also assumed that the limitations on bigeye catches resulted in the same reduction of fishing effort for yellowfin as for bigeye.

Bigeye tuna: For each year in the projection (2008-2012), quarterly fishing mortality was set equal to the average for 2005-2007 adjusted to remove the effect of the conservation measures. The *Stock Synthesis II* software used for this assessment of bigeye does not allow effort to be predicted by quarter, so the effect of the resolutions is spread over all quarters. For 2004-2006, purse-seine catch in the third quarter was increased by 86%, and the catch in the southern longline fishery was increased by 39% in all quarters. For all quarters of 2008-2012, purse-seine effort was increased by 13% and the effort in the southern longline fishery was increased by 39%.

Yellowfin tuna: For each year in the projection (2008-2012), quarterly fishing mortality was set equal to the average for 2005-2007 adjusted to remove the effect of the conservation measures. For all years (2004-2012), the purse-seine effort in the fourth quarter was increased by 86%, and the effort in the southern longline fishery was increased by 39% in all quarters.

4.2. Results

With the management restrictions, the spawning biomass of bigeye at the end of 2007 is about 131% greater than it would have been if no restrictions had been implemented (Table 6). The spawning biomass has recently increased, due to recent spikes in recruitment, and will continue increasing through 2011 before declining again. It is predicted to increase above the level corresponding to the maximum sustainable yield (MSY), but decrease below that level by 2013 (Figure 1). It will decline even further if no restrictions are implemented.

If no restrictions had been implemented, the purse-seine catch of bigeye in 2004-2007 would have been 12% greater, and the longline catch 39% greater. (This is a consequence of the method used to model the effect of the restriction.) However, it is predicted that by 2008, the catches based on the lesser effort resulting from the restrictions would be greater than those based on the unrestricted effort (Table 6).

The spawning biomass of yellowfin at the end of 2007 with the management restrictions is about 12% greater than it would be if no restrictions had been implemented (Table 7, Figure 2).

If no restrictions had been implemented, the purse-seine catch of yellowfin in 2004 and 2005 would have been 10% and 4% greater, and the longline catch 32% and 21% greater, respectively. It is predicted that the purse-seine catch in 2006 would have been lower without the restriction; however, by 2007 it would be similar with and without restrictions. Catches in the longline fishery are predicted to remain lower with the restricted effort than without the restrictions.

5. DISCUSSION

Most yellowfin are taken in sets on schools associated with dolphins, and all the effort on such schools is directed at yellowfin. Fishing effort of this type, measured by days fished, increased in 2004 and decreased in 2005-2007, relative to 2003. The effect of the resolutions was reduced by the fact that nine large purse-seine vessels continued to fish during the closure in 2004, contributing to the greater effort.

In all the years with closures, the effort on unassociated schools was greater than in 2003. However, some of the effort on unassociated schools during the second and third quarters of the year is directed at bluefin tuna. Notwithstanding these factors, the simulation probably overestimates the effect of the management measures on yellowfin.

In the floating-object fishery, the fishing effort decreased in 2004 and increased in 2005-2007, relative to 2003.

The capacity of the purse-seine fleet, in cubic meters of well volume, increased steadily during 2003-2007, from 203,000 to 227,000 m³. This growth in capacity, together with the operational adjustments to the closures made by the fleet, is constraining the effect of the management measures. A comparison of changes in effort over time, by purse-seine set type, indicates that the majority of this increase in capacity is directed at tuna associated with floating objects or unassociated schools (Figure 3).

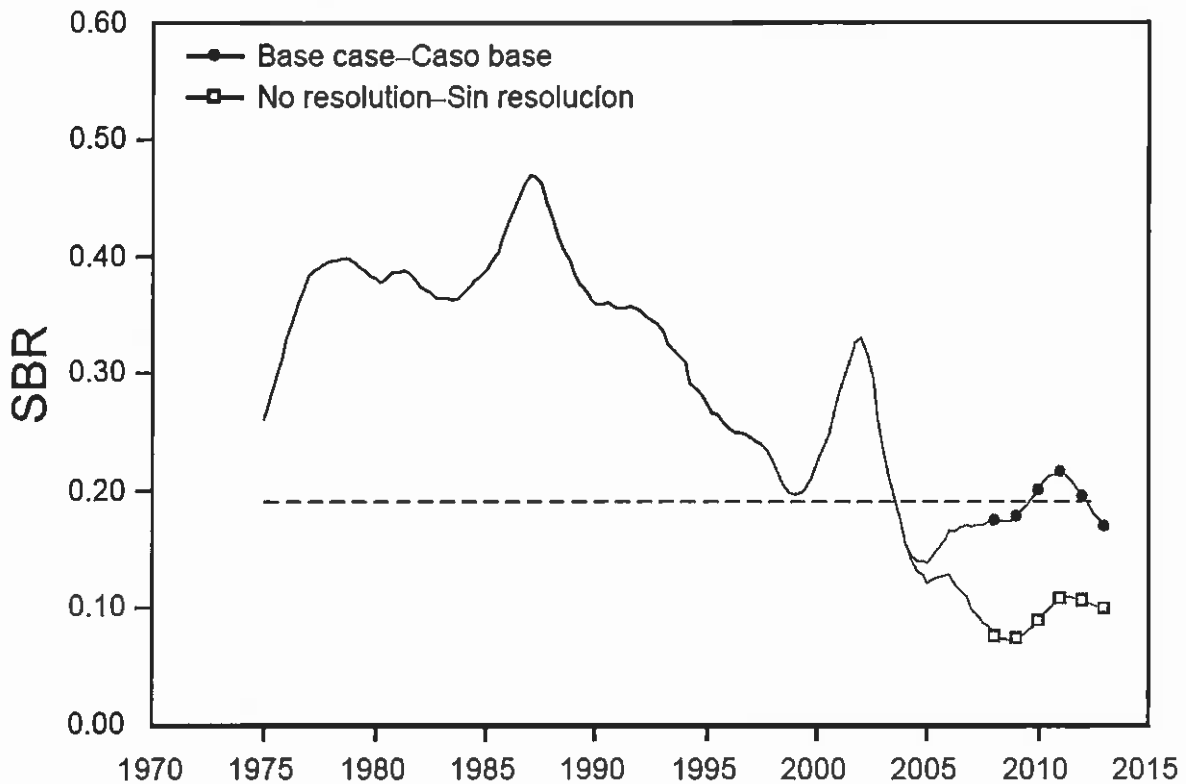


FIGURE 1. Maximum likelihood estimates of the projected spawning biomass ratios (SBRs) of bigeye, using average fishing mortality rate for 2005-2007 (“Base case”) and with purse-seine effort in the third quarter increased by 86% and effort increased in all quarters by 39% for the southern longline fishery to approximate the effect of no restrictions (“No resolution”). The horizontal line indicates the SBR_{MSY} (0.19).

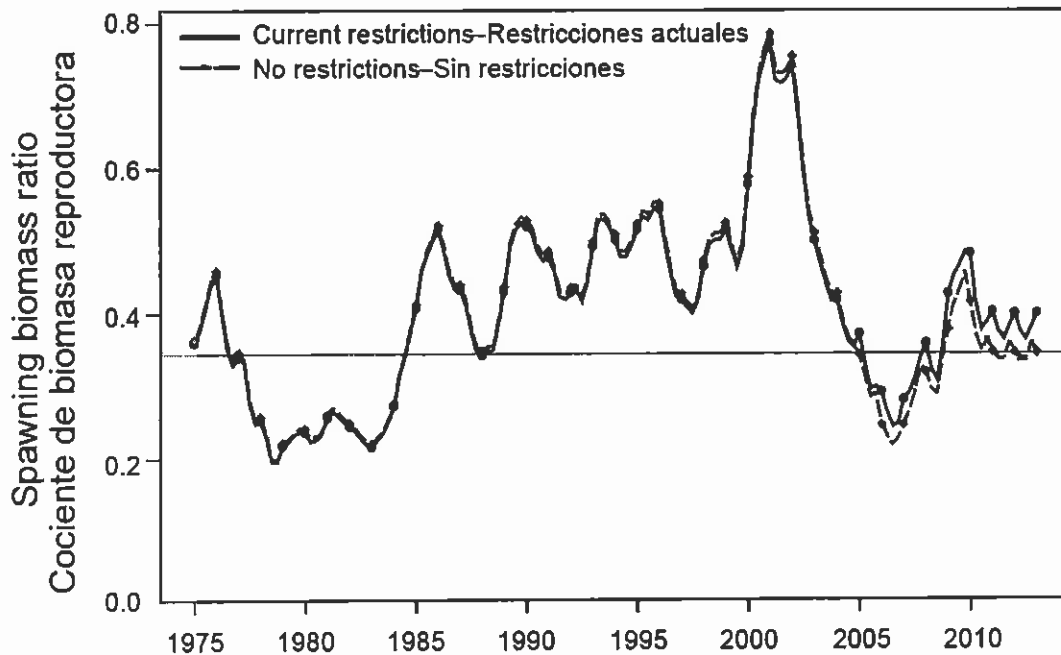


FIGURE 2. Maximum likelihood estimates of the projected spawning biomass ratios (SBRs) of yellowfin, with current fishing effort (based on the average fishing mortality during 2005-2007) (“Current restrictions”) and with purse-seine effort in the fourth quarter since 2004 increased by 86% and effort since 2004 increased in all quarters by 39% for the southern longline fishery to approximate the effect of no restrictions (“No restrictions”). The horizontal line indicates the SBR_{MSY} (0.37).

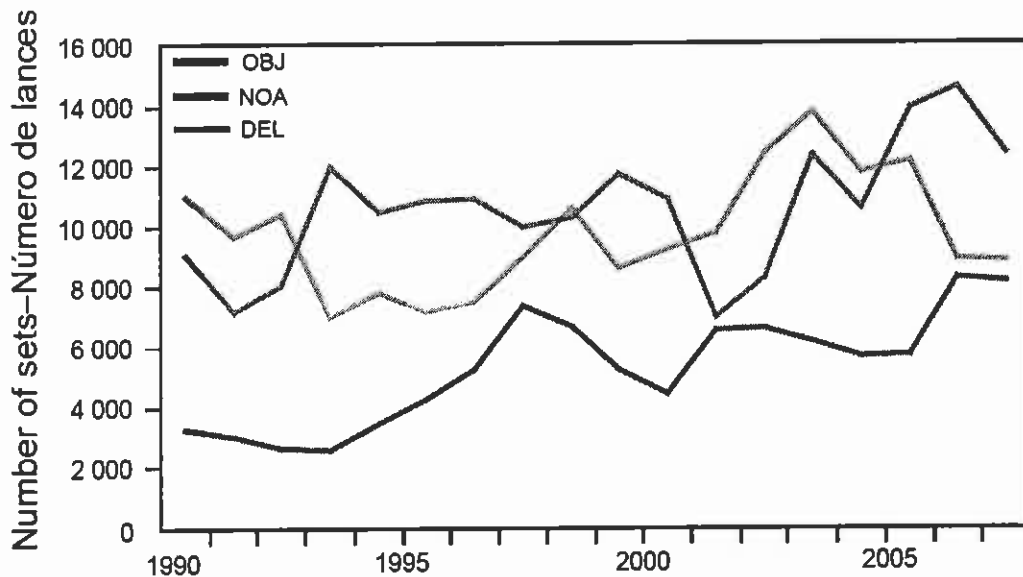


FIGURE 3. Purse-seine effort, in number of sets, by set type, 1990-2007. OBJ: floating object; NOA: unassociated; DEL: dolphin.

TABLE 1. Effort, in days fished, for the floating-object fisheries defined in the bigeye assessment.

Year	Quarter	Fishery 2	Fishery 3	Fishery 4	Fishery 5	Total
2003	1	1086	386	1203	336	3011
	2	1108	581	1025	828	3540
	3	628	2401	1465	1389	5884
	4	1123	2746	878	722	5470
Total		3944	6114	4571	3275	17905
2004	1	1517	438	1162	287	3404
	2	1416	305	412	787	2920
	3	605	1094	449	1040	3189
	4	872	2462	446	690	4469
Total		4410	4299	2469	2804	13982
2005	1	1114	769	1309	478	3670
	2	1055	1346	1705	1190	5296
	3	492	1457	1326	1061	4335
	4	1096	2327	1315	903	5641
Total		3756	5899	5655	3632	18942
2006	1	1337	965	1720	341	4363
	2	1561	1511	1299	1184	5554
	3	917	2558	648	1298	5422
	4	1066	3308	1150	802	6327
Total		4881	8343	4817	3626	21666
2007	1	1644	1045	1497	405	4591
	2	1759	1239	887	868	4753
	3	980	1474	516	1319	4289
	4	1192	2272	1044	1047	5555
Total		5574	6030	3945	3640	19188

TABLE 2. Change in effort relative to that in 2003 for the floating-object fisheries defined in the bigeye assessment.

Year	Quarter	Fishery 2	Fishery 3	Fishery 4	Fishery 5	Total
2004	1	1.40	1.13	0.97	0.85	1.13
	2	1.28	0.52	0.40	0.95	0.82
	3	0.96	0.46	0.31	0.75	0.54
	4	0.78	0.90	0.51	0.95	0.82
Total		1.12	0.70	0.54	0.86	0.78
2005	1	1.03	1.99	1.09	1.42	1.22
	2	0.95	2.32	1.66	1.44	1.50
	3	0.78	0.61	0.90	0.76	0.74
	4	0.98	0.85	1.50	1.25	1.03
Total		0.95	0.96	1.24	1.11	1.06
2006	1	1.23	2.50	1.43	1.02	1.45
	2	1.41	2.60	1.27	1.43	1.57
	3	1.46	1.07	0.44	0.93	0.92
	4	0.95	1.20	1.31	1.11	1.16
Total		1.24	1.36	1.05	1.11	1.21
2007	1	1.51	2.71	1.24	1.21	1.53
	2	1.59	2.13	0.87	1.05	1.34
	3	1.56	0.61	0.35	0.95	0.73
	4	1.06	0.83	1.19	1.45	1.02
Total		1.41	0.99	0.86	1.11	1.07

TABLE 3. Effort, in days fished, for the unassociated and dolphin-associated fisheries defined in the yellowfin assessment.

Year	Quarter	Fishery 5	Fishery 6	Fishery 7	Fishery 8	Fishery 9	Unassociated	Dolphin
2003	1	1093	2679	981	1685	469	3772	3135
	2	1241	2637	916	1267	532	3878	2715
	3	1359	1231	1101	1598	375	2589	3075
	4	1125	1568	908	1499	387	2694	2793
Total		4818	8115	3905	6048	1764	12933	11718
2004	1	938	2710	540	1942	1119	3648	3602
	2	1407	3440	976	1807	1265	4846	4048
	3	1674	1306	1264	1824	583	2979	3671
	4	686	1568	804	879	419	2254	2102
Total		4705	9024	3584	6453	3387	13728	13424
2005	1	1338	3207	656	1382	510	4544	2548
	2	1408	2544	1217	1920	554	3952	3691
	3	2009	866	763	1638	161	2875	2563
	4	702	2993	861	1498	330	3695	2689
Total		5457	9610	3498	6438	1555	15067	11491
2006	1	1117	4071	311	2525	701	5188	3536
	2	1485	3017	662	1581	435	4502	2678
	3	1626	1107	772	1476	192	2733	2439
	4	416	1146	487	1155	199	1562	1841
Total		4644	9341	2232	6736	1527	13985	10495
2007	1	1332	3932	173	2032	340	5264	2546
	2	1509	2816	806	1906	579	4325	3291
	3	3013	856	945	1050	248	3869	2242
	4	565	1388	565	1673	134	1953	2371
Total		6419	8992	2488	6661	1301	15411	10450

TABLE 4. Change in effort relative to that in 2003 for the unassociated and dolphin-associated fisheries defined in the yellowfin assessment.

Year	Quarter	Fishery 5	Fishery 6	Fishery 7	Fishery 8	Fishery 9	Unassociated	Dolphin
2004	1	0.86	1.01	0.55	1.15	2.38	0.97	1.15
	2	1.13	1.30	1.07	1.43	2.38	1.25	1.49
	3	1.23	1.06	1.15	1.14	1.55	1.15	1.19
	4	0.61	1.00	0.89	0.59	1.08	0.84	0.75
	Total		0.98	1.11	0.92	1.07	1.92	1.06
2005	1	1.22	1.20	0.67	0.82	1.09	1.20	0.81
	2	1.13	0.96	1.33	1.52	1.04	1.02	1.36
	3	1.48	0.70	0.69	1.03	0.43	1.11	0.83
	4	0.62	1.91	0.95	1.00	0.85	1.37	0.96
	Total		1.13	1.18	0.90	1.06	0.88	1.17
2006	1	1.02	1.52	0.32	1.50	1.49	1.38	1.13
	2	1.20	1.14	0.72	1.25	0.82	1.16	0.99
	3	1.20	0.90	0.70	0.92	0.51	1.06	0.79
	4	0.37	0.73	0.54	0.77	0.52	0.58	0.66
	Total		0.96	1.15	0.57	1.11	0.87	1.08
2007	1	1.22	1.47	0.18	1.21	0.72	1.40	0.81
	2	1.22	1.07	0.88	1.50	1.09	1.12	1.21
	3	2.22	0.70	0.86	0.66	0.66	1.49	0.73
	4	0.50	0.88	0.62	1.12	0.35	0.73	0.85
	Total		1.33	1.11	0.64	1.10	0.74	1.19

TABLE 5. Annual longline catches of bigeye, in metric tons, for China, Japan, Korea, and Chinese Taipei, total catch, and change relative to 2001.

	China	Japan	Korea	Chinese Taipei	Total catch	Relative to 2001
2001	2639	38048	12576	9285	68754	1.00
2002	7614	34193	10358	17253	74424	1.08
2003	10066	24888	10272	12016	59776	0.87
2004	2645	21236	10729	7384	43478	0.63
2005	2104	19401	11580	6441	41720	0.61
2006	709	18017	8694	6412	35363	0.51
2007		13262	5611	5859	25560	0.37
Catch limit	2639	34076	12576	7953		

TABLE 6. Bigeye spawning biomass and catch adjusted to represent no restrictions as a ratio of those quantities estimated under current effort levels, which are restricted by Resolution C-06-02.

	End-of-year spawning biomass	Purse-seine catch	Longline catch¹
2004	0.88	1.13	1.36
2005	0.77	1.13	1.38
2006	0.59	1.13	1.40
2007	0.43	1.12	1.39
2008	0.41	0.82	0.64
2009	0.44	0.90	0.72
2010	0.50	0.96	0.78
2011	0.55	0.99	0.83
2012	0.59	1.00	0.88

¹ The catch ratio in 2004-2007 differed slightly from the ratio of 1.39 used to restrict catches because catch is implemented in the assessment model in both weight and numbers, but presented in weight in this table.

TABLE 7. Yellowfin spawning biomass and catch adjusted to represent no restrictions as a ratio of those quantities estimated under current effort levels, which are restricted by Resolution C-06-02.

Year	End-of-year spawning biomass	Purse-seine catch	Longline catch
2004	0.92	1.10	1.32
2005	0.85	1.04	1.21
2006	0.88	0.95	1.12
2007	0.89	1.03	1.12
2008	0.88	1.03	1.16
2009	0.86	1.02	1.15
2010	0.86	0.98	1.13
2011	0.86	1.00	1.13
2012	0.87	1.00	1.13