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NOTES ON THE ESTIMATION OF FISHING EFFORT CORRESPONDENCE FOR ALBACORE FISHERIES

by
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SUMMARY

*At its 1999 meeting, the Commission requested that the SCRS calculate effective fishing effort correspondence for the various fleets that exploit northern albacore (*Thunnus alalunga*). A method that can be used for this calculation is presented. For illustration purposes, the method is applied to the 1975-1997 data that were used during the 1998 albacore stock assessment. The document also highlights some of the difficulties that can be encountered when carrying out this sort of exercise.*

RÉSUMÉ

À sa réunion de 1999, la Commission a demandé au SCRS de calculer la correspondance de l'effort de pêche effectif pour les diverses flottilles qui exploitent le germon du nord. Le présent document propose une méthode susceptible d'être employée aux fins de ce calcul. À titre d'illustration, la méthode est appliquée aux données de 1975-1997 qui ont été utilisées lors de l'évaluation des stocks de germon de 1998. Le document souligne également certaines des difficultés auxquelles on peut se heurter en réalisant cet exercice

RESUMEN

En su reunión del año 1999, la Comisión solicitó al SCRS que calculase la correspondencia del esfuerzo de pesca efectivo para las diversas flotas que pescan el atún blanco del norte. Este documento presenta un método que puede aplicarse en dicho cálculo. Como ilustración, este método se aplica a los datos del período 1975-1997 que se usaron en la evaluación del stock de atún blanco realizada en 1998. Asimismo, el documento pone de relieve algunas de las dificultades que pueden presentarse al llevar a cabo este tipo de ejercicio.

KEYWORDS

Catch/effort, Fishing power, Tuna fisheries, Fishing effort

INTRODUCTION

In one of its 1999 Recommendations, the Commission stated:

> "*The Commission requests the SCRS to carry out an evaluation of the fishing capacity of the different fleets/gears that participate in the fishery with a view to establishing effective fishing effort correspondence, taking as the reference period the years 1993-1995. Contracting Parties, Non-Contracting Parties/ Entities/ Fishing Entities which have directed fisheries for northern albacore will provide SCRS with all the information required to establish fishing effort correspondence. In the event of the continuation of the lack of data, the SCRS should estimate the missing data from those available*."

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The objective of this document is to present a method that can be used for the purpose of estimating one aspect of effective effort correspondence and to illustrate its application with albacore effort data. Undoubtedly, there are many ways in which “effort correspondence” could be estimated, but essentially they should all boil down to estimating a catchability associated with the measure of effort used for the fishing fleets. However, it should also be recognized that the Commission´s Recommendation is not very clear in terms of whether what is being requested is a metric to compare between fleets, or a metric to compare within fleets, between years, or both. This document focuses on the problem in terms of the latter.

A comparison of catchabilities between fleets is made more difficult by the problem that the various gears do not capture albacore of the same sizes, such that their impacts on the stock differ in terms of yield, spawning potential, etc. The task could be somewhat easier in the case of fisheries that were exploited by the same type of gear, with the same operational characteristics. But this is not the case for northern albacore, which is exploited by a variety of gears that operate in different areas at different times, and which target different size groups. Furthermore, the nominal fishing effort data that are reported to ICCAT can be in different units even if the same gear is used.

The methodological approach taken in this paper is to use the stock assessment itself to look at all of the fleets from the perspective of a common metric, which is the fishing mortality exerted by each fishery. The approach is illustrated using the dataset and analyses that were available during the 1998 albacore assessment, which pertain to the period 1975-1997.

METHODS

The approach can be summarized in two steps:

1 - Partition the fishing mortality (*F*) estimates from the assessment according to the partial catches for each fleet.
2 - Estimate a catchability coefficient for each series by regressing the *F* from the previous step against the available nominal fishing effort. If possible, allow for time trends in catchability.

The effort correspondence is then measured by the relative values of the catchability coefficients.

Partial Fs

The fishing mortality for each fleet g, f_g, can be calculated from the total mortality F, multiplied by the ratio of the fleet´s catch to the total catch. In the case of an age-structured assessment (such as that for albacore), the calculation for a given year y and age a is:

$$f_{yag} = F_{ya} \frac{C_{ayg}}{\sum_g C_{ayg}} .$$

For the purpose of these analyses, it is convenient to estimate a single f value for each year, so that some sort of average over ages is necessary. In this study, the weighting is done by the catches:

$$\bar{f}_{yg} = \frac{\sum_a f_{yag} C_{yag}}{\sum_a C_{yag}} .$$

There are other possibilities such as a simple average, a geometric mean, or some other type of weighting, e.g. by stock size. These possibilities were not investigated.

Catchabilities

The catchability coefficients q are derived from the basic fisheries equation $F = qE$, where E is fishing effort. Given a dataset of partial fishing mortalities and fishing effort values, the q coefficients can be estimated from the model

$$\bar{f}_{yg} = q_g \, E_{yg} \, e^{\varepsilon_y} , \qquad (1)$$

where the ε_y are assumed to be normally distributed and q_g is a constant. This amounts to a simple linear regression of $\bar{f}$ against E passing through the origin.

Model (1), above, assumes that there are no time trends in catchability. This is probably not a good assumption when nominal fishing effort is used. Also, year-to-year changes in selectivity can effectively change the catchability associated with the scalar $\bar{f}$. It may thus be preferable to assume that catchability can change with a time series structure, for example as suggested by Ianelli and Fournier (1998). A plausible model is

$$q_{(y+1)g} = q_{yg} e^{\psi_y} , \qquad (2)$$

where the ψ_y are assumed to be normally distributed. This would be accomplished by minimizing

$$\sum_y \varepsilon_y^2 + \lambda_\psi \sum_y \psi_y^2 .$$

The value of λ_ψ is set based on “prior” information about how much inter-annual change in catchability can be reasonably expected. That is,

$$\lambda_\psi = \frac{1}{2\sigma_\psi^2} ,$$

where the variance term is fixed by the analyst. In this study, a CV of 0.2 is assumed, which amounts to $\lambda_\psi = 12.5$.

Effort Correspondence

The effort value corresponding to a desired level of fishing mortality is simply calculated from the relationship $E = F/q$. Care should be taken, however, to incorporate the temporal variation in catchability, if possible.

The Commission´s recommendation calls for an evaluation of fishing capacity for each fleet, but this cannot be established directly from the Task II data reported to the Secretariat. Nevertheless, if capacity data were available in the same units as the effort data, the potential impact of a level of effort would be evaluated from the relationship $F = qE$ (again, taking time trends in catchability into consideration).

DATA

The fishing mortality matrix used (**Table 1**) corresponds to the base case northern albacore assessment from 1998 (estimated using ADAPT, with an adjustment to eliminate a retrospective pattern).

Eight fisheries were defined for this exercise: Longline fisheries for Japan and Chinese Taipei; Spanish baitboat and Troll (from Cantabria, only); gillnets for France, United Kingdom and Ireland; and, French mid-water trawl. The catch at age had been calculated for some of these fleets during the 1998 assessment. For the rest of the fleets, catch at age was calculated from the catch-at-size dataset available in 1998, using the same aging procedure (based on a MULTIFAN analysis). The total catch and the fleet-specific catches are provided in **Table 2**.

Nominal effort was obtained from the Task II database maintained at the Secretariat. In cases where Task II catch was reported in landings, the effort values were raised to match the Task I data for the corresponding fishery. In cases where Task II was reported in numbers, effort was raised to correspond to the fleet´s catch in numbers from the catch-at-age table. The effort data are provided in **Table 3**. Note that for some fleets there are only a few effort values reported.

RESULTS

The partial fishing mortality values $\bar{f}$ were calculated for all fleets and are given in **Table 4**. These were regressed against the raised effort values given in **Table 3**, as explained above for Model (1). The resulting estimates of q_g for each fleet are given in **Table 5**. **Figure 1** depicts the relationship between observed and predicted F values for each fishery. Note that there is, in general, wide dispersion in the observations around the expected relationship. This is also reflected in the very high standard errors for the estimates of q_g, with CVs generally higher than 100%, except for the Chinese Taipei LL fleet (Ta**ble 5**).

The q estimates were also obtained using Model (2), which allows for a random walk. Due to the lack of effort information for some fisheries, this was only done for the Spanish baitboat and troll fleets, and for the two longline fleets. The catchability estimate from Model (2) for 1997 is also provided in **Table 5**. **Figure 2** shows the observed-predicted F relationship. Note that the dispersion in the observations is much less than that which resulted from the fit to Model (1) (compare against patterns in **Figure 1**). The resulting catchability estimates are shown in **Figure 3**. The model estimates large increases in catchability, in the order of 3.5%-4.0% per year, for the Spanish baitboat and troll fleets over the entire time series. The estimates of catchability for the two longline fleets increase up to the mid-1980s. The Japanese longline catchability then decreases rapidly, in the order of -6.0% per year, while the Chinese Taipei longline catchability decreases sharply over a 5-year period and then shows stability throughout the 1990s.

DISCUSSION

The methodology presented here is simply one method among many that could be used to address the Commission´s request to estimate effort correspondence for the various fleets catching northern albacore. The analyses presented above are purely for illustration purposes, and should not be used without further analyses and discussion by the SCRS.

There are several problems that need to be highlighted with respect to the task at hand and the particular methodology presented here. The first one is the lack or paucity of effort data for many fisheries. The fact that trends in catchability cannot be estimated for these fleets does not imply that such trends do not exist. The effort series need to be improved before an adequate effort standardization analysis is attempted.

A second problem, more related to the analyses presented here, is that this method is not integrated with the assessment. It is a piecemeal approach that depends on the stock assessment to provide an accurate picture of fishing mortality. Also, for some fleets, it uses the effort data twice: Once through the inclusion of GLM-based or nominal CPUE data in the tuning of the stock assessment model; the second time is in the analyses presented here. A more rigorous analysis should standardize the various effort series in integrated fashion with the population dynamics model, for example as is done in the method advocated by Maury (2000, SCRS/00/37) (although one would not necessarily use a biomass dynamic model as in Maury´s application; a tuned-VPA or an age-structured production model could be used just as easily).

A third problem, more specific to the results obtained here, is that the variances of the catchability estimates are exceedingly high. If one were to compute the confidence interval associated with any desired level of effective fishing effort, these bounds would be so wide as to be of little use (except perhaps for the Tai-LL fleet). Still, the Commission may or may not find the point estimates obtained of some value.

A final problem is that of comparing the catchability estimates between fleets. This should not be done with the estimates obtained by such a method as presented here, because the catchabilities will generally pertain to fleets that capture different age/size components of the stock. Such comparisons would require a more complex analysis than suggested here because what would be compared would be matrices (of F at age, by year) rather than vectors (of weighted F, by year). Furthermore, such a comparison could be made from diverse points of view (e.g., yield per recruit, profits per recruit, spawning output per recruit, etc.). As such, the calculation of “effort correspondence” will be ambiguous as long as the Commission´s Recommendation remains open to interpretation.

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Table 1. Fishing mortality matrix estimated in the 1998 assessment of northern albacore.

Year/ Age	1	2	3	4	5	6	7	8
75	0.032	0.201	0.274	0.075	0.204	0.280	0.721	0.721
76	0.117	0.365	0.305	0.333	0.171	0.416	0.434	0.434
77	0.040	0.564	0.465	0.182	0.348	0.170	0.277	0.277
78	0.198	0.328	0.685	0.275	0.202	0.306	0.079	0.079
79	0.131	0.491	0.548	0.227	0.167	0.163	0.124	0.124
80	0.171	0.346	0.508	0.172	0.180	0.085	0.072	0.072
81	0.130	0.262	0.532	0.196	0.069	0.173	0.107	0.107
82	0.035	0.365	0.553	0.309	0.078	0.096	0.205	0.205
83	0.151	0.382	0.733	0.485	0.439	0.249	0.170	0.170
84	0.071	0.350	0.489	0.288	0.336	0.589	0.356	0.356
85	0.155	0.372	0.624	0.232	0.471	0.436	0.432	0.432
86	0.084	0.406	0.738	0.519	0.926	0.862	0.549	0.549
87	0.047	0.415	0.871	0.207	0.147	0.264	0.368	0.368
88	0.291	0.430	0.363	0.219	0.073	0.068	0.142	0.142
89	0.159	0.652	0.658	0.063	0.103	0.077	0.059	0.059
90	0.162	0.772	0.768	0.216	0.083	0.306	0.312	0.312
91	0.166	0.628	0.441	0.213	0.177	0.043	0.232	0.232
92	0.209	0.481	0.596	0.231	0.172	0.190	0.102	0.102
93	0.120	0.648	0.602	0.324	0.200	0.331	0.386	0.386
94	0.135	0.675	0.525	0.193	0.097	0.106	0.516	0.516
95	0.203	0.972	0.601	0.158	0.238	0.598	0.543	0.543
96	0.201	0.722	0.350	0.257	0.131	0.114	0.511	0.511
97	0.279	0.481	0.563	0.147	0.218	0.184	0.244	0.244

Table 2.1 Catch at age: Total.

Year/ Age	1	2	3	4	5	6	7	8
75	315733	1066318	1237487	299015	280100	186106	212809	68034
76	931707	2228301	935988	823222	448893	313768	151055	68898
77	428823	2433768	1397655	321475	454251	277723	108428	72114
78	2487904	2179912	1182421	418111	219033	213060	84188	31706
79	883487	3295114	1767666	179078	150122	108815	51052	121773
80	1661960	1372292	1533717	280723	85452	49805	31750	67929
81	1127638	1524756	1019549	302997	74073	51145	42296	99892
82	239468	1844670	1610921	284073	77559	70137	37154	173027
83	890767	1577368	1628346	619212	207258	156937	80563	106758
84	432954	1204226	972542	275997	209046	124572	123533	225416
85	1052931	1354882	996685	235554	231200	137424	40219	212844
86	821188	1559763	1172319	343754	409680	166179	78931	146896
87	378762	2372142	1358300	146963	50677	45487	27354	70074
88	1725728	2070614	1039478	140129	33163	15686	14680	21340
89	1113168	1826467	1385188	106313	41240	23941	9374	10010
90	1101655	2609762	790747	212087	97017	74879	60175	63898
91	1197076	2190165	588433	96016	105347	34942	32053	51821
92	1367443	1895016	833741	161041	47378	69838	56897	22928
93	988442	2102203	1031346	208371	83237	52766	79599	178022
94	708148	2863041	696340	160490	36962	27918	40370	163956
95	1327523	2302110	992772	108378	118960	122804	78394	93902
96	1315366	2272722	302359	200615	57551	35176	44403	70858
97	1758488	1681003	681530	72491	99104	51206	46792	27501

Table 2.2 Catch at age: Chinese Taipei longline.

Year/ Age	1	2	3	4	5	6	7	8
75	677	8004	117604	136701	80679	45508	53501	28105
76	3930	20625	110919	267439	206916	127664	62566	29343
77	2055	25506	130719	122264	227435	142092	60194	39084
78	845	2358	58387	111893	122751	125723	50297	15838
79	2882	32263	71613	48715	68205	51369	30048	62593
80	10836	14023	119100	111482	56875	34060	21647	48676
81	10747	29024	62736	96319	38412	26434	27092	69689
82	11250	67783	151933	119530	58476	53898	25025	115500
83	8006	49625	162733	239222	118373	100967	52898	82696
84	21488	56542	128831	167504	151424	79661	62894	136840
85	4287	31390	106341	135704	176272	102264	29379	165136
86	8941	32052	92679	207010	348902	142385	65886	124171
87	66144	85954	104652	60162	27649	27904	19321	61656
88	123	4083	71760	42457	6332	2291	3959	13382
89	674	13	26034	19085	21453	11262	1522	349
90	0	8	8887	23971	38597	11777	1697	4862
91	0	14	94566	27532	92448	23152	7031	12421
92	0	289	17639	22351	22613	31948	17784	6396
93	2025	19154	84338	65883	69497	24628	33747	56260
94	3165	25322	39961	26040	10477	10969	22885	121014
95	23953	18269	88299	49967	45340	33248	12944	7432
96	19848	22369	47217	39397	22451	9442	7127	40075
97	0	4703	4521	37323	50992	22877	24205	11598

Table 2.3 Catch at age: Japan longline.

Year/ Age	1	2	3	4	5	6	7	8
75	49	3215	28269	22170	15908	8372	6417	2632
76	603	2180	13410	30135	22429	11907	4140	1520
77	301	2996	15060	11273	14600	5347	1137	391
78	480	2427	9040	8251	6619	3930	1612	817
79	349	3818	25595	22095	15084	7306	2444	3299
80	460	3122	28785	21313	5638	4366	1896	1987
81	432	8995	30327	36656	17298	9700	4902	4079
82	468	793	10831	14847	7296	5710	1967	5663
83	1679	3261	25054	22645	10641	5334	2505	1947
84	2171	7305	6546	5764	6357	2839	1650	3322
85	35	734	7782	11429	14970	4880	1563	4511
86	31	635	4511	5760	7661	2567	1540	2297
87	16	817	5567	4106	5220	4558	2536	2712
88	59	1423	12256	9060	8797	4494	3492	1648
89	0	5	34348	15660	3564	1186	204	46
90	160	1948	7391	11706	14112	3077	1725	2344
91	2504	3234	15155	16505	2156	2701	3709	3225
92	4063	4593	4879	10493	2156	2604	2246	681
93	0	29	12579	15347	1485	1767	1167	751
94	0	2670	14302	12172	2634	1776	1546	1881
95	0	1160	9319	5434	3945	2826	1183	655
96	2438	1303	6834	7423	3576	2913	2298	960
97	2919	823	4846	4588	4807	2338	1283	326

Table 2.4 Catch at age: France gillnet.

Year/ Age	1	2	3	4	5	6	7	8
75	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0
87	2783	10006	2372	42	1	0	0	0
88	27204	82803	19724	369	8	0	0	0
89	20817	189935	29522	220	18	1	0	0
90	7847	311721	45308	581	98	2	0	0
91	26368	417971	118062	1807	598	23	40	58
92	40023	539531	102142	858	73	69	84	72
93	39990	537408	142869	3639	302	16	7	24
94	30963	654422	38071	156	218	380	116	18
95	24337	349102	51449	299	6	0	0	0
96	67907	141241	25029	42697	1610	18	0	0
97	164135	165515	10229	223	243	32	2	0

Table 2.5 Catch at age: Spain troll.

Year/ Age	1	2	3	4	5	6	7	8
75	105279	277603	219179	20661	4002	740	151	4
76	319682	868544	170801	55467	3520	965	209	27
77	163985	1072445	337614	33125	3324	107	2	0
78	896500	1110002	431459	54590	3558	2004	382	68
79	326373	1475575	478404	13223	2279	978	702	460
80	622096	697178	340107	11171	686	262	128	54
81	400795	737850	279272	19308	463	322	183	97
82	121311	853645	442353	18410	261	37	5	1
83	60100	801920	492374	47134	1700	127	10	1
84	152386	727322	317812	13418	1331	290	45	5
85	397290	658528	311157	13801	3753	880	164	233
86	373964	897436	310601	14233	3217	1049	291	348
87	158451	870459	369234	29428	1924	144	5	0
88	478706	777430	356437	52456	7781	2769	1770	1575
89	360785	794452	474864	14717	1334	317	183	172
90	279435	1079029	267442	31985	2781	1575	819	613
91	491444	1047260	190009	8426	983	163	247	153
92	437051	649901	240454	12082	1000	461	141	13
93	311226	590780	198722	7950	480	19	3	1
94	218340	701089	139133	5734	236	42	30	224
95	755041	1023576	260209	8100	1808	182	31	43
96	481194	831173	62484	9964	277	80	39	13
97	559252	794718	186086	4768	1451	300	97	46

Table 2.6 Catch at age: Spain baitboat.

Year/ Age	1	2	3	4	5	6	7
75	155614	416751523287	814661367598641010471616377				
76	281621	4968895183873599111957081343				23507	9252
77	142864	566352631977	76152	8996954916		18206	4903
78	916015	278752352306155611		2763716440		5600	855
79	340029	818583850618	60332	1923914259		2584	6143
80	772930	381258885949115200		11574	2505	1893	1515
81	575629	506980524491116685		10577	7801	1911	693
82	73320	685229863424114049		6327	1303	569	1552
83	799174	550101820503240208		3808212897		2176	888
84	202612	152958380664	64205	25884	4281	992	1060
85	563519	519528490655	55480	1992210443		1142	2088
86	389276	515692714633107872		31626	4943	1265	886
87	1178721246848802131		43790	5332	2719	548	738
88	11409041035446509931		23804	2835	1421	1518	1553
89	676550	640307737185	49130	7496	2476	1197	874
90	777619	976121397519111376		1580820308		1739417736	
91	668663	678653145757	27558	1884	1977	776414310	
92	683888	526390381630	78559	6520	5095	5678	1830
93	614746	547722412103	74143	2251	5702	1019738281	
94	383710	796179350932	87126	7628	1875	189919135	
95	515877	648208362490	12943	2401	1725	3762	7861
96	525084	942935118042	46300	10319	3411	3472	4304
97	789518	234326425318	28451	2802713005		8237	5318

Table 2.7 Catch at age: UK gillnet.

Year/ Age	1	2	3	4	5	6	7	8
75	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0
92	582	7845	1485	12	1	1	1	1
93	4351	58462	15542	396	33	2	1	3
94	4785	101124	5883	24	34	59	18	3
95	1859	26662	3930	23	0	0	0	0
96	1625	3380	599	1022	39	0	0	0
97	3154	3181	197	4	5	1	0	0

Table 2.8 Catch at age: Ireland gillnet.

Year/ Age	1	2	3	4	5	6	7	8
75	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0
90	139	5501	800	10	2	0	0	0
91	433	6856	1937	30	10	0	1	1
92	4446	59931	11346	95	8	8	10	8
93	1013	147066	83315	6297	514	61	8	82
94	19427	410602	23887	98	137	238	73	11
95	1255	54570	47702	3035	99	22	21	35
96	28980	60276	10681	18221	687	8	0	0
97	83549	84251	5207	114	124	16	1	0

Table 2.9 Catch at age: France mid-water trawl.

Year/ Age	1	2	3	4	5	6	7	8
75	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0
87	9333	20094	9084	1182	142	136	96	51
88	65591	125660	57422	7563	1146	888	638	301
89	44540	165550	71607	3952	1237	1320	2167	4366
90	31183	49326	31142	12945	1216	1052	919	957
91	6759	35027	13759	4911	138	53	80	45
92	196608	106687	72024	19925	355	27	1	0
93	14873	199873	53136	1353	112	6	2	9
94	56807	131127	66696	12326	236	41	60	1564
95	4019	174756	152760	9719	316	70	69	114
96	261153	185629	23171	3233	8	0	0	0
97	311689	221941	20264	1052	1188	159	10	1

Table 3. Nominal effort by fleet. Task II E is the effort as reported to the Secretariat; Raised E is that effort, times the ratio of Task II landings (or catch in numbers) to Task I landings (or to the fleet´s total catch in numbers according to the catch-at-size estimation procedure). A "--" means no data reported to the Secretariat as of 10/1998.

	Chi tai Il		Jpn Il		Sp BB		Sp troll		FR gill		FR Mwt		UK gill		IR gill	
Year	Task II E	Raised	Task II E	Raised	Task II E	Raised	Task II E	Raised	Task II E	Raised	Task II E	Raised	Task II E	Raised	Task II E	Raised
1975	15.121	20.051	43.738	42.931	9500	9500	15351	15351	0	0	0	0	0	0	0	0
1976	29.993	42.354	25.990	25.976	17588	17588	29902	29902	0	0	0	0	0	0	0	0
1977	30.895	39.929	16.790	16.790	9960	9960	20144	20144	0	0	0	0	0	0	0	0
1978	20.018	28.763	16.635	16.634	10022	10022	22536	22536	0	0	0	0	0	0	0	0
1979	9.015	16.456	19.402	19.401	10175	10175	16974	16974	0	0	0	0	0	0	0	0
1980	9.753	15.787	27.004	27.001	10383	10383	16739	16739	0	0	0	0	0	0	0	0
1981	10.588	13.901	40.729	40.722	11547	11547	17178	17178	0	0	0	0	0	0	0	0
1982	18.135	19.380	35.654	35.647	10904	10904	17241	17241	0	0	0	0	0	0	0	0
1983	22.391	27.481	20.502	20.495	16123	16123	16057	16057	0	0	0	0	0	0	0	0
1984	30.908	31.303	23.225	23.218	7222	7222	12428	12428	0	0	0	0	0	0	0	0
1985	33.066	38.208	28.078	24.581	9936	9936	23355	23355	0	0	0	0	0	0	0	0
1986	54.717	57.816	24.383	19.530	12753	12753	20660	20660	0	0	0	0	0	0	0	0
1987	24.943	24.104	21.082	18.037	10345	10345	24699	24699	--	--	--	--	0	0	0	0
1988	7.457	4.911	25.789	23.233	12046	12046	19733	19733	--	--	--	--	0	0	0	0
1989	4.913	4.065	40.134	45.984	9501	9501	21899	21899	1450	1502	2909	2909	0	0	0	0
1990	18.621	19.093	33.896	29.869	8607	8607	18911	18911	1291	1230	805	784	0	0	--	--
1991	37.068	41.754	34.216	34.223	7503	7503	13967	13967	--	--	--	--	0	0	--	--
1992	27.831	31.700	34.709	33.308	8552	8552	12506	12506	2624	2624	--	--	--	--	--	--
1993	24.463	31.016	30.208	30.202	6269	6269	11351	11351	--	--	--	--	--	--	841	666
1994	32.882	26.409	34.448	42.728	6608	6608	10834	10834	4033	4033	--	--	--	--	--	--
1995	19.696	14.728	41.687	41.814	6403	6403	16270	16270	--	--	--	--	264	263	--	--
1996	25.694	30.225	59.938	66.660	5677	5677	12287	12287	--	--	--	--	242	237	--	--
1997	20.371	37.245	--	--	6414	6414	11464	11464	--	--	--	--	112	111	--	--
93-95 mean		24		38		6427		12818		4033		N/A		263		666

Table 4. Estimated mean fishing mortality by fleet (from the 1998 base case assessment, as modified by each fleet´s partial catches).

Year	Tai-LL	Jpn-LL	Spn-BB	Spn-trol	Fra-gil	Fr-mwt	UK-gil	Ire-gil
75	0.072	0.009	0.107	0.042	0.000	0.000	0.000	0.000
76	0.106	0.010	0.109	0.104	0.000	0.000	0.000	0.000
77	0.109	0.007	0.140	0.191	0.000	0.000	0.000	0.000
78	0.102	0.005	0.095	0.144	0.000	0.000	0.000	0.000
79	0.055	0.015	0.164	0.179	0.000	0.000	0.000	0.000
80	0.059	0.010	0.169	0.120	0.000	0.000	0.000	0.000
81	0.053	0.018	0.135	0.106	0.000	0.000	0.000	0.000
82	0.085	0.009	0.208	0.149	0.000	0.000	0.000	0.000
83	0.147	0.014	0.216	0.190	0.000	0.000	0.000	0.000
84	0.182	0.006	0.110	0.172	0.000	0.000	0.000	0.000
85	0.249	0.017	0.166	0.147	0.000	0.000	0.000	0.000
86	0.527	0.011	0.241	0.178	0.000	0.000	0.000	0.000
87	0.101	0.014	0.310	0.157	0.001	0.003	0.000	0.000
88	0.042	0.014	0.196	0.127	0.013	0.020	0.000	0.000
89	0.026	0.013	0.223	0.213	0.056	0.043	0.000	0.000
90	0.029	0.010	0.232	0.256	0.084	0.015	0.000	0.001
91	0.095	0.019	0.138	0.216	0.107	0.009	0.000	0.002
92	0.053	0.007	0.151	0.133	0.119	0.033	0.002	0.013
93	0.109	0.015	0.147	0.128	0.140	0.052	0.015	0.045
94	0.214	0.011	0.170	0.131	0.141	0.031	0.022	0.089
95	0.070	0.007	0.192	0.279	0.125	0.079	0.010	0.025
96	0.088	0.009	0.208	0.187	0.036	0.047	0.001	0.015
97	0.094	0.007	0.175	0.167	0.036	0.054	0.001	0.018

Table 5. Estimates of catchability for each fleet. The first row of values correspond to estimates from Model (1). The third row corresponds to estimates from Model (2) for the last year of data.

	Tai-LL	Jpn-LL	Spn-BB	Spn-TRL	Fra-GIL	Fra-MWT	UK-GIL	Ire-GIL
q_g	3.92E-03	3.70E-04	1.7253E-05	9.028E-06	4.4801E-05	1.7064E-05	9.3819E-06	6.7915E-05
SE	3.99E-04	2.36E-04	1.10E-03	2.34E-04	6.36E-04	1.10E-03	3.97E-04	N/A
q_{g97}	3.45E-03	2.49E-04	2.466E-05	1.36E-05	--	--	--	--
SE	8.18E-04	2.47E-04	1.10E-03	2.35E-04	--	--	--	--

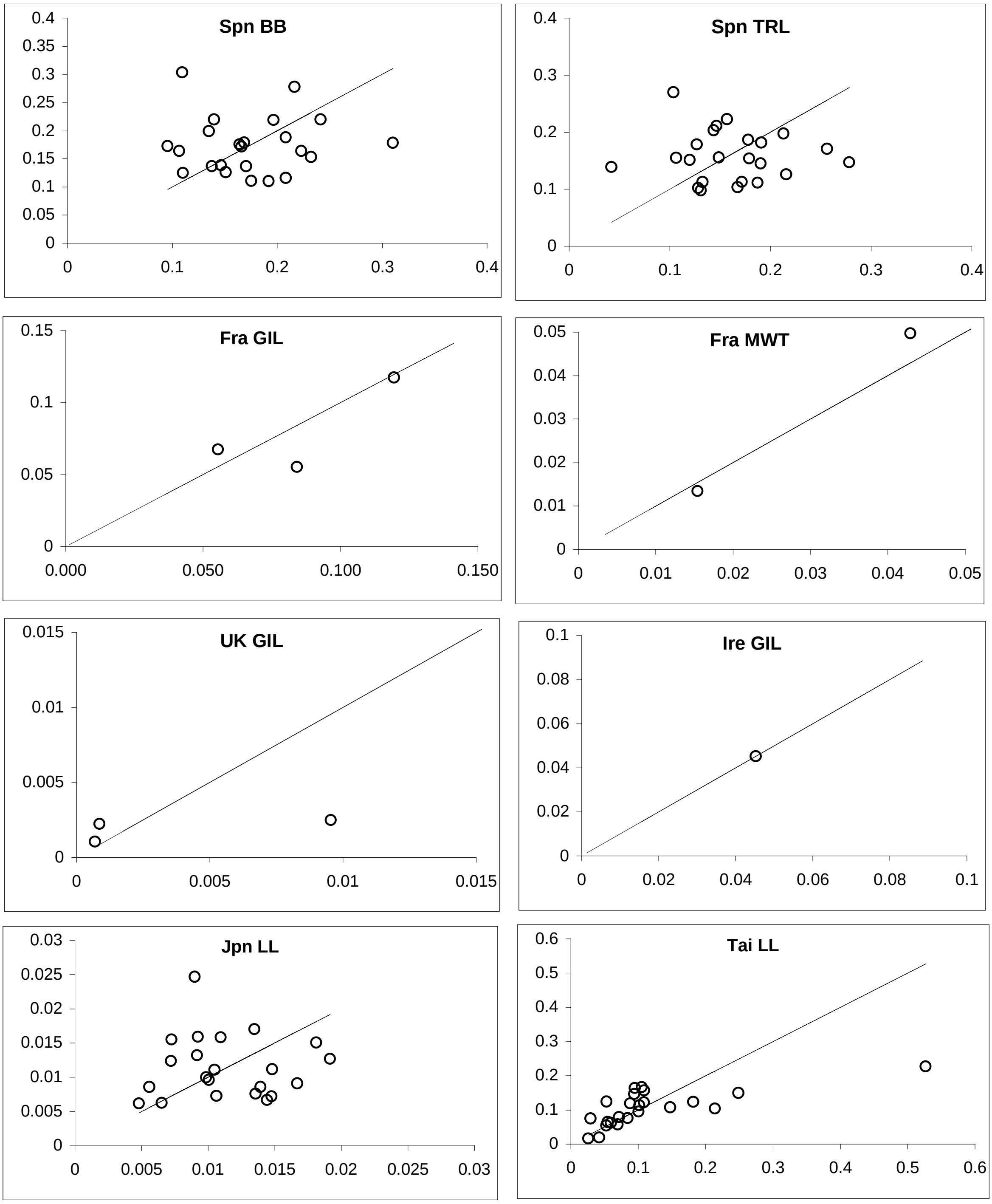

Figure 1. Observed (X-axis) and predicted (Y-axis) *F* by fleet, from Model (1).

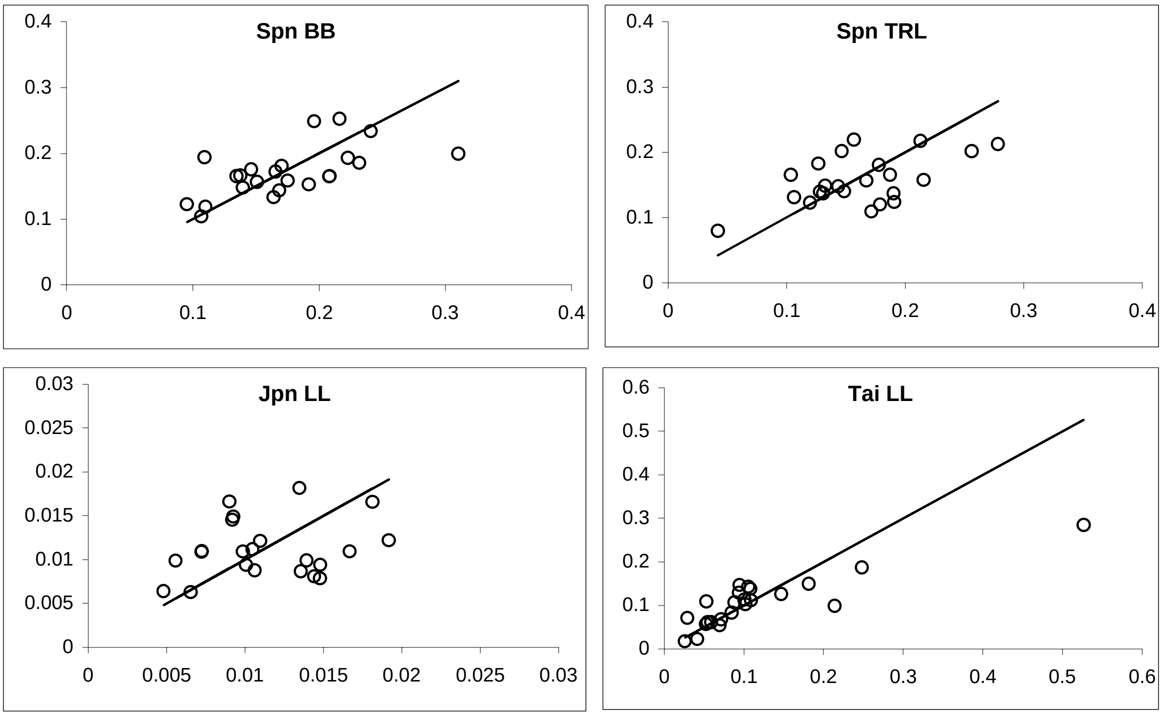

Figure 2. Observed (X-axis) and predicted (Y-axis) *F* from Model (2).

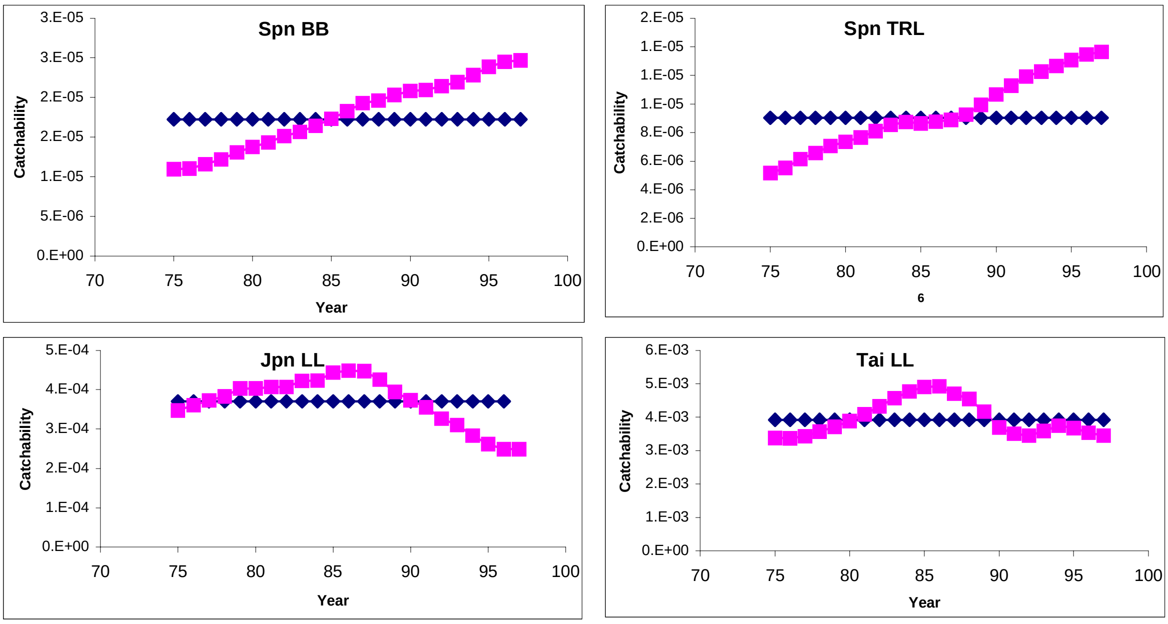

Figure 3. Catchability estimates from Model (1) (straight horizontal lines) and from Model (2).