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PRELIMINARY ANALYSIS OF HISTORICAL AND RECENT SKIPJACK TUNA TAGGING DATA TO EXPLORE INFORMATION ON EXPLOITATION RATES

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1. INTRODUCTION

The Inter-American Tropical Tuna Commission (IATTC) carried out numerous tuna-tagging experiments during the 1950s to the early 1980s, and resumed tagging on a more limited scale beginning in 2000. These data have not been used in the stock assessments of skipjack tuna except to provide information on growth rates (Bayliff 1988; Maunder 2002). This preliminary analysis is an investigation into the information content of the tagging data about exploitation rates to evaluate their use in the stock assessment.

2. DATA

Tag release and recapture data from eight trips by pole-and-line vessels between 1973 and 1981 were obtained from the IATTC records (Table 1a). Release information was obtained in summary form from printed records. Releases were coastal and north of the equator (Figure 1). The recapture information was obtained from an electronic data base. Detailed information such as length at release was not used because it is not currently available in electronic form. Tag identification numbers are not available in electronic form for releases, so the recaptures can be matched only to the release trip, and not to the specific details of release (*e.g.* month). Recaptures without information on the month of recapture were assigned to months based on the proportion by month of recaptures with month information within the appropriate year and trip. Recaptures without information on the year of capture were assigned to years based on the proportion by year of recaptures with year information within the appropriate trip. The data were summarized by month. The release month was set to the month with the most releases (Table 2). A few recaptures had to be moved one month forward in time to match the time at release. There are several months, some consecutive, without recaptures from any trips (Table 3a).

Tag release and recapture data from several trips by pole-and-line vessels between 2000 and 2006 were obtained from the IATTC database (Table 1b). Releases were limited in spatial extent to an area close to the equator (Figure 1). Recaptures without information on the month of capture were assigned to months based on the proportion by month of recaptures with month information within the appropriate recapture year and year and month of release. Recaptures without information on the year of capture were assigned to years based on the proportion by year of recaptures with year information within the appropriate year and month of release. The data were summarized by month. There are several months, some consecutive, without recaptures from any release periods (Table 3b).

3. METHODS

3.1. Tag dynamics

Each tagging trip or release month was modeled as a separate population, but sharing parameters. The model includes initial tagging-related mortality and tag shedding as a combined parameter, chronic (long-term) tag shedding and tagging-related mortality as a combined parameter, non-reporting, and initial non-mixing. The fishing mortality by month was modeled as a random effect around an overall mean fishing mortality. The model was fitted to the recaptures using a negative binomial-based likelihood function.

$$N_{r,t_r} = R_r \exp\left[-M_{init}\right]$$

$$N_{r,t} = \begin{cases} N_{t-1}\exp\left[-\left(\delta_r F_{t-1} + M + L\right)\right] & t = t_r + 1 \\ N_{t-1}\exp\left[-\left(F_{t-1} + M + L\right)\right] & t > t_r + 1 \end{cases}$$

$$p_{r,t} = \begin{cases} \dfrac{\delta_r F_t}{\delta_r F_t + M + L}\left(1 - \exp\left[-\left(\delta_r F_t + M + L\right)\right]\right) & t = t_r \\ \dfrac{F_t}{F_t + M + L}\left(1 - \exp\left[-\left(F_t + M + L\right)\right]\right) & t > t_r \end{cases}$$

$$C_{r,t} = N_{r,t} p_{r,t}\left(1 - \exp\left[-\tau\right]\right)$$

$$F_t = \mu_F \exp\left[\varepsilon_t \sigma\right]$$

$$\varepsilon_t \sim N\left(0,1\right)$$

where

$N_{r,t}$: number of tagged fish alive from release r at time t

R_r : number of releases in release group r

t_r : time of release r

M : natural mortality, assumed constant over time and common among release groups

$C_{r,t}$: predicted reported recaptures in time t from release group r

F_t : fishing mortality for time t, assumed common among release groups

M_{init} : initial tagging-related mortality and tag shedding

δ_r : fishing mortality multiplier in the time period of release to deal with non-mixing

L : chronic (long-term) tag shedding and tag-related mortality

τ : parameter representing reporting rate

If effort data are available, fishing mortality can be made proportional to fishing effort

$$F_t = qE_t \exp\left[\varepsilon_t \sigma\right]$$

where q is the catchability coefficient.

3.2. Likelihood

The likelihood function is based on the negative binomial (NB)

$$q\left(y_{r,t} \mid C_{r,t}, \theta\right) = \frac{\Gamma\left(\theta + y\right)}{\Gamma\left(\theta\right) y!}\left(\frac{\theta}{\theta + C_{r,t}}\right)^{\theta}\left(\frac{C_{r,t}}{\theta + C_{r,t}}\right)^{y}$$

where C and θ are the mean and size parameters, respectively. Formally y = 0, 1, 2,…, but our data have fractional recoveries due to unknown month and year or recapture and reporting rate calculation.

As $1/\theta$ approaches zero, the NB distribution is reduced to the Poisson distribution.

The total likelihood is just the product of the likelihood for all the individual recaptures:

$$q\left(\mathbf{y} \mid \mathbf{C}, \theta\right) = \prod_{r,t} q\left(y_{r,t} \mid C_{r,t}, \theta\right)$$

4. APPLICATION

Maunder and Harley (2005) used an age-specific schedule for natural mortality. Natural mortality is very high for young skipjack, followed by a decrease, and then increases. Based on mid-sized skipjack (45-65 cm) in Maunder and Harley (2005) and the values used in historical yield-per-recruit analyses, we assume a natural mortality of 0.15 per month.

Bayliff and Mobrand (1972) estimated tag shedding for yellowfin tuna from double-tagging experiments. "The Type-1 shedding, which occurs immediately after release of the fish, is about 10 percent. The Type-2 shedding is assumed to be constant throughout the life of the fish after tagging; it occurs at an instantaneous rate of about 0.278 per year." Based on these estimates, the following parameters are set to represent tag shedding

$$M_{init} = -\ln\left[1 - 0.1\right] = 0.105$$

$$L = 0.278 / 12 = 0.023$$

These values do not include tag-related mortality. Chronic tag-related mortality is thought to be low, but initial tag-related mortality could be substantial, particularly for skipjack. Maunder *et al*. (2007) estimated immediate tag shedding of 3% and continuous tag shedding of $0.1y^{-1}$, for skipjack, yellowfin, and bigeye tuna combined, but tag shedding may have been influenced by poorly-trained taggers. Hampton (2000) assumed a combined instantaneous tag shedding and instantaneous non-reporting of tags and used an estimate of 0.45 for the three species of tunas, and Type-2 tag shedding of $0.0023 \cdot \text{month}^{-1}$, based on Hampton (1997). He assumed tagging-related mortality was insignificant. Hoyle (2011) found that recovery rates differed substantially among taggers, suggesting that tagger-related differences in the tagging and release processes can translate into substantial variability in survival rates. He assumed the tagging-related mortality rate for expert taggers was 7%, with 95% confidence intervals (CI) from 3% to 16%. He also estimated the additional (tag shedding + mortality) effect for the average tagger relative to the best tagger as 11%.

We believe the reporting rate for these tagging studies to be relatively high. Data presented in Bayliff (1971) indicate that the reporting rate was around 91%, but this estimate is based on limited data. Based on this estimate, the following parameter is set to represent reporting rate

$$\tau = -\ln(-(0.91 - 1)) = 2.408$$

Maunder *et al*. (2007) estimated reporting rates of 0.5 to 0.7 for skipjack tuna from tag-seeding experiments, with reporting rate decreasing with size. Hoyle (2011) found low reporting rates of around 50%.

The tags were modeled for only 18 months to reduce the calculations and avoid biases that might be caused by fitting to a long series of zero observed recoveries. The model was run with and without effort data to determine if they explained additional variation in the recaptures. The effort data are the number

of days fished, using either floating-object or unassociated purse-seine sets. The effort used for the historic tag data was from IATTC length-composition measurement areas 1, 2, 4, and 8, and for the recent tag data from IATTC length-composition measurement areas 7 and 9. These areas relate approximately to the areas of release, and are two of the areas proposed for sub-stocks in future skipjack stock assessments.

5. RESULTS

The model fits the recaptures reasonably well (Figure 2), as expected, since temporal variation in fishing mortality is modeled and tags do not remain in the population for long. The fishing mortality is highly variable over time (Figure 3), and the standard deviation of the fishing mortality temporal deviate on the logarithmic scale was 1.36 for the historic data and 1.06 for the recent data. The fishing mortality scaling parameter for the month at release to adjust for non-mixing was substantially above one for most trips for the historic data, but not for the recent data (Table 5). Some of the time periods did not have recaptures, so there was little or no information on fishing mortality for those time periods (Figure 3). The maximum monthly fishing mortality, not including the non-mixing scalar, was 0.65 for the historic data and 0.20 for the recent data. μ_F was estimated as 0.021 and 0.016, which has no lognormal bias correction, and the mean calculated over the whole time is 0.044 and 0.024 for historic and recent data, respectively. The mean calculated only for time periods where the temporal deviate was not zero (*i.e.* time periods for which information in the recaptures exists) is higher at 0.049 and 0.025. There is a large amount of uncertainty in the estimates of fishing mortality (Figure 4) with coefficients of variation (CVs) around 40% to 140%.

The results are similar when the fishing mortality is proportional to effort. For the historic tag data the negative log likelihood increases to 381.1 from 372.7 when including the effort data, indicating that the fishing effort data does not relate to fishing mortality experienced by these tagged skipjack. For the recent tag data the negative log likelihood decreases to 150.6 from 163.0 when including the effort data, indicating that the fishing effort data relates somewhat to fishing mortality experienced by these tagged skipjack. However, the standard deviation of the random effect distribution for the fishing mortality deviates only reduces to 0.80 from 1.06, indicating that there is still a lot of unexplained variation in the fishing mortality on these tagged skipjack.

6. DISCUSSION

There is a large amount of temporal variability and uncertainty in the estimates of fishing mortality based on the tagging data. Adding effort data did not improve the analysis substantially. This analysis suggests that it is unlikely that the historical tagging data will provide a substantial amount of information on fishing mortality to improve the skipjack stock assessment. However, there are spatial differences in some of the historic tagging trips and given the possibility of limited skipjack movement and local effects of fishing effort, further refinement to the analysis could be made by spatial segregation of the data and addition of catch data. Catch data will provide further information on the temporal variability in fishing mortality allowing the tagging data to inform the absolute levels of fishing mortality. The planned skipjack assessment, which will simultaneously analyze the catch, length composition and tagging data, will use spatial structure.

Under the assumption that tag shedding, tagging-related mortality, and reporting rates are the same for the historic and recent data, the analysis indicates that recent fishing mortality rates in the area of the recent tagging are lower than the historic fishing mortality rates in the areas of the historic tagging. However, it is likely that reporting rate differs, and the other quantities may as well.

There appears to be a substantial amount of movement indicated by the recent tag data (Figure 5) but the true extent of the movement is unknown due to a large proportion of the recapture information being incorrect, due to misreporting of the vessel name and/or well numbers from which tagged fish were recovered. Therefore, it is unclear if the assumption that all tags are recaptured in the area in which they were released is valid or how violation of this assumption will bias the stock assessment results.

Entering detailed information about individual releases for the historic data would allow a more detailed analysis of the information and facilitate its integration into the stock assessment model. However, a well-planned and executed comprehensive tagging study is probably the only way to provide an adequate stock assessment for skipjack tuna in the EPO.

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TABLE 1a. Number of releases and recaptures, by tagging trip, for the historic data.
TABLA 1a. Número de liberaciones de recapturas, por viaje de marcado, para los datos históricos.

Trip Viaje	Release year Año de liberación	Releases Liberaciones	Recaptures Recapturas	Recapture rate Tasa de recaptura
1070	1973	1937	527	0.27
1075	1975	1035	285	0.28
1078	1975	1803	887	0.49
1079	1976	4180	1239	0.30
1082	1976	8455	5543	0.66
1084	1979	2507	606	0.24
1089	1980	1818	102	0.06
1095	1981	2203	417	0.19

TABLE 1b. Number of releases and recaptures, by date, for the recent data.
TABLA 1b. Número de liberaciones de recapturas, por fecha, para los datos recientes.

Year	Month	Releases	Recaptures	Recapture rate
Año	Mes	Liberaciones	Recapturas	Tasa de recaptura
2000	4	131	18.3	0.14
	5	1105	244.7	0.22
2002	3	1	0.0	0.00
	4	210	26.0	0.12
	5	38	5.0	0.13
2003	3	21	1.0	0.05
	4	11	4.0	0.36
	5	116	17.0	0.15
2004	3	178	39.0	0.22
	4	587	108.0	0.18
	5	146	11.0	0.08
2005	4	381	32.0	0.08
2006	3	43	7.0	0.16
	4	551	68.0	0.12

TABLE 2. Number of releases, by trip and month of release, for the historic data.
TABLA 2. Número de liberaciones, por viaje y mes de liberación, para los datos históricos.

Months since May 1973	Trip number							
Meses desde mayo de 1973	Número de viaje							
	1070	1075	1078	1079	1082	1084	1089	1095
0	68							
1	1688							
2	181							
25		257						
26		778						
29			302					
30			1501					
37				4180				
41					8455			
70						3		
71						2502		
72						2		
83							1818	
94								424
95								1759
96								20

TABLE 3a. Recaptures used in the model after adjusting for unknown month and year and recaptures before the assumed month of release for the historic data.
TABLA 3a. Recapturas usadas en el modelo tras ajustar por mes y año desconocidos, y recapturas antes del mes de liberación supuesto, para los datos históricos.

Year	Month	Trip number							
		1070	1075	1078	1079	1082	1084	1089	1095
Año	Mes	Número de viaje							
		1070	1075	1078	1079	1082	1084	1089	1095
1973	6	78.20							
	7	127.65							
	8	51.75							
	9	71.30							
	10	120.75							
	11	56.35							
	12	13.80							
1974	1	1.44							
	2	1.44							
	3								
	4	1.44							
	5								
	6	1.44							
	7								
	8	1.44							
	9								
	10								
	11								
	12								
1975	1								
	2								
	3								
	4								
	5								
	6								
	7		69.42						
	8		175.51						
	9		13.10						
	10		2.62						
	11		3.93	795.05					
	12		2.62	18.38					
1976	1		3.14	15.32					
	2		2.10	25.54					
	3		1.05	2.55					
	4		1.05	2.55					
	5			10.21					
	6		1.05	2.55	280.94				
	7		2.10	6.38	477.60				
	8		1.05		28.09				
	9		2.10	5.11	206.49				
1976	10		3.14		126.42	4103.21			
	11			1.28	42.14	1187.39			

Year	Month	Trip number							
		1070	1075	1078	1079	1082	1084	1089	1095
Año	Mes	Número de viaje							
		1070	1075	1078	1079	1082	1084	1089	1095
	12				16.86	177.15			
1977	1				27.02	39.42			
	2				14.05	25.08			
	3				2.16				
1977	4		1.05		2.16	1.19			
	5				1.08	4.78			
	6				5.40	1.19			
	7			1.04	4.32				
	8				1.08				
	9				2.16	2.39			
	10								
	11								
	12					1.19			
1978	1				1.02				
	2								
	3								
	4								
	5								
	6								
	7			1.04					
	8								
	9								
	10								
	11								
	12								
1979	1								
	2								
	3								
	4						25.55		
	5						123.91		
	6						283.60		
	7						63.87		
	8						56.21		
	9						25.55		
	10						16.61		
	11						2.55		
	12						5.11		
1980	1						1.01		
	2								
	3								
	4							14.18	
	5							2.36	
	6							8.27	
	7							33.08	
	8							9.45	
	9						1.01	8.27	

Year	Month	Trip number							
		1070	1075	1078	1079	1082	1084	1089	1095
Año	Mes	Número de viaje							
		1070	1075	1078	1079	1082	1084	1089	1095
	10							10.63	
	11							4.73	
	12							4.73	
1981	1						1.01	2.10	
	2								
	3							2.10	123.51
1981	4							2.10	162.85
	5								71.04
	6								19.67
	7								5.46
	8								6.56
	9								8.74
	10								6.56
	11								2.19
	12								4.37
1982	1								
	2								
	3								2.42
	4								1.21
	5								
	6								1.21
	7								
	8								1.21

TABLE 3b. Recaptures used in the model after adjusting for unknown month and year, for the recent data.

TABLA 3b. Recapturas usadas en el modelo tras ajustar por mes y año desconocidos, para los datos recientes.

	Year	**2000**		**2002**			**2003**			**2004**			**2005**	**2006**	
Year	Month	4	5	3	4	5	3	4	5	3	4	5	4	3	4
	Año	**2000**		**2002**			**2003**			**2004**			**2005**	**2006**	
Año	Mes	4	5	3	4	5	3	4	5	3	4	5	4	3	4
2000	4	1.02													
	5	11.17	164.50												
	6	5.08	61.94												
	7		8.12												
	8	1.02	4.06												
	9		2.03												
	10														
	11														
	12		1.02												
2001	1														
	2														
	3														
	4														
	5														

	Year	2000		2002			2003			2004			2005	2006	
Year	Month	4	5	3	4	5	3	4	5	3	4	5	4	3	4
	Año	2000		2002			2003			2004			2005	2006	
Año	Mes	4	5	3	4	5	3	4	5	3	4	5	4	3	4
	6														
	7														
	8														
	9														
	10														
	11														
	12														
2002	1														
	2														
	3														
	4														
	5				3.00	1.00									
	6				12.00	3.00									
2002	7				2.00	1.00									
	8				6.00										
	9				2.00										
	10														
	11				1.00										
	12														
2003	1														
	2														
	3														
	4							3.00							
	5							1.00	4.00						
	6								6.00						
	7								1.00						
	8						1.00		2.00						
	9		1.02												
	10		2.03						3.00						
	11														
	12														
2004	1														
	2														
	3														
	4									2.00	1.02				
	5									20.00	70.30	1.22			
	6									13.00	21.40	4.89			
	7									1.00	1.02				
	8										1.02	1.22			
	9								1.00		3.06	2.44			
	10									2.00	3.06	1.22			
	11										3.06				
	12										3.06				
2005	1										1.02				
	2														
	3														
	4												1.00		

	Year	2000		2002			2003			2004			2005	2006	
Year	Month	4	5	3	4	5	3	4	5	3	4	5	4	3	4
	Año	**2000**		**2002**			**2003**			**2004**			**2005**	**2006**	
Año	Mes	4	5	3	4	5	3	4	5	3	4	5	4	3	4
	5												3.00		
	6												8.00		
	7												6.00		
	8														
	9									1.00			4.00		
	10												6.00		
	11														
	12												2.00		
2006	1												1.00		
	2														
	3														
	4														4.32
	5														6.48
	6													3.50	17.27
	7												1.00		9.71
2006	8														2.16
	9													1.17	10.79
	10														3.24
	11													2.33	5.40
	12														3.24
2007	1														1.08
	2														
	3														
	4														1.08
	5														1.08
	6														
	7														1.08
	8														1.08
	9														
	10														
	11														
	12														

TABLE 4a. Effort data (days fished) used in the analysis of the historic data.
TABLA 4a. Datos de esfuerzo (días de pesca) usados en el análisis de los datos históricos.

Year	Month	Effort	Year	Month	Effort	Year	Month	Effort
Año	Mes	Esfuerzo	Año	Mes	Esfuerzo	Año	Mes	Esfuerzo
1973	6	596	1977	1	574	1980	1	907
	7	1111		2	846		2	1494
	8	1116		3	531		3	1478
	9	405		4	585		4	1421
	10	374		5	1033		5	1793
	11	234		6	1482		6	2033
	12	242		7	916		7	894
1974	1	747		8	947		8	764
	2	1033		9	820		9	1030
	3	979		10	549		10	808
	4	803		11	519		11	653
	5	657		12	357		12	549
	6	796	1978	1	391	1981	1	725
	7	928		2	850		2	961
	8	751		3	872		3	1357
	9	449		4	1126		4	1628
	10	483		5	727		5	1175
	11	494		6	1017		6	1091
	12	211		7	1356		7	1129
1975	1	961		8	902		8	1039
	2	1017		9	507		9	1236
	3	838		10	611		10	1122
	4	960		11	661		11	1173
	5	1485		12	272		12	426
	6	1051	1979	1	533	1982	1	421
	7	1079		2	1214		2	678
	8	753		3	1520		3	1251
	9	569		4	1671		4	1253
	10	492		5	1459		5	750
	11	417		6	1432		6	666
	12	224		7	1118		7	783
1976	1	545		8	1144		8	972
	2	686		9	1016		9	826
	3	1086		10	701		10	858
	4	1069		11	906		11	691
	5	746		12	425		12	371
	6	1231				1983	1	263
	7	1029					2	384
	8	782					3	500
	9	1099					4	729
	10	653						
	11	614						
	12	182						

TABLE 4b. Effort data (days fished) used in the analysis of the recent data.
TABLA 4b. Datos de esfuerzo (días de pesca) usados en el análisis de los datos recientes.

Year	Month	Effort	Year	Month	Effort	Year	Month	Effort
Año	Mes	Esfuerzo	Año	Mes	Esfuerzo	Año	Mes	Esfuerzo
2000	4	1099	2002	11	845	2005	6	1008
	5	671		12	114		7	840
	6	961	2003	1	377		8	115
	7	755		2	231		9	630
	8	557		3	234		10	1165
	9	536		4	346		11	976
	10	316		5	295		12	634
	11	447		6	519	2006	1	569
	12	766		7	747		2	501
2001	1	897		8	1009		3	405
	2	251		9	925		4	708
	3	437		10	1127		5	493
	4	560		11	1163		6	776
	5	531		12	708		7	1389
	6	875	2004	1	407		8	407
	7	635		2	370		9	1234
	8	518		3	471		10	1588
	9	518		4	397		11	1179
	10	636		5	989		12	955
	11	746		6	977	2007	1	755
	12	752		7	644		2	339
2002	1	375		8	249		3	310
	2	423		9	814		4	760
	3	511		10	1452		5	1051
	4	304		11	1203		6	1070
	5	452		12	726		7	1271
	6	857	2005	1	606		8	239
	7	681		2	330		9	576
	8	620		3	169		10	943
	9	662		4	265			
	10	793		5	627			

TABLE 5. Estimates of Finit, the fishing mortality scaling parameter for the month at release to adjust for non-mixing. a) historic data and b) recent data.
TABLA 5. Estimaciones de Finit, el parámetro de escala de la mortalidad por pesca para el mes de liberación para ajustar por ausencia de mezcla. Datos a) históricos, y b) recientes.

a.								
Trip	1070	1075	1078	1079	1082	1084	1089	1095
Finit	2.68	4.95	50.46	3.91	4.62	0.65	1.61	6.10

b.														
Year	2000		2002			2003			2004			2005	2006	
Month	4	5	3	4	5	3	4	5	3	4	5	4	3	4
Finit	0.51	2.08	0.01	0.01	1.76	0.01	34.77	1.94	0.01	0.14	0.06	0.31	0.01	1.04

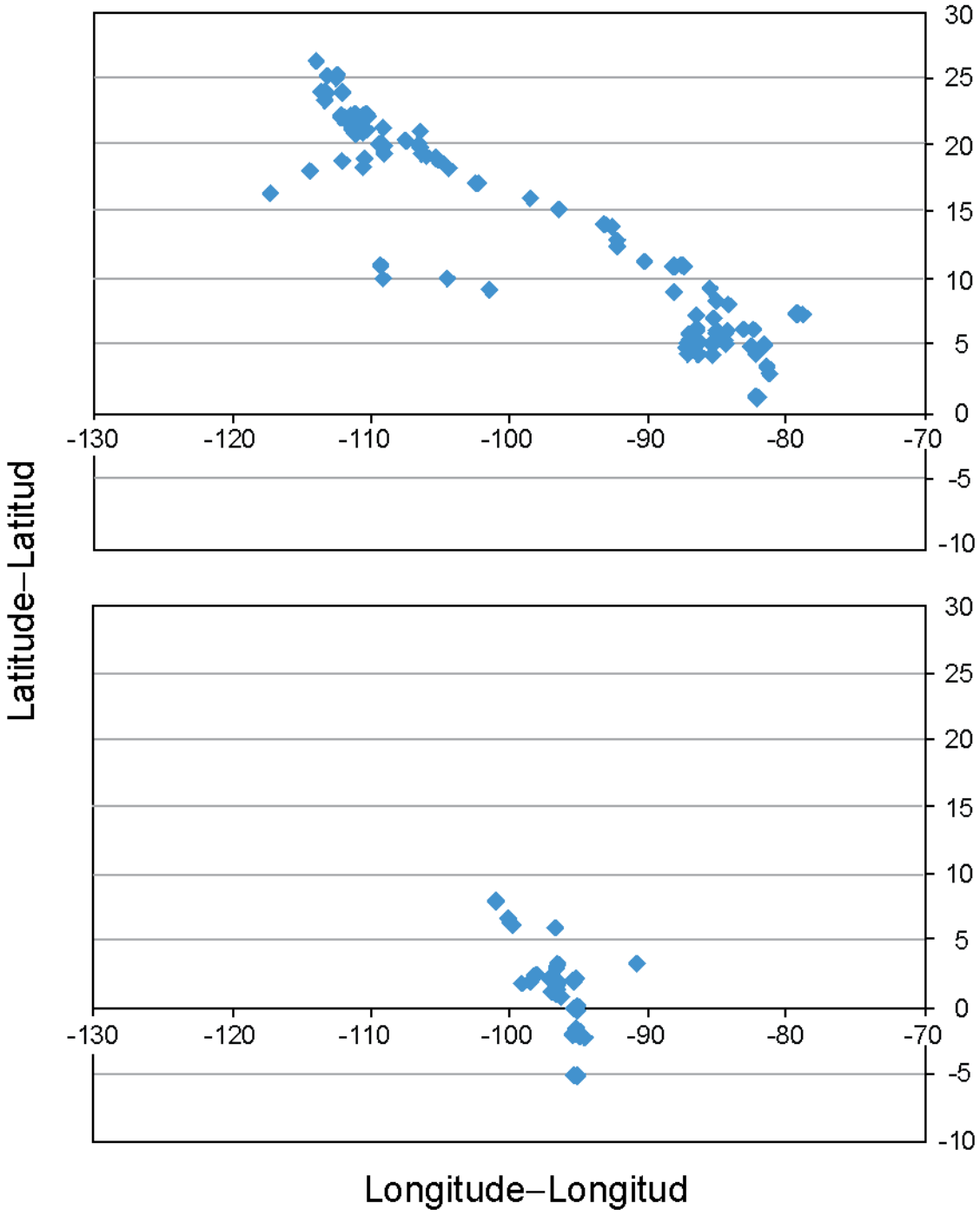

FIGURE 1. Release positions of the historic (top) and recent (bottom) releases
FIGURA 1. Posiciones de liberación de las liberaciones históricas (arriba) y recientes (abajo).

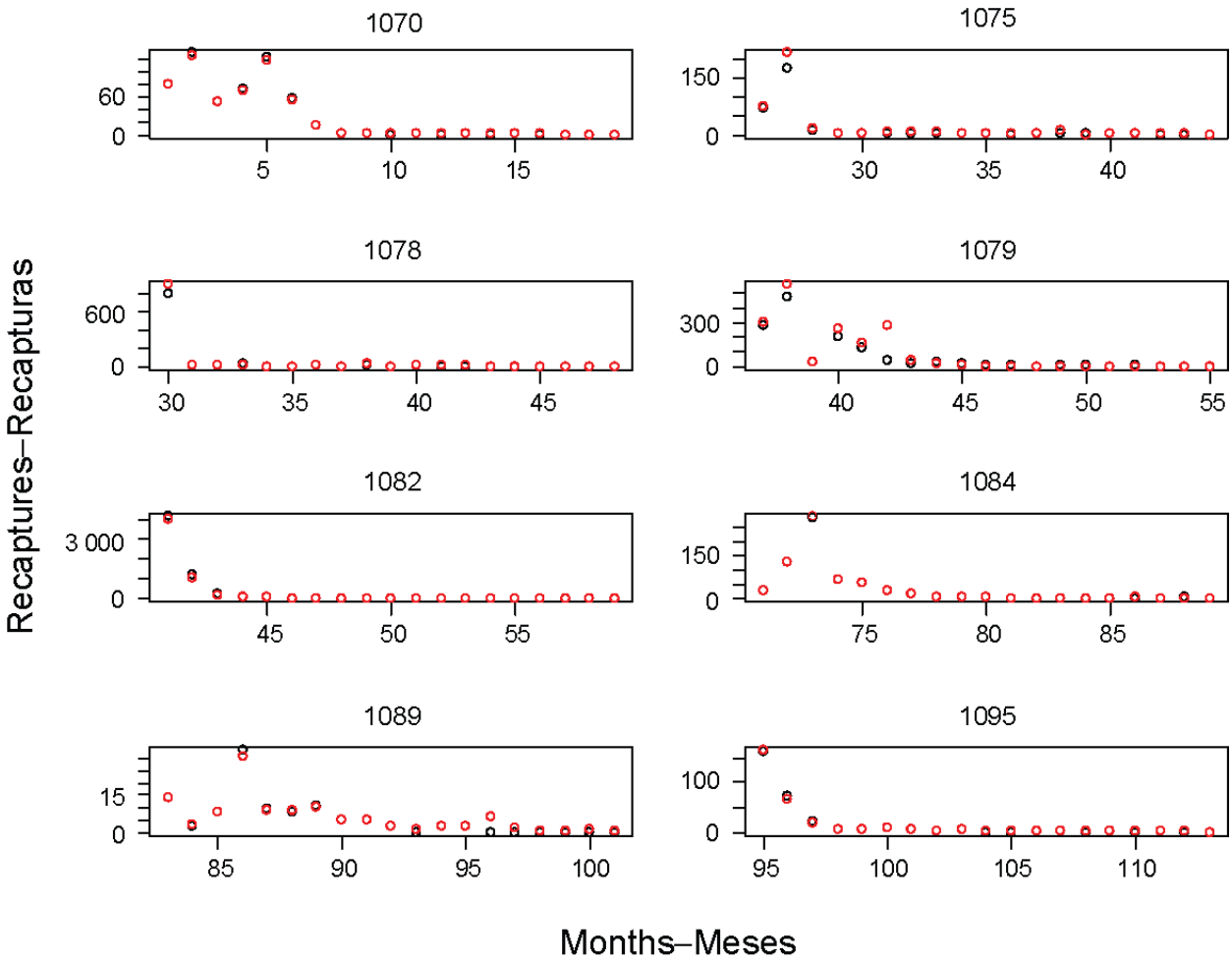

FIGURE 2a. Fit of the model to the recapture data, by trip, for the historic data. Month 1 = June 1973.
FIGURA 2a. Ajuste del modelo a los datos de recaptura, por viaje, para los datos históricos. Mes 1 = junio de 1973.

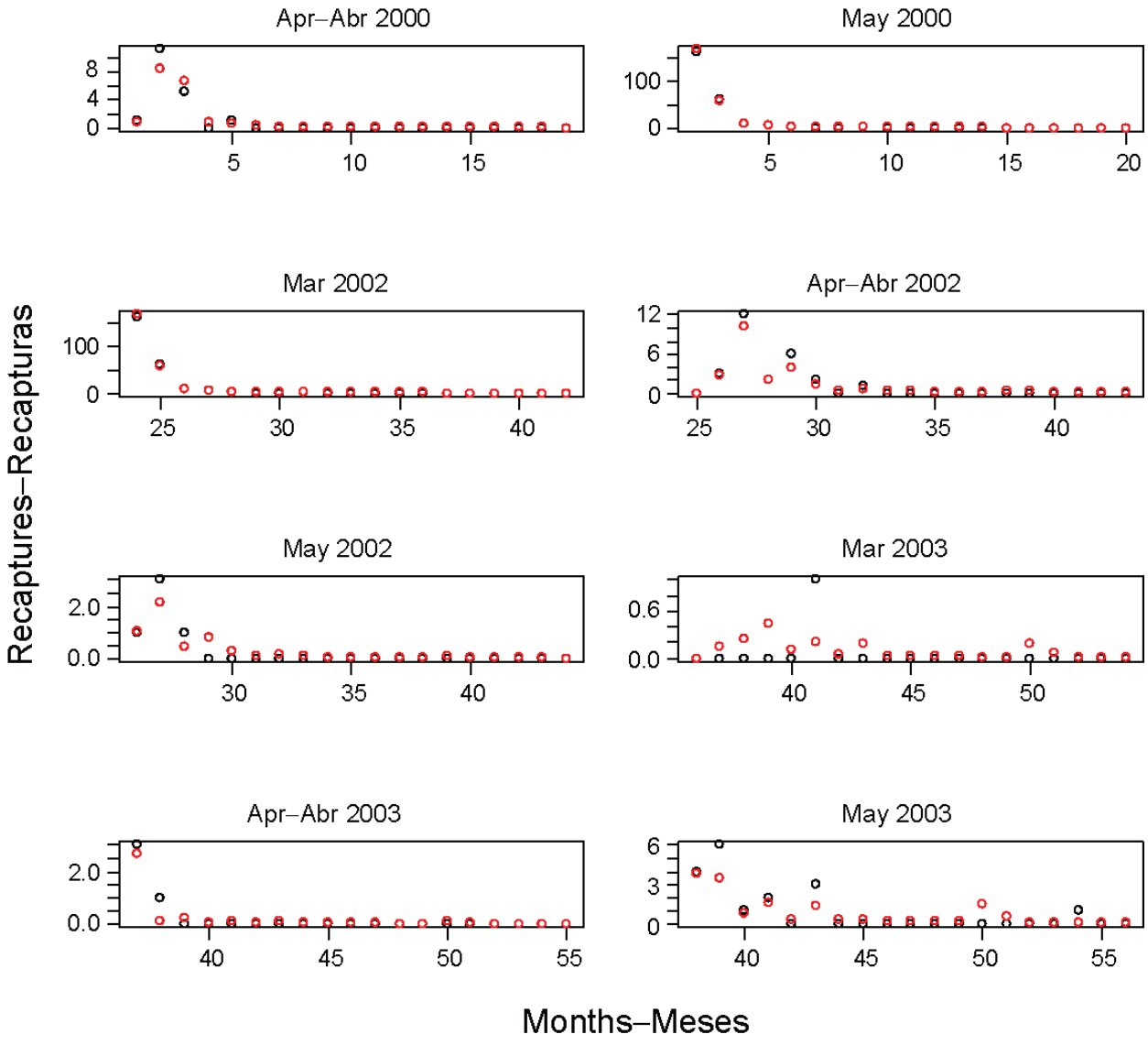

FIGURE 2b. Fit of the model to the recapture data, by month, for the recent data. Month 1 = April 2000.
FIGURA 2b. Ajuste del modelo a los datos de recaptura, por mes, para los datos recientes. Mes 1 = abril de 2000.

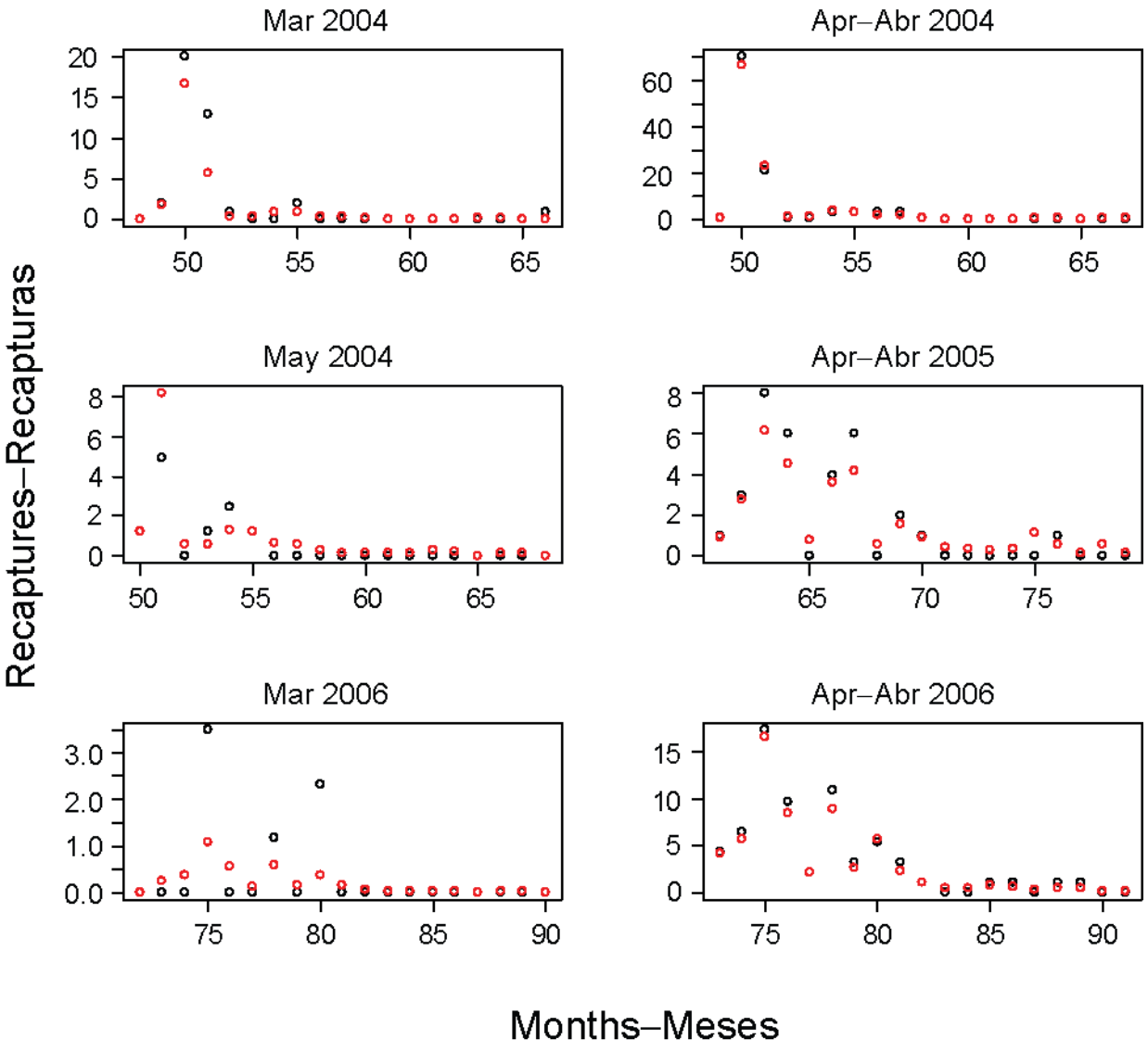

FIGURE 2b. (continued).
FIGURA 2b. (continuación).

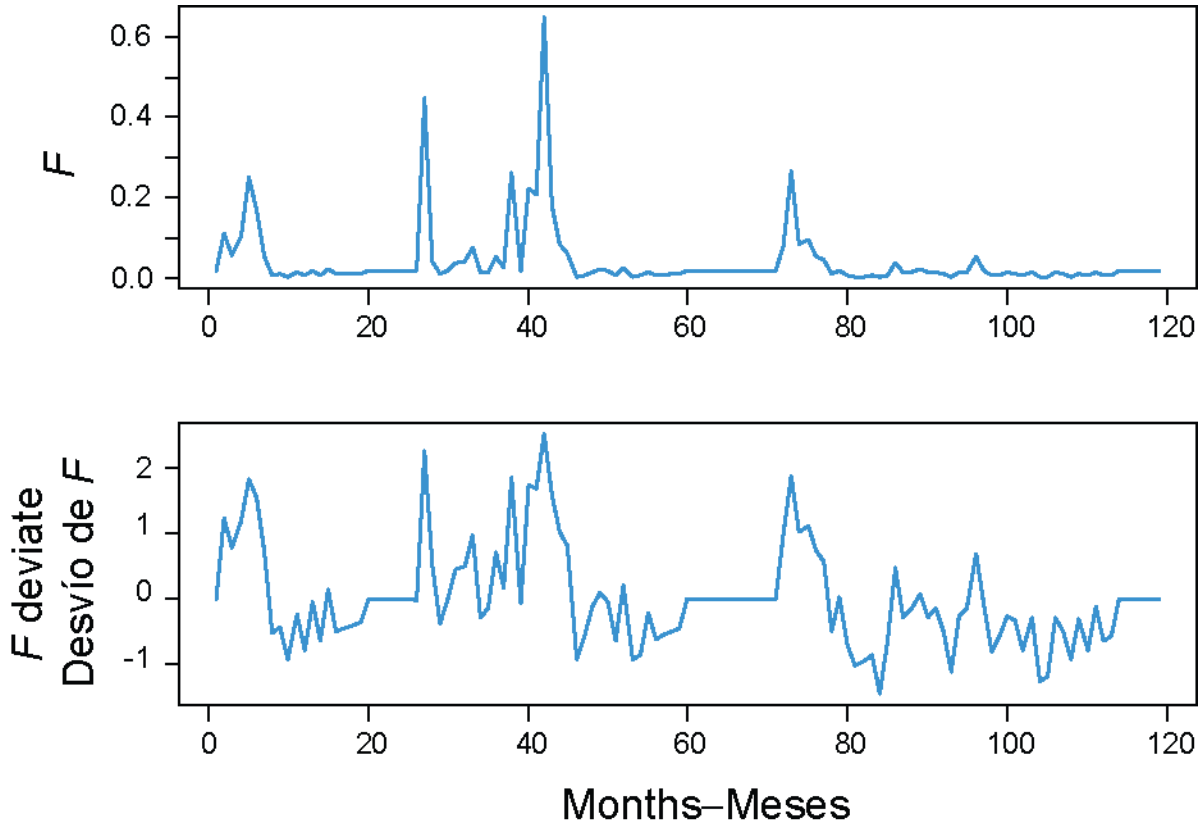

FIGURE 3a. Estimates of the monthly fishing mortality (*F*) (upper panel) and the associated temporal deviate (lower panel) for the historic data. Month 1 = June 1973.
FIGURA 3a. Estimaciones de la mortalidad por pesca (*F*) mensual (panel superior) y el desvío temporal asociado (panel inferior) para los datos históricos. Mes 1 = junio de 1973.

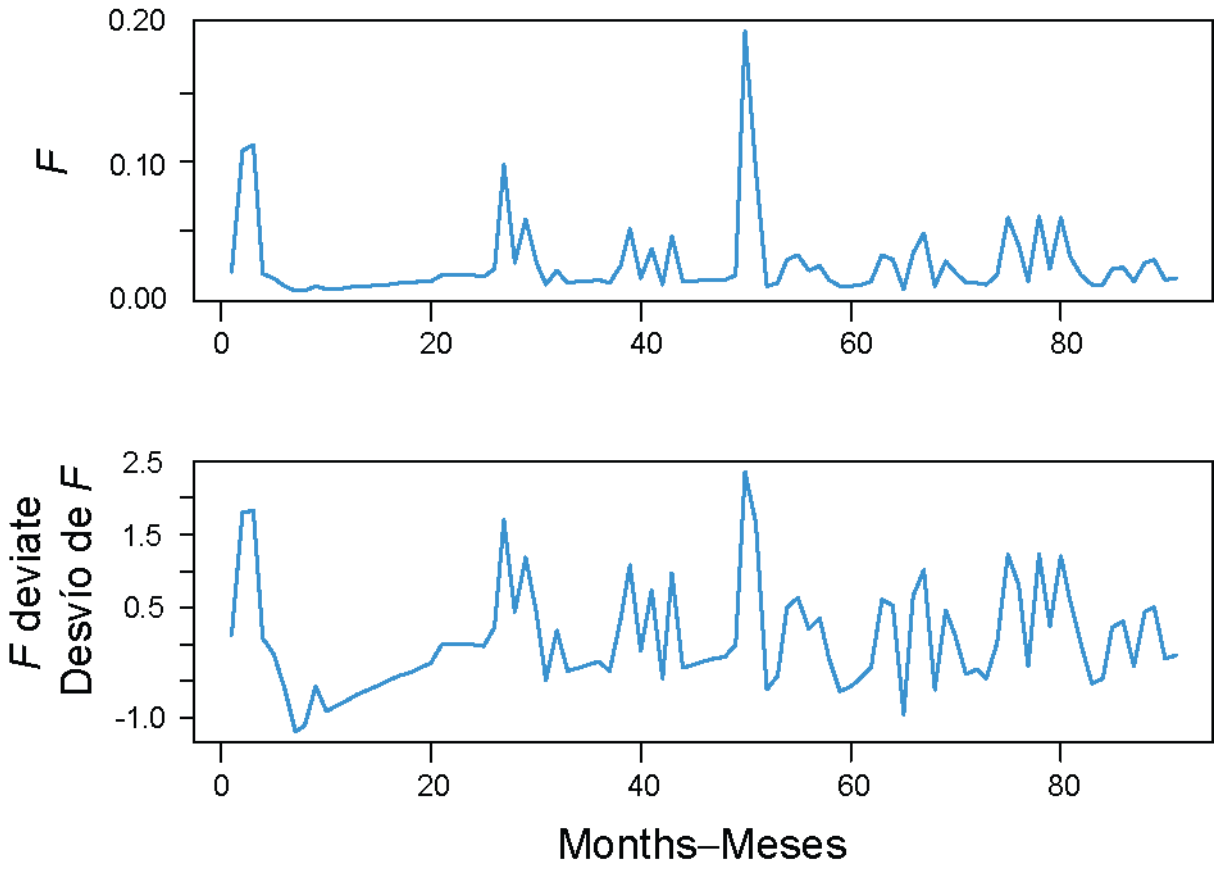

FIGURE 3b. Estimates of the monthly fishing mortality (*F*) (upper panel) and the associated temporal deviate (lower panel) for the historic data. Month 1 = April 2000.
FIGURA 3b. Estimaciones de la mortalidad por pesca (*F*) mensual (panel superior) y el desvío temporal asociado (panel inferior) para los datos recientes. Mes 1 = abril de 2000.

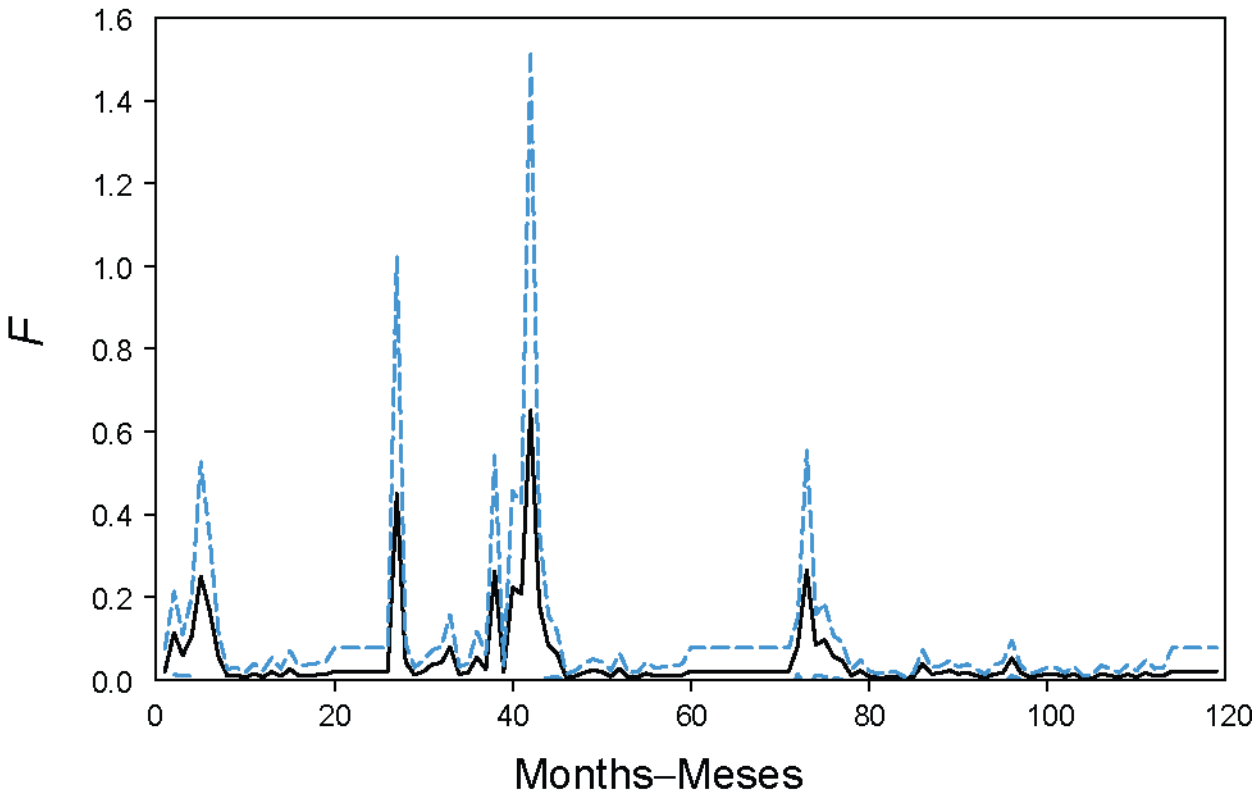

FIGURE 4a. Estimates of fishing mortality (*F*), with 95% confidence intervals, for the historic data. Month 1 = June 1973.
FIGURA 4a. Estimaciones de la mortalidad por pesca (*F*), con intervalos de confianza de 95%, para los datos históricos. Mes 1 = junio de 1973.

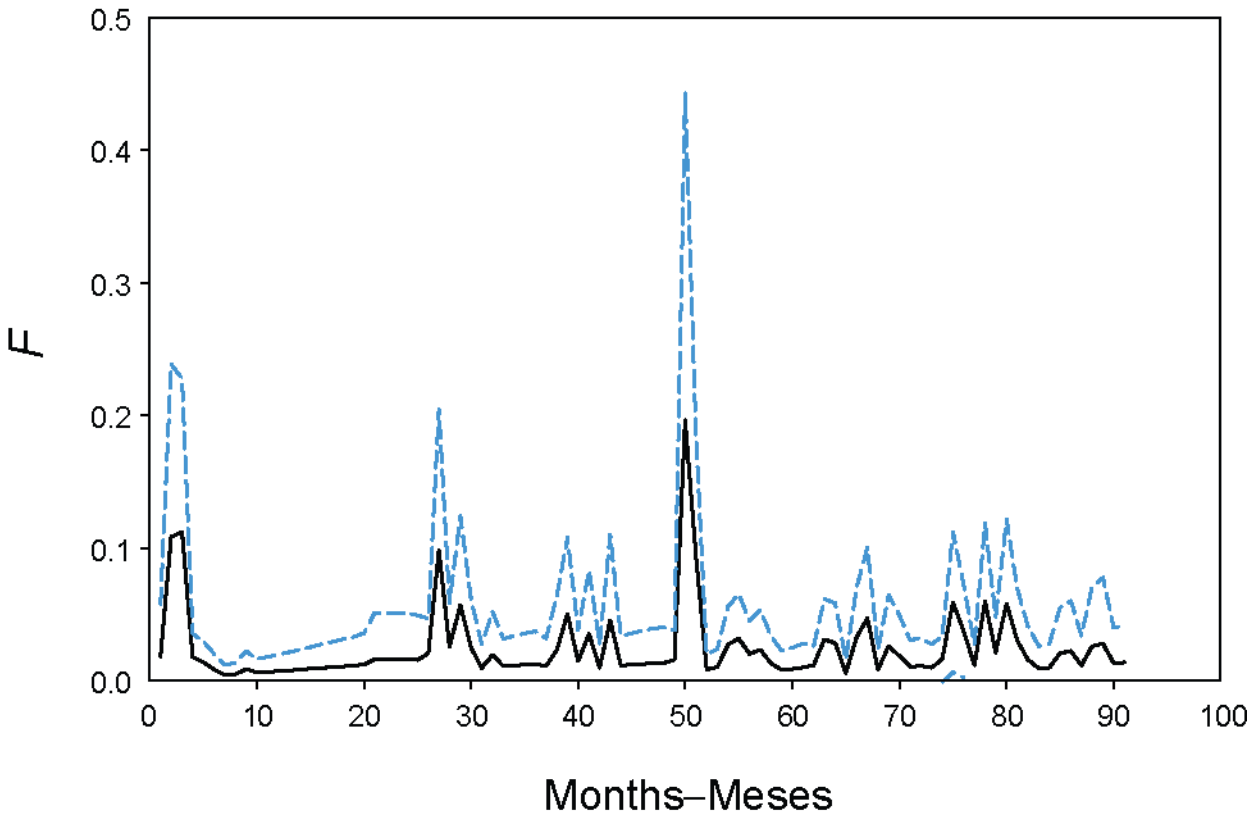

FIGURE 4b. Estimates of fishing mortality (*F*), with 95% confidence intervals, for the recent data. Month 1 = April 2000.
FIGURA 4b. Estimaciones de la mortalidad por pesca (*F*), con intervalos de confianza de 95%, para los datos recientes. Mes 1 = abril de 2000.

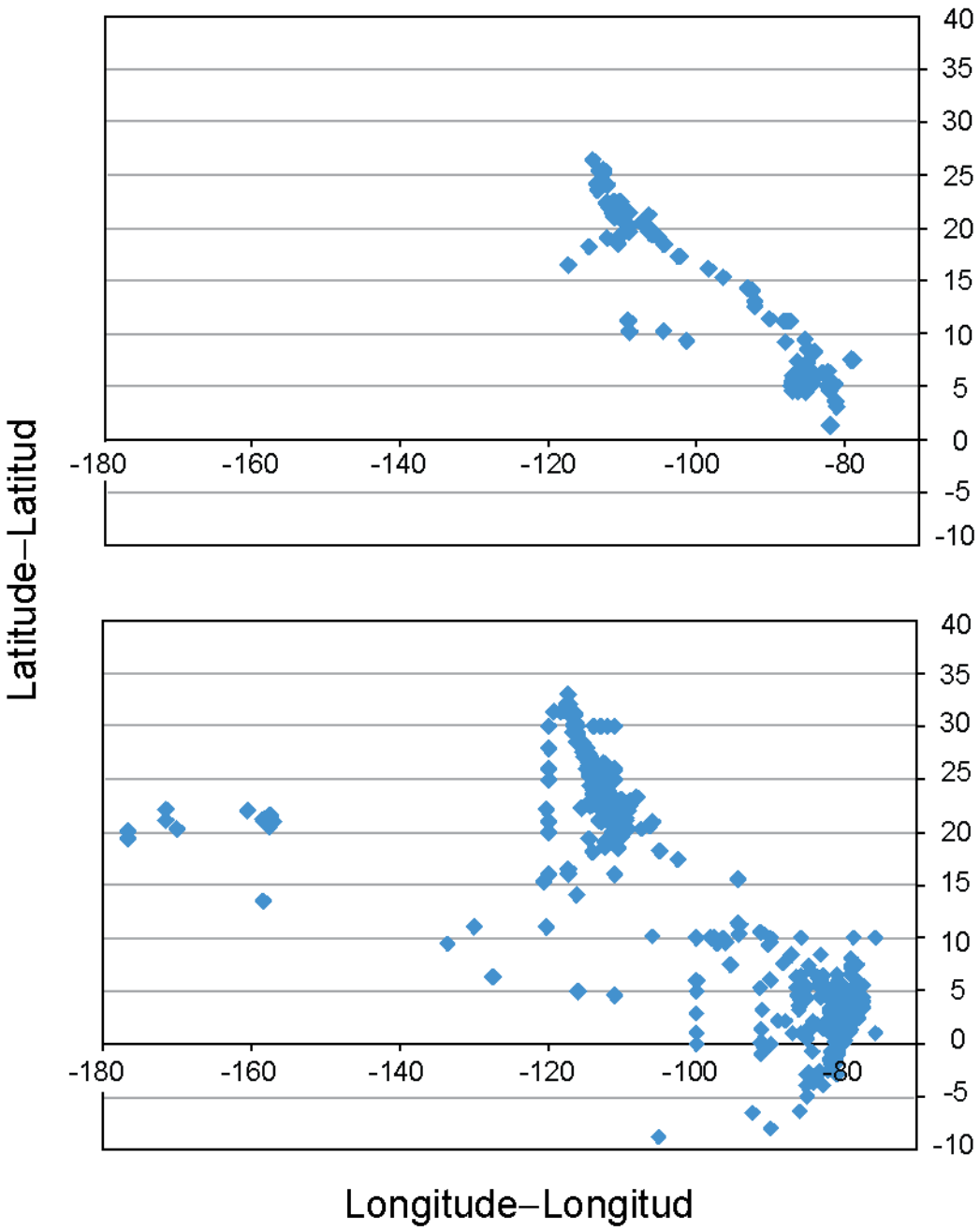

FIGURE 5a. Release (top) and recapture (bottom) positions of the historic tags.
FIGURA 5a. Posiciones de liberación (arriba) y recaptura (abajo) de las marcas históricas.

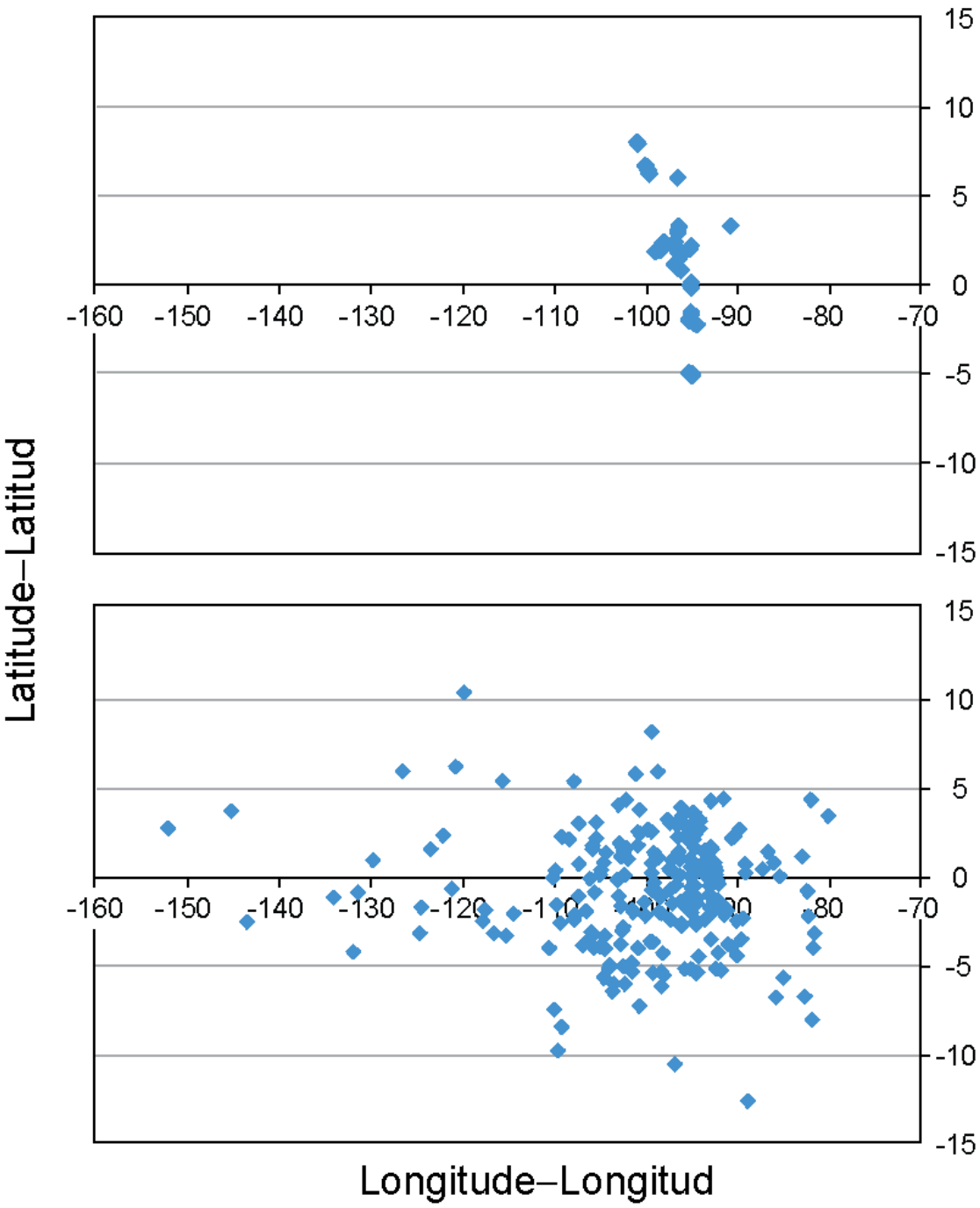

FIGURE 5b. Release (top) and recapture (bottom) positions of the recent tags
FIGURA 5b. Posiciones de liberación (arriba) y recaptura (abajo) de las marcas recientes.