International Dolphin Conservation Program

TECHNICAL WORKSHOP ON CALCULATING N_{min} FOR THE DOLPHIN STOCKS OF THE EASTERN PACIFIC OCEAN

La Jolla, California (USA)
2-5 August 2005

REPORT OF THE MEETING

AGENDA

1. Welcome, introductions, meeting arrangements
2. Overview of abundance estimation techniques used by NMFS
3. Techniques for combining annual abundance estimates as a basis for estimating N_{min}
4. Examination of equivalent calculations of N_{min}
5. Estimation of probability of mortality exceeding SMLs based on different values of N_{min} with current mortality rates
6. Recommendations to the Scientific Advisory Board

DOCUMENTS

NMIN-02 Estimates of the abundance of seven dolphin stocks
NMIN-03 Alternative population estimates for calculating N_{min}

1. Welcome, introductions, meeting arrangements

Dr. Robin Allen welcomed the participants (Appendix 1) and discussed the background and objectives for the workshop. The provisional agenda (NMIN-01) was approved. Dr. Allen acknowledged the offers of financial support for the workshop from the U.S. National Marine Fisheries Service (NMFS) and Ocean Conservancy.

2. Overview of abundance estimation techniques used by NMFS

Tim Gerrodette reviewed the NMFS abundance surveys conducted between 1979 and 2003 (Document NMIN-02; Wade and Gerrodette, 1993, Gerrodette and Forcada 2002a,b, Gerrodette and Forcada 2005, Gerrodette *et al*. 2005). The 1986-2003 surveys are all relatively consistent in design and effort, but there was concern that earlier surveys had less effort and a less-well defined survey design. The estimates from the 2003 survey are still preliminary. Dr. Gerrodette discussed some of the features of the NMFS surveys, which are more complex than traditional line-transect surveys: group size estimation can be difficult, species identification can be ambiguous, the species proportions in mixed-species herds have to be estimated, the search effort has to be distributed over a very large area, and line segments have to be combined due to off-effort travel.

Michael Scott reviewed the definition of N_{min} and its background (Document NMIN-03, see also Wade 1994).

a. Common dolphins

For the purposes of the AIDCP, common dolphins have been divided into three management units, northern, central, and southern, separated at the 15°N and 2°S latitudes. Two species of common dolphins inhabit the area: the short-beaked common dolphin (*Delphins delphis*) and the long-beaked common dolphin (*D. capensis*). For 2003, the total abundance of short-beaked common dolphins was estimated, but not separately for the three stocks. Because the northern management unit includes both the short-beaked and long-beaked species, additional work will be required to calculate abundance estimates that correspond with the stock-based mortalities. The current Stock Mortality Limits (SMLs) are based on the 1992 survey estimates for central common dolphins and the 1993 survey estimates for northern common dolphins, surveys designed for these two stocks. The 1992 survey covered only the eastern portion of the central common stock area (see map, Appendix 2), however, and the 1993 survey may have included northern common dolphins in California waters that were outside the normal survey area. The group estimated stock-specific abundances for common dolphins using the 2003 survey data (Appendix 2).

The group explored the issue of estimating N_{min} for common dolphin stocks that extend beyond the fishing area and that show a wide variability in the proportion of the stock in the area of the fishery. The proportion of the northern and southern common dolphin stock ranges covered by the surveys changed between 1986-1990 and 1998-2003. This proportion would be affected by El Niño events. All of the proposed methods would have problems providing consistent estimates of these stocks as the surveys have either covered only parts of the stocks or covered parts of the stock that are out of the fishery. A population model would require an additional parameter to account for the proportion of the population in the area; the El Niño index could also be used as an environmental co-variate.

3. Techniques for combining annual abundance estimates as a basis for estimating N_{min}

The group listed a range of options for combining survey estimates to calculate N_{min}:

- Estimates obtained by pooling data from a series of surveys;
- Average of survey estimates weighted by the reciprocal of CV^2;
- Average of survey estimates giving more-recent estimates more weight;
- Estimates based on fitting smoothed trends to survey estimates (empirical trend);
- Fitting population dynamics models:
  - Simple model;
  - Age-structured model.

The group decided to discard the pooled-data option because the weighted-average option achieved a similar result more simply and with greater flexibility. The group also discarded the time-weighted-average option because the empirical trend option accounts for time with lower bias. The group then broke up into small working groups to produce the remaining estimates described and to generate 2003 estimates of abundance for common dolphin stocks.

4. Examination of equivalent calculations of N_{min}

Weighted Average: Weighted averages of the survey-specific abundance estimates were calculated, weighting by the reciprocal of the squared survey-specific coefficient of variation (CV). The group discussed whether to base the estimated variance on the survey-specific estimates of variance, or to use a weighted sample variance of the survey-specific abundance estimates. The group preferred using the first method, as the weighted sample variance ignores the information contained in the absolute size of the standard error. Further, when only a few years are considered (*e.g.*, the most recent estimates) the weighted sample variance is based on a few degrees of freedom, producing imprecise estimates of variance.

The group calculated the weighted averages based on the 1998-2003 data for spotted, spinner, and common dolphins (Appendix 3). Both methods of estimating variance were used to calculate N_{min}. For the analyses conducted, estimates of abundance for 1998-2003 varied remarkably little for several stocks, given the size of the standard errors, resulting in small weighted sample variances. This potential underestimation of variance may lead to overestimation of N_{min}. Although, for these years, there was relatively little difference in precision between the two methods, the survey-specific estimates of variance were preferred due to unreliable variance estimation using the weighted sample variance of the abundance estimates.

Empirical Trends: The group initially recommended using the 1986-2003 data (ignoring the unpublished 1992-1993 common dolphin surveys) to estimate the trends. However, it was subsequently decided to use all available data for the estimation of trends because, given the local behavior of trend estimation techniques, the data from the earlier period would have only limited influence on the smoothed point estimates of the recent years, but would contribute valuable information on the inter-annual variability in the point estimates, resulting in a more realistic estimate of variance of the trend.

Smoothing splines were used to obtain empirical estimates of the long-term trend in the survey-specific abundance estimates. Smoothing splines are one of several statistical techniques that can be used to summarize the overall trend in a time series of estimates. Smoothing splines can be robust to inter-annual variability and they do not require restrictive assumptions about the trend (*e.g.*, they do not assume a linear relationship). A statistical computer program (the mgcv package in R) was used to smooth the survey-specific abundance estimates. The relative precision of the survey estimates was taken into consideration by weighting the point estimates by the reciprocal of the squared coefficient of variation. The default smoothing option was found to smooth the estimates too little. This was inferred by noting that trends were changing more rapidly than is consistent with the biology of marine mammals. Further, the rather large standard errors of the survey estimates indicated that more smoothing was appropriate than under the default option. A subjective assessment of different levels of smoothing resulted in the decision to smooth the longer time series (1979-2003; northeastern spotted and eastern spinner dolphins) using 3 degrees of freedom, and the shorter series using 2 degrees of freedom. The N_{min} values in Appendix 4 were obtained assuming a log-normal distribution.

The group calculated N_{min} estimates projected for 2003-2006 based on trends from 1979-2003 for northeastern spotted and eastern spinner dolphins or 1986-2003 for western/southern spotted and whitebelly spinner dolphins (Appendix 4). For northeastern spotted dolphins especially, the earlier estimates (1979-1983) were included to help fit a plausible smoothed curve through the highly variable abundance estimates for 1986-1990. The participants had doubts about this approach for common dolphins due to distributional changes during the surveyed time period.

Simple Population Model: The simple population dynamics approach used a logistic model that accounted for observed mortality and used the 1986-2003 abundance data. The group produced estimates for northeastern and western/southern spotted dolphins and eastern and whitebelly spinner dolphins for 2003-2006 (Appendix 5). Estimates for common dolphins will be produced later.

A Bayesian implementation of a logistic model with both process and observation error was used to estimate population trajectories and N_{min} values. The model was implemented in the Bayesian modeling package WinBUGS (Spiegelhalter *et al.* 1999). The 20^{th} percentile of the Bayesian posterior distribution on abundance was used as the estimate of N_{min}. The model estimated carrying capacity (K), growth rate (r_{max}), and process error (sigma). The same prior distributions were used for all species. Sensitivity to priors on K and r_{max} was investigated. The two species with more contrast in the abundance data (those with more catch: northeastern spotted and eastern spinner) were not very sensitive to the priors. The other two species were more sensitive to the prior on r_{max}. The final prior for this parameter was chosen to reflect a plausible range of r_{max} values for dolphins: uniform from 0 to 0.08.

Age-Structured Model: The complex age-structured modeling approach has been published for spotted dolphins (Hoyle and Maunder 2004). These models are more complex and require additional parameters, and concern was expressed that this would complicate a very simple and easy-to-explain management scheme. It was noted that age-structured models could be fitted with or without the use of mortality-based age-structure data. There was also concern about potential bias in the age structure when estimated from mortality data, and about the ability to model common dolphin stocks because changes in abundance are likely due to changes in distribution. It was suggested that a random effects model be used to account for environmental stochasticity. This approach may be more difficult for non-spotted dolphin stocks that do not have age-related color phases that can serve as a proxy for age.

The group produced estimates for 2003-2008 of NE spotted dolphins using maximum likelihood and Bayesian techniques (Appendix 6). The method differs from that published by Hoyle and Maunder (2004) due to the addition of new estimates of dolphin mortality (2003-2004) and population size (2003). The 20th percentile of the Bayesian posterior distribution on abundance was used as the estimate of N_{min}.

The following table summarizes the estimates made using the various alternative calculations.

	SML options for 2005				
Stock	Current SML[1]	Weighted average	Empirical trend	Logistic model	Age-structured model
Northeastern spotted	648	627	618	673	659
Western/southern spotted	1,145	685	582	750	
Eastern spinner	518	516	466	494	
Whitebelly spinner	871	468	248	512	
Northern common	562	377			
Central common	207	518			
Southern common	1,845	1,293			

5. Estimation of probability of mortality exceeding SMLs based on different values of N_{min} with current mortality rates

The Stock Mortality Limits (SML = 0.001 N_{min}) that would result from the various N_{min} estimates were compared with past mortality estimates to compare their performance with current SMLs based on the 1986-1990 pooled estimates (Appendix 7). It should be noted that the AIDCP has been in force since 1999. The current SMLs have only been in force since 2001; previously the SMLs were 0.2% of N_{min}.

Only for the SMLs based on the empirical trends approach would the mortality have exceeded the SML in the past (2001 for eastern spinner, 2000-2001 for whitebelly spinner). For the SMLs based on the recommended logistic-model approach, none of the seven stocks would have exceeded this SML.

6. Recommendations to the Scientific Advisory Board

There appeared to be an inverse relationship between the best approach from a scientific point of view (the population models) and the simplest approach from a management point of view (the weighted averages). The group recommended using the logistic model to estimate N_{min}. The group produced estimates for the northeastern and western/southern spotted dolphins and the eastern and whitebelly spinner dolphins, but additional work for the common dolphin stocks will be conducted to incorporate an additional parameter to account for changes in the proportion of the population present in the survey area.

References

Gerrodette, T., and J. Forcada. 2002a. Estimates of abundance of northeastern offshore spotted, coastal spotted, and eastern spinner dolphins in the eastern tropical Pacific Ocean. SWFSC Admin. Rep. LJ-02-06, 43 p.

Gerrodette, T., and J. Forcada. 2002b. Estimates of abundance of western/southern spotted, whitebelly spinner, striped and common dolphins, and pilot, sperm and Bryde's whales in the eastern tropical Pacific Ocean. SWFSC Admin. Rep. LJ-02-20. 24 pp.

Gerrodette, T., and J. Forcada. 2005. Non-recovery of two spotted and spinner dolphin populations in

[1] Based on 1986-1990 pooled data

the eastern tropical Pacific Ocean. Mar. Ecol. Prog. Ser. 291:1-21.
Gerrodette, T., G. Watters, and J. Forcada. 2005. Preliminary estimates of 2003 dolphin abundance in the eastern tropical Pacific. SWFSC Admin. Rep. LJ-05-05. 21 pp.
Hoyle, S.D., and M.N. Maunder. 2004. A Bayesian integrated population dynamics model to analyze data for protected species. Animal Biodiversity and Conservation 27.1:247-266.
D.J. Spiegelhalter, A. Thomas, and N.G. Best. 1999. WinBUGS Version 1.2 User Manual, MRC Biostatistics Unit.
Wade, P.R. 1994. Managing populations under the Marine Mammal Protection Act of 1994: A strategy for selecting values for N_{MIN}, the minimum abundance estimate, and F_R, the Recovery Factor. SWFSC Admin. Rep. LJ-94-19. 26 pp.
Wade, P.R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Rep. int. Whal. Commn 43:477-493.

Appendix 1.

PARTICIPANTS

IATTC

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Appendix-Anexo 2.

TABLE 2.1. Estimates of abundance for short-beaked common dolphins, *Delphinus delphis*, 2003.
TABLA 2.1. Estimaciones de abundancia del delfín común de hocico corto, *Delphinus delphis*, 2003.

Stock	Point estimate Estimación de punto	Standard error Error estándar	% CV
Northern—Norteño	229,335.2	83,703.52	36.50
Central	581,379.4	138,306.14	23.79
Southern—Sureño	572,708.1	280,576.94	48.99
Total	**1,383,422.7**	**335,515.06**	**24.25**

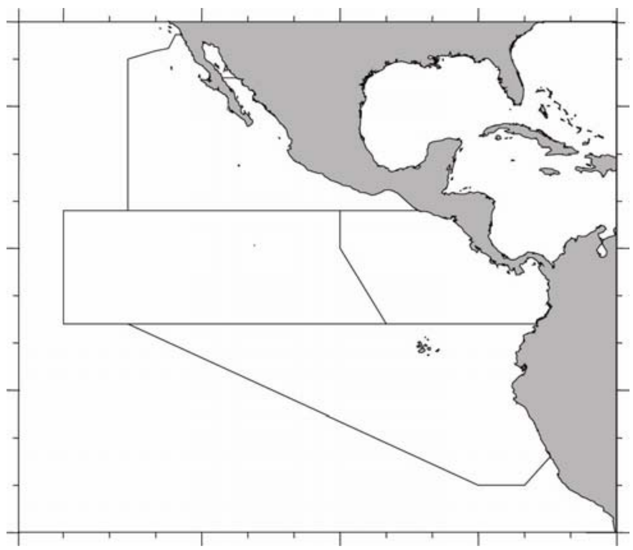


FIGURE 2.1. Short-beaked common dolphin stock areas covered in research vessel surveys.
FIGURA 2.1. Zonas de los stocks del delfín común de hocico corto abarcadas en los estudios por buques de investigación.

Appendix-Anexo 3.

TABLE 3.1. Weighted averages of abundance for spotted, spinner, and common dolphins, calculated using the 1998-2003 data.
TABLA 3.1. Promedios ponderados de abundancia de los delfines manchado, tornillo, y común, calculados con los datos de 1998-2003.

Species and stock / **Especie y stock**	***N***	**se_1**	**N_{min1}**	**se_2**	**N_{min2}**
Spotted dolphin – Delfín manchado					
Northeastern—Nororiental	670,835	53,560	627,306	29,675	642,431
Western-southern—Occidental-sureño	781,139	122,348	685,213	51,996	731,936
Spinner dolphin – Delfín tornillo					
Eastern—Oriental	542,259	30,798	516,968	31,984	511,875
Whitebelly—Panza blanca	559,492	119,074	468,666	141,166	438,758
Common dolphin – Delfín común					
Northern—Norteño	449,462	93,591	377,910	84,005	374,931
Central	577,048	73,096	518,914	14,656	562,887
Southern—Sureño	1,525,207	300,946	1,293,885	338,228	1,230,899

se_1=sqrt(sum(wt_i^2*var(N_i))/(sum(wt_i)^2) where wt_i=1/(cv_i)^2, N_i = estimate for year *i*
se_2=sqrt(sum(wt_i(N_i-N)^2)/(sum(wt_i)*(k-1)) where N = weighted average of N_i, k = no. of years
Notes:
The annual estimates for a stock seem to be in better agreement than would be expected, given their std errors. Perhaps estimation is more precise than the estimated standard errors indicate?
$z_{0.8}$=0.842, while $t_{3,0.8}$=0.978. By contrast, $z_{0.975}$=1.96 and $t_{3,0.975}$=3.18. So for 60% confidence limits, the penalty for having just 3 df is quite small.

Appendix-Anexo 4.

TABLE 4.1. Empirical trends obtained by smoothing 1979-2003 estimates.
TABLA 4.1. Tendencias empíricas obtenidas mediante una suavización de las estimaciones de 1979-2003.

	N_{min} estimates—Estimaciones de N_{min}			
	Spotted dolphin – Delfín manchado		Spinner dolphin – Delfín tornillo	
	Northeastern—Nororiental	Western-southern—Occidental-sureño	Eastern—Oriental	Whitebelly—Panza blanca
2003	633,675	605,099	486,466	339,283
2004	626,272	593,365	476,408	290,939
2005	618,310	582,280	466,783	248,258
2006	610,440	572,584	457,684	211,503

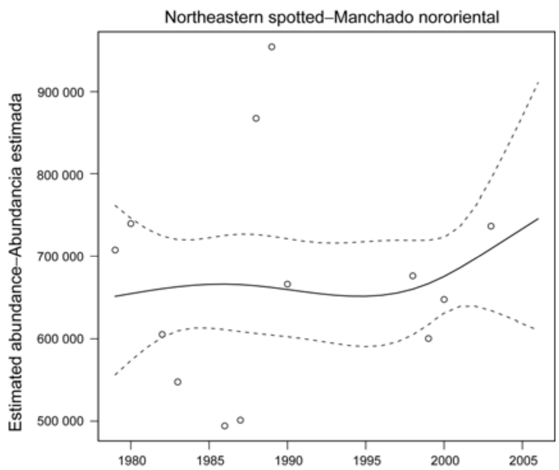


FIGURE 4.1a. Smoothed population estimates for northeastern spotted dolphins. The solid line is the estimated population size and the dashed lines are 60% confidence intervals.
FIGURA 4.1a. Estimaciones suavizadas de la población del delfín manchado nororiental. La línea sólida representa el tamaño estimado de la población, y las líneas de trazos los intervalos de confianza de 60%.

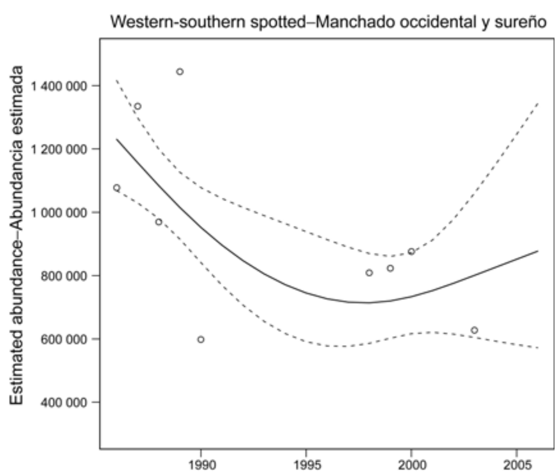


FIGURE 4.1b. Smoothed population estimates for western-southern spotted dolphins. The solid line is the estimated population size and the dashed lines are 60% confidence intervals.
FIGURA 4.1b. Estimaciones suavizadas de la población del delfín manchado occidental-sureño. La línea sólida representa el tamaño estimado de la población, y las líneas de trazos los intervalos de

confianza de 60%.

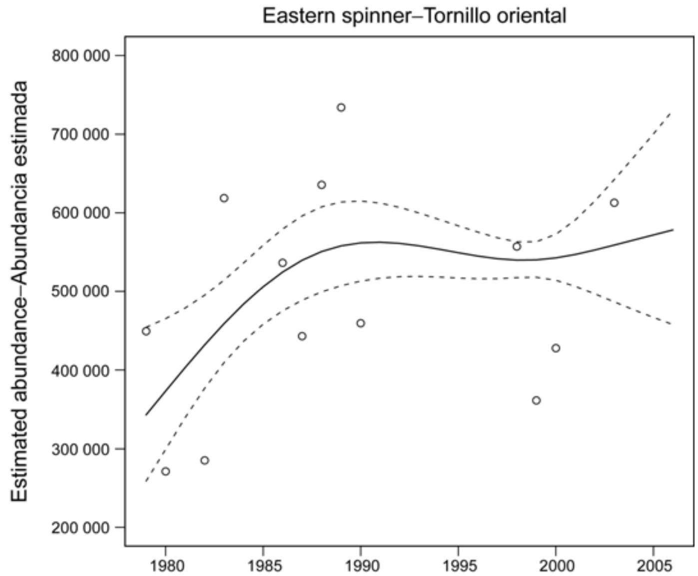


FIGURE 4.1c. Smoothed population estimates for eastern spinner dolphins. The solid line is the estimated population size and the dashed lines are 60% confidence intervals.
FIGURA 4.1c. Estimaciones suavizadas de la población del delfín tornillo oriental. La línea sólida representa el tamaño estimado de la población, y las líneas de trazos los intervalos de confianza de 60%.

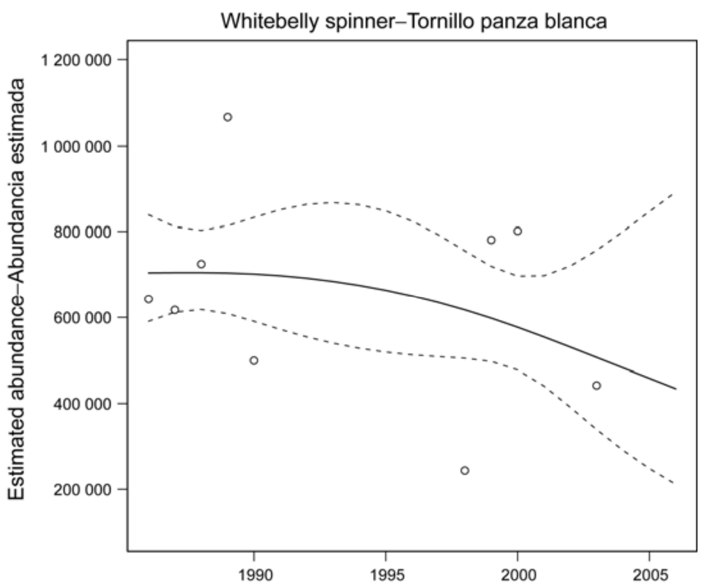


FIGURE 4.1d. Smoothed population estimates for whitebelly spinner dolphins. The solid line is the estimated population size and the dashed lines are 60% confidence intervals.
FIGURA 4.1d. Estimaciones suavizadas de la población del delfín tornillo panza blanca. La línea sólida representa el tamaño estimado de la población, y las líneas de trazos los intervalos de confianza de 60%.

Appendix-Anexo 5.

TABLE 5.1. Simple population dynamics using the logistic model.
TABLA 5.1. Dinámica poblacional sencilla usando el modelo logístico.

	N_{min} estimates—Estimaciones de N_{min}			
	Spotted dolphin – Delfín manchado		**Spinner dolphin – Delfín tornillo**	
	Northeastern—Nororiental	**Western-southern—Occidental-sureño**	**Eastern—Oriental**	**Whitebelly—Panza blanca**
2003	663,800	746,200	491,400	514,300
2004	668,400	747,000	494,900	513,280
2005	673,180	750,400	499,600	512,880
2006	678,000	753,000	504,400	514,300

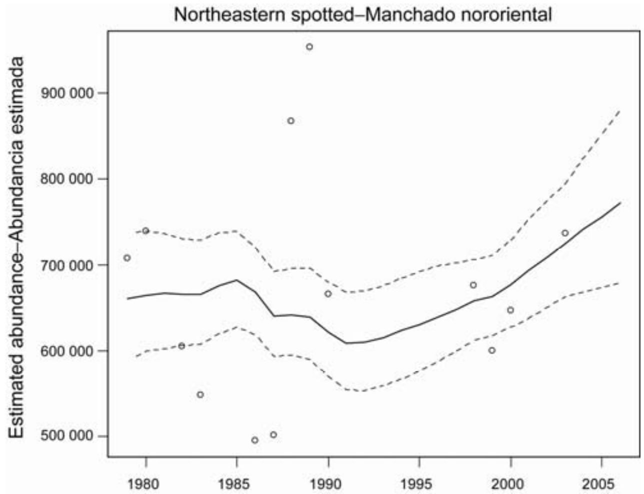
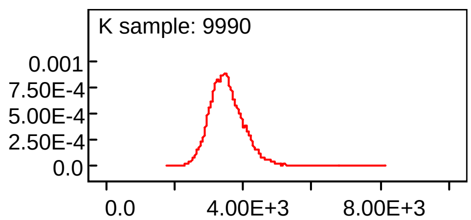
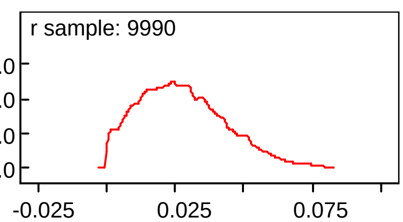


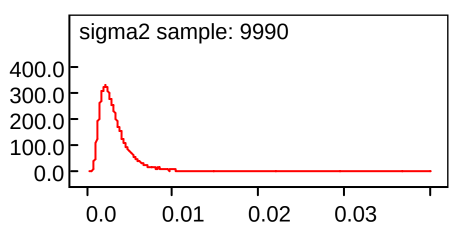
FIGURE 5.1a. Logistic model fitted to survey abundance estimates for northeastern spotted dolphins.
FIGURA 5.1a. Modelo logístico ajustado a las estimaciones de abundancia de los estudios en el mar del delfín tornillo oriental.



node	K
mean	3547.0
sd	526.2
MCerror	14.04
10.0%	2955.0
25.0%	3196.0
median	3493.0
75.0%	3835.0
90.0%	4195.0



node	r
mean	0.02787
sd	0.01579
MCerror	2.362E-4
10.0%	0.008181
25.0%	0.01576
median	0.02638
75.0%	0.038
90.0%	0.04981



node	sigma2
mean	0.003467
sd	0.002308
MCerror	2.651E-5
10.0%	0.001564
25.0%	0.002057
median	0.002864
75.0%	0.004093
90.0%	0.005926

	mean	sd	MC error	10.0%	25.0%	median	75.0%	90.0%
2003	729.8	78.22	1.052	632.8	675.2	725.6	780.0	831.8
2004	747.3	93.8	1.257	631.9	682.1	741.3	805.6	868.3
2005	765.0	109.5	1.355	633.1	688.2	756.3	832.1	905.0
2006	782.9	124.4	1.543	634.4	696.6	772.3	856.6	946.6

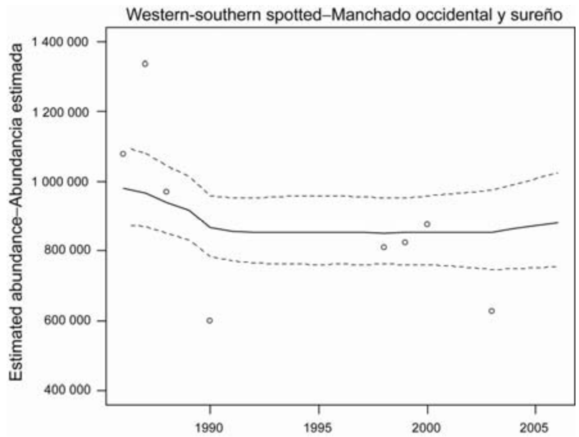
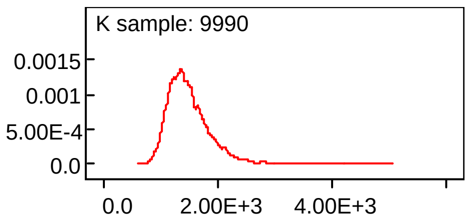
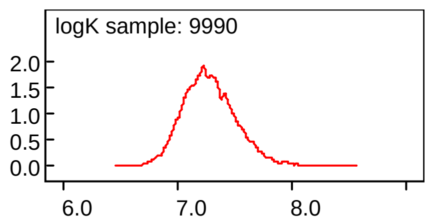


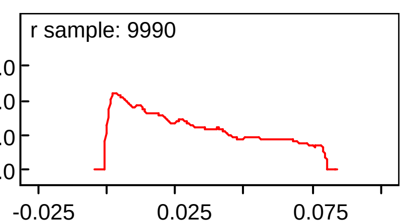
FIGURE 5.1b. Logistic model fitted to survey abundance estimates for western-southern spotted dolphins.
FIGURA 5.1b. Modelo logístico ajustado a las estimaciones de abundancia de los estudios en el mar del delfín manchado occidental-sureño.



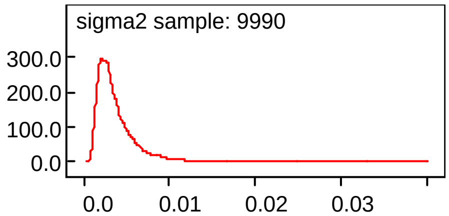
node	K
mean	1503.0
sd	379.4
MCerror	13.84
10.0%	1102.0
25.0%	1242.0
median	1436.0
75.0%	1686.0
90.0%	1981.0
start	11
sample	9990



node	logK
mean	7.287
sd	0.2335
MCerror	0.008253
10.0%	7.005
25.0%	7.125
median	7.269
75.0%	7.43
90.0%	7.591
start	11
sample	9990



node	r
mean	0.03233
sd	0.02277
MCerror	4.647E-4
10.0%	0.004606
25.0%	0.0123
median	0.0285
75.0%	0.05059
90.0%	0.06701
start	11
sample	9990



node	sigma2
mean	0.003777
sd	0.002585
MCerror	3.339E-5
10.0%	0.001655
25.0%	0.002189
median	0.003069
75.0%	0.00453
90.0%	0.006587
start	11
sample	9990

	mean	sd	MCerror	10.0%	25.0%	median	75.0%	90.0%	start	sample
2003	861.7	137.0	2.293	692.6	767.8	853.2	948.7	1037.0	11	9990
2004	872.0	147.2	2.485	691.8	768.6	863.4	966.3	1060.0	11	9990
2005	882.4	156.9	2.519	691.2	772.5	873.6	981.4	1084.0	11	9990
2006	892.6	166.3	2.667	689.0	778.7	879.9	996.3	1112.0	11	9990

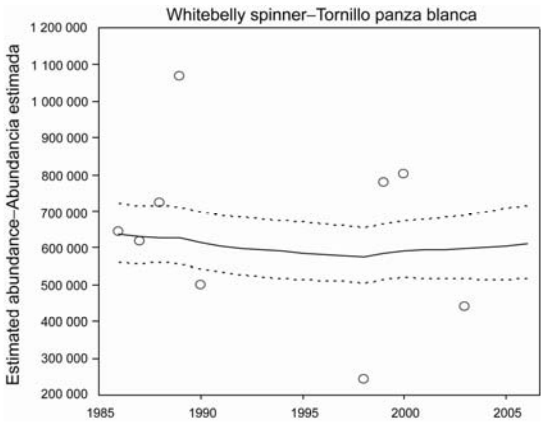
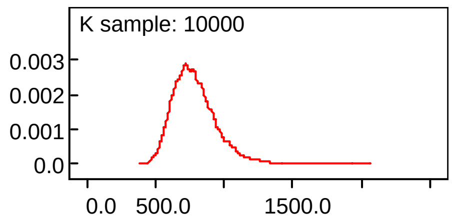
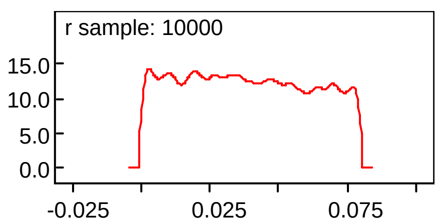


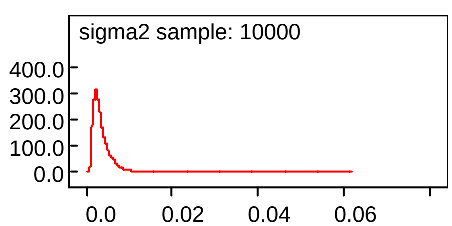
FIGURE 5.1c. Logistic model fitted to survey abundance estimates for whitebelly spinner dolphins.
FIGURA 5.1c. Modelo logístico ajustado a las estimaciones de abundancia de los estudios en el mar del delfín tornillo panza blanca.



node	K
mean	789.3
sd	163.5
MCerror	3.909
2.5%	539.9
median	768.1
97.5%	1172.0
start	1001
sample	10000



node	r
mean	0.03868
sd	0.02305
MCerror	3.481E-4
2.5%	0.001833
median	0.03777
97.5%	0.07798
start	1001
sample	10000



node	sigma2
mean	0.003604
sd	0.002423
MCerror	3.133E-5
2.5%	0.001238
median	0.002966
97.5%	0.009516
start	1001
sample	10000

	mean	sd	MC error	2.5%	median	97.5%	start	sample
2003	603.4	105.2	1.406	418.0	596.6	826.6	1001	10000
2004	607.8	110.4	1.487	413.2	600.8	843.3	1001	10000
2005	612.7	115.3	1.536	410.9	605.4	856.3	1001	10000
2006	617.1	120.6	1.546	408.1	610.0	872.9	1001	10000

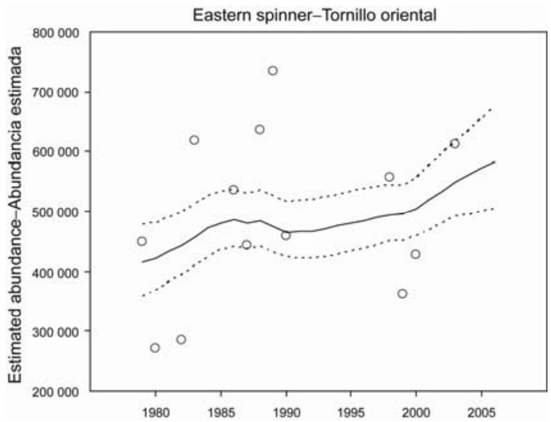
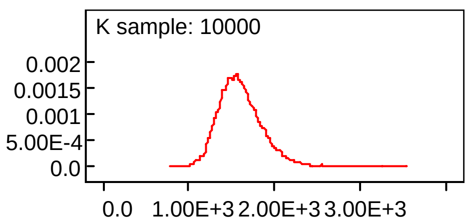
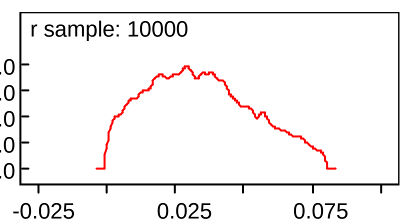


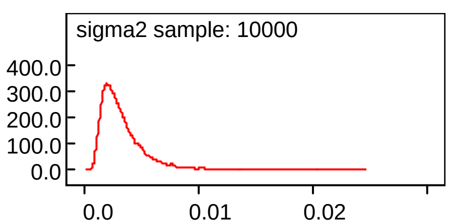
FIGURE 5.1d. Logistic model fitted to survey abundance estimates for eastern spinner dolphins.
FIGURA 5.1d. Modelo logístico ajustado a las estimaciones de abundancia de los estudios en el mar del delfín tornillo oriental.



node	K
mean	1608.0
sd	259.3
MCerror	7.543
2.5%	1193.0
median	1578.0
97.5%	2191.0
start	1001
sample	10000



node	r
mean	0.03444
sd	0.01921
MCerror	3.617E-4
2.5%	0.002955
median	0.03298
97.5%	0.07369
start	1001
sample	10000



node	sigma2
mean	0.003426
sd	0.002105
MCerror	2.413E-5
2.5%	0.001186
median	0.002871
97.5%	0.009002
start	1001
sample	10000

	mean	sd	MC error	2.5%	median	97.5%	start	sample
2003	554.5	75.07	1.211	420.7	548.8	715.2	1001	10000
2004	567.2	85.37	1.434	417.0	561.1	752.0	1001	10000
2005	579.9	95.15	1.582	413.2	573.3	784.5	1001	10000
2006	592.2	104.8	1.751	407.5	583.8	816.1	1001	10000

Appendix-Anexo 6.

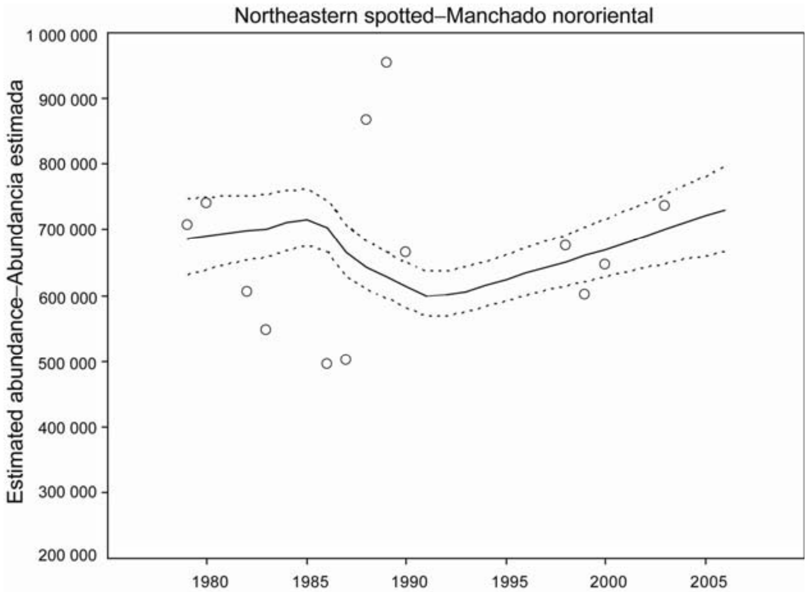


FIGURE 6.1. Age-structured model fitted to survey abundance estimates for eastern spinner dolphins.

FIGURA 6.1. Modelo por edad ajustado a las estimaciones de abundancia de los estudios en el mar del delfín tornillo oriental.

Appendix-Anexo 7.

TABLE 7.1. Comparison of various SML options for 2005 with dolphin mortality estimates since AIDCP came into force (1999-2004).
TABLA 7.1. Comparación de varias opciones de LMS para 2005 con la mortalidad estimada de delfines desde la entrada en vigor del APICD (1999-2004).

	SML options for 2005 Opciones para los LMS de 2005					Estimated mortality Mortalidad estimada					
Species and stock	**Current SML**[2]	**Weighted average**	**Empirical trend**	**Logistic model**	**Age-structured model**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Especie y stock	**LMS actual**[2]	**Promedio ponderado**	**Tendencia empírica**	**Modelo logístico**	**Modelo por edad**						
Spotted dolphin – Delfín manchado											
Northeastern—Nororiental	648	627	618	673	659	358	295	591	439	281	250
Western-southern—Occidental-sureño	1,145	685	582	750		253	435	309	206	333	248
Spinner dolphin – Delfín tornillo											
Eastern—Oriental	518	516	466	494		469	405	287	405	287	220
Whitebelly—Panza blanca	871	468	248	512		372	186	169	189	169	214
Common dolphin – Delfín común											
Northern—Norteño	562	377				85	54	94	69	133	159
Central	207	518				34	223	203	155	140	100
Southern—Sureño	1,845	1,293				1	10	46	4	99	222

[2] Based on 1986-1990 pooled data—Basados en datos de 1986-1990 agrupados

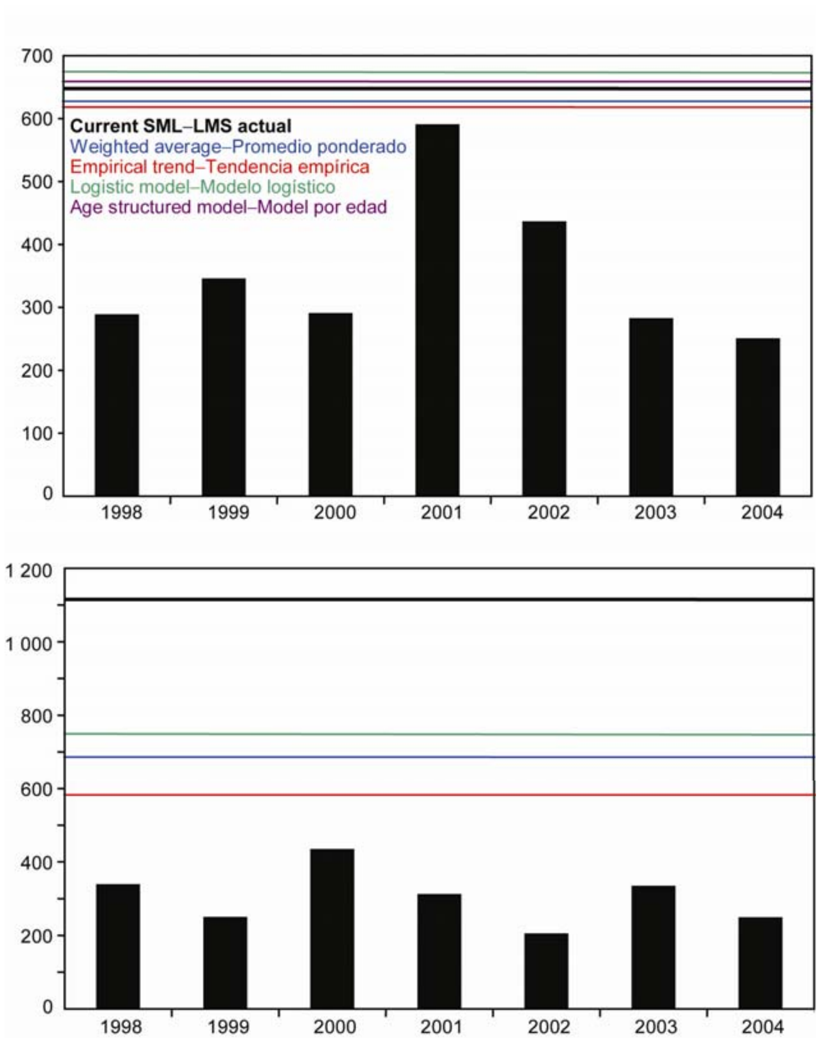


FIGURE 7.1a. Comparison of 1988-2004 spotted dolphin mortalities with current and alternative stock mortality limits (SMLs).

FIGURA 7.1a. Comparación de la mortalidad de delfines manchados en 1988-2004 con los límites de mortalidad por stock (LMS) actual y alternativo.

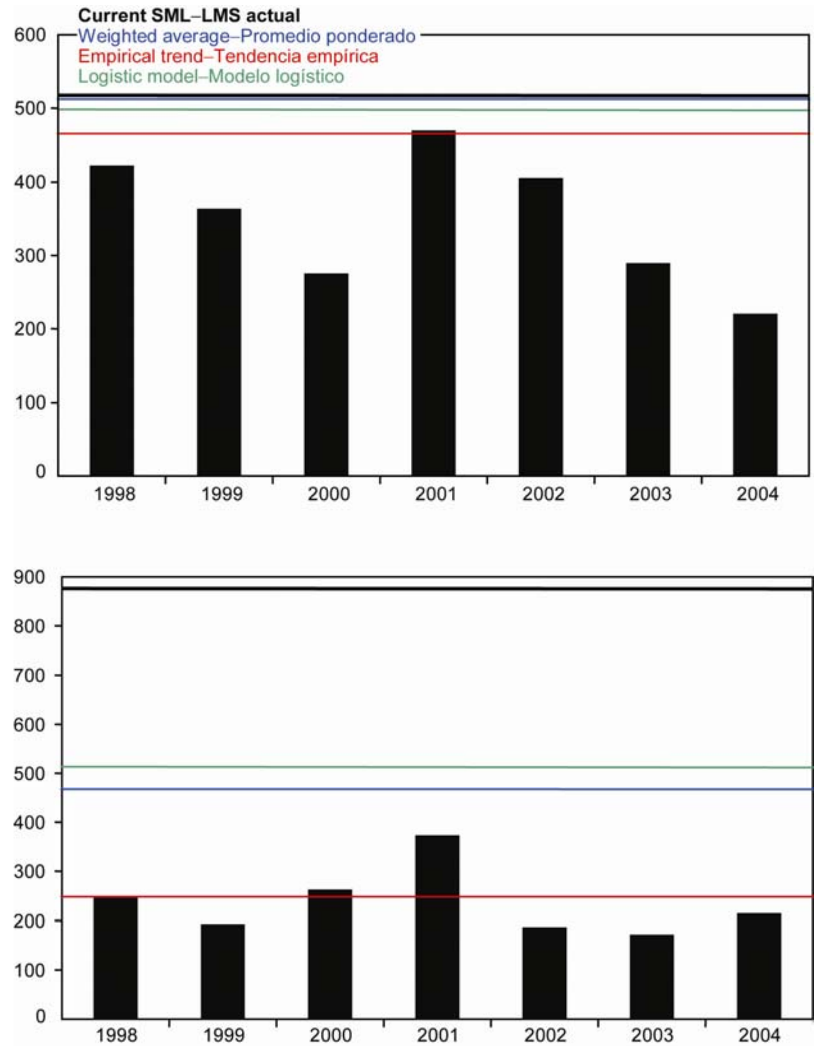


FIGURE 7.1b. Comparison of 1988-2004 spinner dolphin mortalities with current and alternative stock mortality limits (SMLs).

FIGURA 7.1b. Comparación de la mortalidad de delfines tornillo en 1988-2004 con los límites de mortalidad por stock (LMS) actual y alternativo.

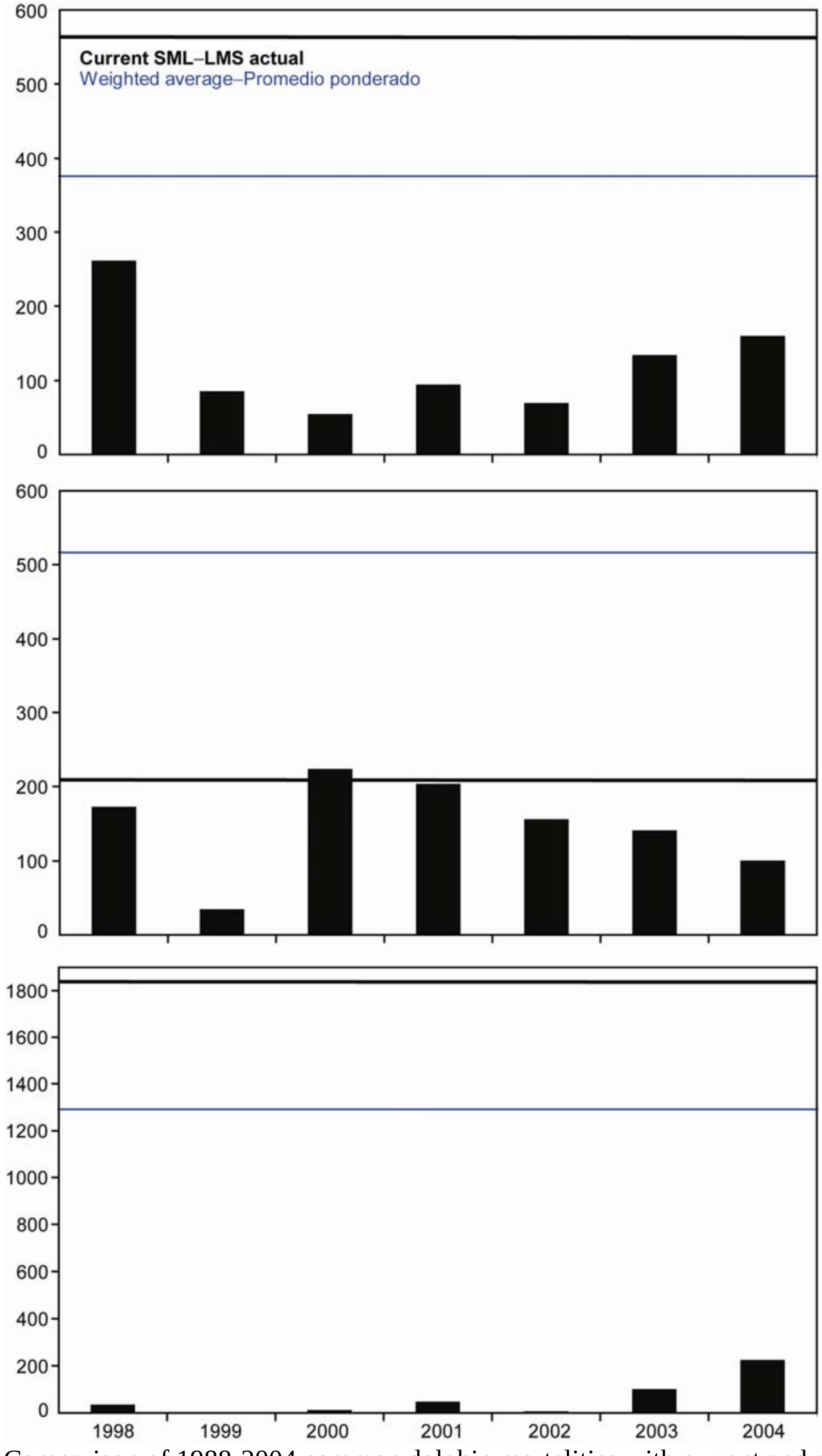


FIGURE 7.1c. Comparison of 1988-2004 common dolphin mortalities with current and alternative stock mortality limits (SMLs).
FIGURA 7.1c. Comparación de la mortalidad de delfines comunes en 1988-2004 con los límites de mortalidad por stock (LMS) actual y alternativo.